1.10 มาตรฐานและคุณสมบัติทางเทคนิค (Standard and Specification)

(Specification No. M-8/2017)

(สำหรับรายการที่ 1 และ รายการที่ 2)

22 kV INDOOR SWITCHGEARS

Contents

Invitation to Bid No.:

C Material, equipment and specifications for 22 kV INDOOR SWITCHGEARS

C1 General Conditions

1a Scope

There specifications cover the minimum technical requirements for the design, manufacture, testing in the Manufacturer's workshops, supply and delivery, transportation to the site(s), erection, installation, field-test, and commissioning of 22 kV indoor switchgear, complete in every respect with all components and necessary accessories for reliable continuous operation, even if not all details are expressively stated in these specifications, operated with a Computer-based Substation Control System (CSCS) remotely or locally operated.

1b Standards

All design, calculations, materials, equipment required within the scope of works, manufacture, construction and testing shall conform as a basic requirement with the latest edition of the following standards:

IEC 62271-1	High-voltage switchgear and controlgear – Part 1: Common specifications
IEC 62271-100	High - voltage switchgear and controlgear – Part 100: High voltage alternating - current circuit-breakers
IEC 62271-102	High - voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches
IEC 62271-103	High-voltage switchgear and controlgear – Part 103: Switches for rated voltages above 1 kV up to and including 52 kV
IEC 62271-105	High - voltage switchgear and controlgear – Part 105: Alternating current switch – fuse combinations for rated voltages above 1 kV up to and including 52 kV
IEC 62271-200	High-voltage switchgear and controlgear – Part 200: A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
IEC 61869-1	Instrument transformers – Part 1 : General requirements
IEC 61869-2	Instrument transformers – Part 2 : Additional requirements for current transformers
IEC 61869-3	Instrument transformers – Part 3 : Additional requirements for inductive voltage transformers
IEC 60255	Electrical relays
IEC 60947	Low - voltage switchgear and controlgear
IEC 60282-1	High - voltage fuses – Part 1: Current – limiting fuses

IEC 60071	Insulation co-ordination
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60909	Short - circuit currents in three-phase a.c. systems

And all other relevant TIS or IEC standards, unless otherwise specified in these specifications.

The latest edition of each standard shall mean the edition available on the date of signing the Contract.

If not applicable equipment shall comply with relevant standard.

ASTM	American Society for Testing and Materials
IEEE	The Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
TIS	Thailand Industrial Standard Institute
ANSI	American National Standard Institute
AWS	American Welding Society
SSPC	The Society For Protective Coating

For standards and regulations not covered by the above-mentioned standards and regulations, other internationally recognized standards and regulations may apply, if approved by the Authority.

1c Principal requirements

1c.1 General

The switchgears for 22 kV system shall be of metal-clad air insulated switchgears with withdrawable vacuum circuit-breaker.

The switchgears shall be of a type tested, factory assembled, standardized design for freestanding indoor installation. Each switchgear cubicle shall be completely mounted and wired with all instruments, protective devices and equipment installed and tested at the factory.

The cubicles shall be lined up side by side and be individually separable. The operating side of the switchgear shall be aligned, a displacement of the front of switchgear cubicles shall not be accepted.

The switchgears shall be manufactured such that ingress of dust, vermin, and small objects is prohibited

The switchgears shall be protected against corrosion under stated environmental conditions. All steel surfaces which are not galvanized shall receive a standard protection. As a minimum following standards painting conditions shall be applied:

The enclosure shall be prepared and painted with a high-solid epoxy coating as specified below. The paint shall be gray RAL 7032.

Surface preparation:

All steel surfaces shall be prepared per SSPC-SP2, 3, 6, 7, 10, 11 or the paint manufacturer's recommendations. Exceptions to the manufacturer's requirements shall be approved by the paint manufacturer and provided with the submittal documents.

Inaccessible surfaces:

Prepare and coat steel surfaces inaccessible to preparation and coating after fabrication with all coats before fabrication. Inaccessible surfaces shall be considered Zone 2A per SSPC specifications.

Primer specification:

All surfaces, inside and outside, shall be primed with a High-Solid Epoxy (primer coat shall have a 2 to 4 mil dry film thickness) paint. The primer shall have following minimum performance and properties:

- Salt Spray (ASTM B117) 3,000 Hours with no face blistering
- Humidity (ASTM D2247) 750 Hours with no face corrosion or blistering
- Immersion (NACE TM-01-69) fresh water 1 year with no blistering
- Abrasion resistance (ASTM D4060) 1kg load/1,000 cycles, CS-17 wheel: 102 mg weight loss
- Impact resistance (ASTM D2794): Direct 24 in.lb and Reverse 6 in.lb.
- Moisture vapor transmission (ASTM F1249): 4.49 g/m^2.
- Adhesion (ASTM D4541): 900 PSI
- NFPA Class A Qualification

Top coat specification:

All surfaces, inside and outside, shall be top coated with a High-Solid Epoxy paint with a dry film thickness of 2 to 4 mils. This will provide a total dry film thickness of 4 mils minimum and 8 mils maximum. The minimum acceptable measure total dry film thickness shall not be less than 4 mils.

The paint utilized on the top-coat shall have the following properties:

- Salt Spray (ASTM B117) 5,500 Hours with no face blistering
- Humidity (ASTM D2247) 5,500 Hours with no face corrosion or blistering
- Gloss retention (ASTM G53) QUV-B bulb: Greater than 50% gloss retention at 26 weeks
- Elongation (ASTM D5222) 14%
- Abrasion resistance (ASTM D4060) 1kg load/1,000 cycles, CS-17 wheel: 53 mg weight loss
- Impact resistance (ASTM D2794): Direct 24 in.lb and Reverse 6 in.lb.
- Adhesion, elcometer (ASTM D4541): 2,700 PSI
- NFPA Class A Qualification

Paint shall also provide excellent chemical resistance to splash, spillage, fumes and weather for acidic, alkaline, salt solutions (acidic, neutral, and alkaline salt solutions), fresh water, solvents and petroleum product environments.

The switchgear design shall allow for future extension on either end without modifications to existing cubicles.

All the switchgear cubicles shall be mounted on base frames specially provided for this purpose.

For maintenance purposes easy direct access from outside shall be possible to each compartment. Separating walls between the compartments shall provide complete protection of live parts in neighboring compartments.

To fulfill the high safety requirements for personnel, the switchgear shall be designed to provide ultimate protection in the event of an arc fault, i.e. for the design of high-voltage switchgear, IEC 60298, Appendix AA, internal fault shall be applied at every high-voltage compartment (e.g. busbar compartment, switching device compartment, and cable connection compartment) of AIS.

In case of an internal arc the effects of the arc shall be limited to the compartment concerned, the separating walls shall withstand the pressure and shall not blow, no secondary arc shall occur in another compartment.

All operations (such as in/out service, manual close, manual open and manual charge spring) of the truck/rack, circuit-breaker and earthing switch for cable earthing shall be executed from outside of the cubicle without the need to open any cubicle door.

Each switchgear cubicle shall be provided with an earthing bus, copper flat bar of not less than 150 mm^2 cross-sectional area, running through the length of the switchboard with connecting points in each cubicle for earthing leads. This earthing bus shall be connected to the substation earthing system at least at four (4) points for each main bus section. All grounding terminal of high-voltage equipment shall be grounded through earthing bus.

Indicating lamps shall be provided on each cubicle, showing each phase energization condition.

Alarms will be transferred to CSCS and annunciator.

1c.2 Site and service conditions

The equipment shall be capable of operating at its full ratings under site and service conditions as mentioned below:

Seismic activity:	0.1g
Maximum wind speed:	(≈100 km/h)
Maximum recorded rainfall:	250 mm/day
Number of days with thunderstorm:	100 days/year

Average rainfall:	20 mm/day
Mean maximum annual relative humidity:	94%
Mean minimum annual relative humidity:	79%
Minimum daily relative humidity:	17%
Maximum temperature of surfaces exposed to sunbeam:	80°C
Mean minimum daily temperature:	24°C
Maximum ambient temperature:	40°C[(1)]
Minimum ambient temperature:	11°C

The switchgear room has no air conditioning system.

[(1)] According to IEC 62271-1 over $40^{O}C$ will be possible under special requirement.

1c.3 Construction

1c.3.1 Air Insulated Switchgear (AIS)

1c.3.1.1 Requirements

The switchgear shall be suitable for indoor installation.

Each switchgear cubicle shall be of rigid, torsion resistant, sheet steel construction with 2 mm at least in thickness (except pressure relief flap), built as self-supporting structure. Barriers between the primary section of adjacent units and between the primary major sections of each circuit shall not be less than 3 mm. All other covers, barriers, panels and doors shall be not less than 2 mm. The cubicle shall be divided into at least four (4) compartments partitioned as follows:

1. Busbar compartment
2. Switching device compartment
3. Cable connection compartment
4. Low voltage compartment

Each compartment (except busbar one) can be maintained separately, ensuring other feeders service will continue.

To minimize the possibility of communicating faults between primary sections shall have no intentional openings. The automatic shutters shall be provided in the stationary structure to prevent accidental contact with live parts of the primary circuit when the removable element is in the test position, disconnected position, or has been removed.

Metal-clad switchgear shall be dust-proof enclosure suitable for indoor tropical installation. All exposed ports of metal-clad switchgear. The switchgear shall be suitable to be installed on uneven concrete floor. Any materials for floor level adjustment shall be supplied.

The switchgear shall be at least installed for a distance of 1.5 m from the walls and ceilings of switchgear room. Free access from the front of switchgear shall be at least 2 m allowing walking access for operation and maintenance.

The switchgear shall be delivered as minimum disassembled units as possible to assure high reliability of the switchgear and to shorten the installation period. Nevertheless the unit shall have the weight and dimensions that it can be transported and lifted to the floor by conventional means. Suggested method shall be described in the bid.

The switching device compartment shall be provided with a pressure resistant front door equipped mechanical indicating mechanism and the mechanical operation cycle counter. This front door shall be hinged door and equipped with door latch and suitable lock to prevent unauthorized access. The fixed mating contacts mounted in the through bushings to busbars and cable connection compartment shall be covered by automatically acting shutters. Theses shutters shall be interlocked with the withdrawable circuit-breaker and shall be in closed position when the circuit-breaker is in the test/isolated and removed positions.

It shall be possible to open the shutters only with tools for testing purposes. These special tools shall be supplied, one set for each bus section.

The front door of the switchgear cubicle shall be able to open when the circuit-breaker is in the test/isolated position only.

The cable connection compartment shall be generously designed to allow easy connection of up to two (2) parallel circuits. The built-in cable mounting brackets shall be adjustable.

All high-voltage compartments shall be equipped with separate pressure relief on cubicle top, to ensure quick and safe release of pressure if an arc fault develops without endangering personnel standing in front of or adjacent to the cubicles.

Any formation of condensation water shall be prevented by appropriate heating in each compartment of a cubicle (low-voltage compartment, busbar compartment, switching device compartment and cable connection compartment), through space heaters with hygrostat, single-phase 230 VAC, with common circuit-breaker for each cubicle.

After commissioning no cable access shall remain open. All the openings without cables shall be fitted with pressure-tight screw plugs.

The floor of the cubicle shall be provided with removable fire-resistant plates suitable for tightly sealing outgoing and incoming cables to prevent vermin. Peculiar care shall be taken during installation to prevent rodent from settling between cubicle and ground.

Where building beams obstruct access, dummy cubicle shall be provided.

1c.3.1.2 Control devices

Switchgear cubicles shall be provided with the following indication and control devices:

(a) Switchgear equipment position indicators and local controls

(b) Emergency mechanical manual trip for circuit-breaker without opening front door

(c) Alarm and indication equipment

(d) Measuring and control equipment

(e) Local/Remote control switches for all available remote control devices

(f) Capacitive voltage indication (if any)

(g) Autoreclose switch

1c.3.1.3 Cubicle size

Cubicle size should not be more than:

Width 1.1 m for outgoing feeders

Height 2.5 m

Depth 2.3 m

1c.3.1.4 Ratings

Ratings are specified in **APPENDIX 1** attached to this specification

1c.3.1.5 Low-voltage compartment

For equipment installed in the low voltage compartment, refer to **APPENDIX 3**: Control, Protection and Measures. For wiring, refer to **APPENDIX 4**: Small Wiring

The low-voltage compartment shall be designed, as follows:

(a) To be completely partitioned off from the high-voltage sections and have a separate hinged door to ensure that personnel working on the low-voltage compartment are not on danger.

(b) To be furnished with 230 VAC interior lighting controlled by a door switch.

(c) To have ample space to accommodate all protective devices, metering instruments, connections to Computer-based Substation Control System (CSCS), secondary control equipment, miniature circuit-breakers, terminals, etc.

(d) All equipment mounted on and suspended from the door shall be fastened in such a way that the door will neither be subjected to torsion nor deformed. Manually operated equipment (switches, resetting of protective devices (relays), etc.) shall be mounted not higher than 1,700 mm above floor.

1c.3.1.6 Annunciators

Each annunciator system shall be of the solid-state type consisting of an annuciator with input/output and an annunciator horn relay. Each annunciator horn relay shall be wired to initiate the common horn. One common horn shall be furnished for each substation. The annunciator system shall operate from DC source with rated voltage 125 VDC.

Each annunciator system shall be compact and integrally mounted in a dustproof, back connected, flush-mounted switchboard type cabinet. Each annunciator shall have 8 alarm points including push buttons for the following functions: “Silence the alarm”, “Acknowledged”, “lamp reset” and “lamp test”. Each alarm point shall be provided with a light-emitting diode and shall have a nameplate, writing with black letters. Each alarm point shall be designed to operate either with field contact that closed for alarm or open for alarm.

Automatic acknowledge timer and push button switch shall be installed at bus section cubicle.

A red group pilot lamp for indication of annunciator operation and a white indicating light assembly for monitoring availability of annunciator potential shall be furnished with each annunciator system. They shall be suitable for mounting on the control board panel face.

The alarm horn shall be of the vibrating type, and shall be suitable for surface mounting inside the switchboard.

Each horn shall be furnished, mounted and wired inside the switchboard as specified and wired complete with a horn switch with 125 VDC rating and shall be also be mounted and wired inside the switchboard.

All signal inputs and outputs of annuciator modules shall be provided with optical couplers and RC filter circuits for high voltage surge protection.

Each annunciator shall be provided with a self-supervision system for continuously monitor the hardware and the software of the unit. The self-supervision shall also monitor and supervise the operation of the power supply module.

Each annunciator assembly shall be equipped with a serial interface at the rear port to provide communication with the remote computerized control system.

Each shall be provided with an event register, which stores at least last five events in chronological order. The event register can be read and displayed on the front panel or via the serial interface.

Each power supply shall be of the DC-to-DC converter regulated type and designed to protect it from high voltage and surge and to provide transient surge isolation between the station battery and the sensitive electronic components of the annunciator system. Each power supply shall be provided with necessary equipment to protect it from overloads that occur on the output side of the power supply. Each power supply shall include input reversed polarity protection and overvoltage and short circuit protection on the logic voltage supply. In the event of a short circuit on the power supply output, no damage will occur to the power supply.

Each annunciator system shall be designed for continuous operation at any voltage from 80 per cent to 120 per cent of rated voltage as specified and at a range of ambient temperatures of 10°C to 50°C and 0 to 94% humidity.

The annunciator operational sequence shall be manual lamp reset type and shall conform to the following table:

Designated Event	**Visual**		**Audible**
	Annunciator Lamps	**Group Pilot Lamp**	
Normal	Off	Off	Off
Alert	Bright flashing	On	On
Acknowledged (Horn Reset)	Steady On	Off	Off
Return to Normal	Steady On	Off	Off
Return to Alert before Acknowledge	Bright flashing	On	On
Acknowledged (Horn Reset)	Steady On	Off	Off
Reset	Off	Off	Off
Functional (Lamp test)	Bright flashing	On	On

Each annunciator shall be designed so that the closing of a trouble contact shall flash the annunciator lamp, light the group pilot lamp and sound the alarm.

The operator shall then be able to silence the alarm, stop flashing and extinguish the group pilot lamp by pressing the horn reset pushbutton and extinguish the annunciator lamp by pressing the lamp reset pushbutton, provided the trouble contact has been opened.

Operation of the lamp reset pushbutton shall not cause the alarm to sound. Release of the pushbutton shall not cause the alarm to sound again whether or not any trouble contacts are still closed. Operation of an annunciator lamp shall not interfere with or cause false operation of any other annunciator lamp whether operated simultaneously or in sequence.

Wrong operation of any pushbutton shall not cause malfunction to the correct operation of the system.

Operation of the test pushbutton shall simultaneously simulate inputs and exercise the logic of each alarm point.

1c.3.1.7 Operation and maintenance tools

All specific tools, needed to operate and maintain the switchgear, shall be provided .The following list is given as example and shall not be limited to listed items:

- Truck lifter to withdraw and move circuit breaker.
- Manual close and open
- Manual charging spring device.
- Earthing handle

At least one piece of each of these tools shall be provided for each bus bar section.

1c.3.2 Circuit-breaker

1c.3.2.1 Requirements

The circuit-breaker shall be of the vacuum type in accordance with IEC 62271-100 standard with the ratings conforming to following items.

- The circuit-breaker shall be capable of making and breaking all values of every rating up to the rated short-circuit value without the occurrence of restrikes or excessive overvoltage.
- The circuit-breaker shall be electrically trip-free and having anti-pumping circuits and operated by a spring mechanism rewound by a DC motor.
- The circuit breaker shall have a storage operating ability to perform a O –CO sequence. If the energy storage is not fully recharged with a predetermines time, further operation shall be blocked and suitably indicated and alarmed.
- Time operation for spring charging, shall be monitored. Corresponding motor supply shall be automatically cut off and an alarm activated after 20 seconds delay.
- Manual emergency operation shall be possible.
- It shall be possible to operate mechanically the circuit breaker. Closing of the circuit breaker shall be possible for maintenance operation.
- To ensure the personal safety of the operator it shall only be possible to trip the circuit- breaker from outside of the closed cubicle front door by direct acting mechanical linkages.
- An operating counter shall be furnished.
- The circuit breaker shall be equipped with open/close position indicator.
- Emergency manual charging operating mechanism shall be possible and necessary equipment provided.

- Auxiliary contacts (4 normally open and 4 normally closed), shall be wired to the terminal blocks of low voltage compartment for PEA future use. The auxiliary switches shall be wipe type self leaning.
- In case of auxiliary relays are required for auxiliary contacts extension. Auxiliary contact used for operation, monitoring and interlocking shall be mechanical latching relays. For saving life time of latching relay, the power supply shall be disconnected after latching relay operated.

The withdrawable circuit breakers of sturdy design, free of distortion and run easy without ramp or slope. The circuit breakers shall be moved from service to test-isolated position and vice versa with closed cubicle front door. Cubicle shall be equipped with position indicator, truck-in/truck-out.

The circuit-breakers shall be easily and effortlessly removed and placed back into its test position by one person. Circuit-breakers of the same rating and control scheme shall be completely interchangeable.

Plug-in type connections shall be provided for all auxiliary circuits between the circuit-breaker and the fixed part of the switchgear cubicle.

The plug contacts shall be arranged that the withdrawable circuit-breakers are universally interchangeable without alteration of the wiring.

1c.3.2.2 Ratings

Circuit breaker ratings shall be as stated in the following table:

Description		22 kV System
1. Rated Voltage	kV	24
2. Rated short time breaking current	kA	25
3. Rated short circuit making current	kA	63
4. Rated duration of short circuit	sec	1
5. Rated operating sequence		O-0.3s-CO-15s-CO
6. Rated auto-reclosing duty		O-0.3s-CO-15s-CO
7. Rated total time break	ms	Not more than 70

1c.3.2.3 Interlocking system

The interlocking system shall positively prevent the operator from reaching or creating unintentionally dangerous, or potentially dangerous condition.

The system that can be defeated without the use of tools and/or brute force shall no be accepted.

The interlocking system shall be secure and logical and shall fulfill ultimate safety requirements.

1c.3.3 Earthing switch

The earthing switches shall be designed to withstand full short circuit current.

Ratings shall conform to those specified in **APPENDIX 1**.

Earthing switches shall be of three-phase, fault-making type and shall be provided at the cable side or bus side of each circuit-breaker and load-break switch.

The earthing switches shall be hand operated. Operation of earthing switches shall be performed from outside of the closed door.

Position of earthing switch shall be clearly indicated on the corresponding cubicle.

An interlocking system shall be performed with corresponding circuit-breaker by mechanical interlocking and in conjunction with 115 kV disconnecting switch. Locking shall be performed by magnet equipment.

1c.3.4 Load break switch

1c.3.4.1 Requirements

- A withdrawable loadbreak switch with fuse shall be provided to protect the station service transformer.
- The loadbreak switch shall be designed for automatic, three-pole operation, in case one fuse or more trips.
- The loadbreak switch shall conform to the IEC 62271-105 equipped with HRC fuses to the IEC 60282-1. Operation of a fuse will be indicated through visible and audible alarm.
- The loadbreak switch shall be equipped with a three-phase, quick-acting, fault making earthing switch.
- As circuit breaker, loadbreak switch and earthing switch shall be interlocked

1c.3.4.2 Ratings

Load break will be used for 100 kVA station service transformer the rated normal current for the fuse will be 6 A.

1c.3.5 Primary busbar and branch-bar

Requirements

- Busbar shall have ratings in accordance with **APPENDIX 1**.
- Busbar shall have provision for absorbing thermal expansion and contraction no mechanical stress will be allowed to impose on insulating parts.

- Primary busbars and branch-bars shall be of high conductivity hard drawn electrolytic copper. Busbars shall have high dynamic and dielectric strength with good heat dissipation, and a favorable ratio of the load carrying capacity to the cross-sectional area.
- Busbars shall be of constant cross-sectional area throughout their length with branch-bars as short and straight as possible, and supported by tight cast-resin insulators.
- Busbars shall be extendible at both ends; such extension shall be easily done with the minimum possible disturbance to the existing busbars.

1c.3.6 Arc detection system

1c.3.6.1 System equipment and feature

Each arc detection system shall be consisted of the following main equipment:

(1) Arc monitoring units

(2) Arc detectors/sensors and cables

(3) Current sensing units

The current sensing unit which included with arc monitoring unit shall be accepted.

The arc detection system shall not be activated by interfering light sources, electro-magnetic influences, vibration and torching.

The protection principle of the arc detection system consists of two (2) modes:

- Light intensity and over current
- Light intensity only

1c.3.6.2 Arc monitoring unit

The arc monitoring unit shall detect the occurrence of short-circuit arcing by means of arc detectors/sensors and current sensing units and immediately transmits a tripping signal to trip and lock out all relevant circuit-breakers.

The system shall be performed the proper protection even all outgoing feeders supplied by one (1) incoming feeder by closing bus coupler circuit-breaker.

When the short-circuit arcing occurs at any points in the incoming cable compartments or incoming switching device compartments, the arc monitoring unit shall send the signal for tripping all circuit-breakers connected to the disturbed busbar including the 115 kV upstream circuit-breaker. Unaffected busbar shall remain in service.

When the short-circuit arcing occurs at any point in busbar compartments or switching device compartments except incoming switching device compartments, the arc monitoring unit shall send the signal for tripping all circuit-breakers connected to the disturbed busbars. Unaffected busbar shall remain in service.

When the short-circuit arcing occurs at any point in outgoing cable including cable to capacitor bank compartments, the arc monitoring unit shall send the signal for tripping the corresponding circuit-breakers of the feeders only.

The corresponding tripped circuit-breakers shall be locked against further closing operation and it shall be possible to override this interlocking through and acknowledge switch.

In case of the current sensing unit is out of service, the arc detection system shall be able to perform with complete protection according to able scheme with the event of light only.

The bypass switch for rejection the current sensing unit shall be provided.

For convenience of access to faulty cubicle, the arc detection system shall be installed properly to indicate the location of internal arc by cubicle basis.

The unit shall meet the following requirements:

Power supply : 48 V DC or 125 V DC (see relevant detail)

Detectors/sensors : fiber optic wire/bare fiber optic detector

Current sensing unit (2-phase + 1 ground or 3-phase + 1 ground)

- Current setting, for phase : 0.5 … 5.0 x I_n
- Current setting, for ground : 0.1 … 0.5 x I_n

Indicators

- Fault indication and location
- Relay self supervision
- Fiber optic loop check supervision

Operating time, from detection to initiate circuit-breaker tripping : not more than twenty (20) milliseconds

Degree of protection of enclosure : IP 20 or better

Position of installation : anywhere in or near the switchgear

Complete with controlling and indicating devices, and testing facilities for routine checking the function of the unit while the switchgears in operation.

1c.3.6.3 Arc detectors/sensors and cables

The arc detectors/sensors shall be light detectors sensors and shall be installed in each high-voltage compartment of the switchgear panels as follows:

- Busbar compartment
- Switching device compartment
- Cable connection compartment
- Voltage transformer compartment

The detectors/sensors shall be arranged in the manner that every internal arc is detected.

The signal from the detectors/sensors shall be transmitted to the arc monitor unit(s) by suitable communication cables.

1c.3.6.4 Current sensing unit

The current sensing unit shall be overcurrent two-phase and ground or three-phase and ground relay.

The current input for the current sensing unit shall be provided by PEA's existing current transformers at the incoming switchgear.

The current sensing unit shall block the tripping of the arc monitoring unit at a load current below a preset value.

The unit shall meet the following requirements:

- Power supply : 48 V DC or 125 V DC (see relevant details)
- Rated current : 1 A or 5 A (see relevant details)
- Degree of protection of enclosure : IP 20, or better

Complete with control and indicating devices, and testing facilities for routine checking the function of the unit.

1c.3.6.5 Loss-of-DC alarm relay (27X), with special provision for slow dropout

The DC under voltage relay (27X) for each DC control and protection circuit shall be provided to alarm for loss of DC potential to the alarm annunciator system.

The contact of DC under voltage relay shall be of standard speed, slow dropout characteristic.

1c.3.6.6 Auxiliary tripping and control relays

Auxiliary tripping and control relays shall be used to complete the functions of circuit-breaker tripping and closing, trouble alarms, or any indication, etc., as required in these specifications. The relays shall be vibration-proof and shock-proof.

All auxiliary tripping and control relays shall be flush mounted where applicable or surface mounted, switchboard type with removable cover and transparent window where applicable.

The auxiliary tripping relay shall be of mechanically latched-in type with manual reset device operated from the front of the panel have the operating time and for making not more than 15 ms and for breaking not more than 25 ms .

The external auxiliary lock-out relay with manual reset device operated from the front of the panel shall be also accepted.

Contacts of the tripping relays shall be designed for continuous current carrying capacity of 4 A and 30 A making capacities suitable for their application.

1c.3.6.7 Accessories

The arc detection system shall be provided with the following accessories:

(1) Terminal blocks with terminals

(2) Wiring system

(3) Grounding provisions

(4) Other according to manufacturer's design

1c.3.7 Instrument transformer

1c.3.7.1 General design

Instrument transformers shall be of cast-resin insulated, dry type in accordance with IEC 60044-1 and IEC 60044-2 standards. The current transformer shall be of post type or ring type having ratio-changing on secondary side only.

The current transformer shall be furnished with short circuit device and spark gap at the secondary terminal for over voltage protection caused by open circuit.

All instrument transformers of the feeder cubicles shall be mounted in the fixed part of the switchgear and correspond to the designed short-circuit level of the switchgear.

The high-voltage side of the voltage transformers shall be protected with withdrawable high-voltage HRC fuses.

In case of current transformer, the secondary circuit shall be wired to the terminal blocks with short circuit links at low-voltage compartment.

In case of voltage transformers, the terminals of unearth phase shall be provided with miniature circuit-breakers installed with auxiliary signaling contact to annunciator and CSCS at the low-voltage compartment.

Bus wire of Busbar voltage transformer will be used for under/over voltage, frequency load shedding, power factor regulation shall be furnished with miniature circuit-breaker with auxiliary contact for branch circuit protection of each cubicle.

Burden is the one required for each core simultaneously.

Current transformer shall be sized to fit with substation characteristics. It will be Bidder responsibility to calculate accuracy and burden. Calculation shall be submit by the Contractor to Authority for approval.

Ratings are specified in APPENDIX 2 attached to this specification.

1c.3.7.2 Test block

Separate test terminal shall be provided. All test terminals shall be arranged to isolate completely the measuring and protective devices from the instrument transformers and other external circuits, and provided means for testing either the measuring and protective devices or the instrument transformers.

The test terminal shall be either test block or test switch type. In case of test block type, the test plug shall be provided.

PEA shall accept only the test block for protective device manufacturer from:

- AREVA (ALSTOM)
- ABB
- SIEMENS
- SEL

1c.3.8 Protective devices

Protective relays are described in APPENDIX 3: Control, Protection and Measures.

1c.3.9 Tests and test reports

1c.3.9.1 Routine tests

The switchgear shall pass the manufacturer's standard routine tests in accordance with the reference standards. The test report of the switchgear equipment shall state the following items:

1) Switching devices

- Power frequency voltage tests on the main circuit
- Dielectric tests on control and auxiliary circuits
- Measurement of resistance of main circuit
- Mechanical operation test
- Test of interlocking system
- Verification of correct wiring and labeling
- Interrupter travelling curve measurement
- Electrical functional test

2) Instrument transformers

- Verification of terminal marking
- Power frequency withstand tests on primary windings
- Power frequency withstand tests on secondary windings
- Inter-turn over voltage test (current transformers only)
- Excitation curve check (current transformers only)
- Internal burden measurement (current transformers only)

1c.3.9.2 Type Tests

1) Switchgear

The switchgear shall have passed the type tests in accordance with IEC 62271-100 and IEC 60298 as follows:

- Dielectric tests
- Temperature rise tests
- Measurement of the resistance of the main circuit
- Short time and peak withstand current test
- Verification of making and breaking capacities
- Mechanical operation tests
- Verification of degree of protection
- Arcing due to internal fault

The test for arcing due to internal fault shall be conducted at the international acknowledged reputable independent testing laboratories which are members of Short Circuit Testing Liaison (STL) or of other organizations approved by the Authority.

The type test reports shall be submitted with the bid or within fifteen (15) calendar day after the bid closing date.

The items offered without submitting the type tests certificates shall be rejected.

2) Instrument transformers

The following type tests in accordance with the relevant IEC shall be made on one instrument transformer of identical unit:

- Short time current tests (current transformer only)
- Temperature rise test
- Impulse voltage test

The cost of all tests and tests reports shall be borne by the Contractor.

Note: Conditions for documentation and consideration

1. The Contractor have to supply the following documents in English and/or Thai , before shipment/delivery, for each ordered switchgear, to the following address :

Substation Construction and Maintenance Department
Provincial Electricity Authority
200 Ngam Wong Wan Road, Chatuchak
Bangkok Metropolis 10900
Thailand

All drawings shall be in accordance with the IEC 600113 and sized as follows:

- Size

A1 594 mm x 841 mm

A2 420 mm x 594 mm

A3 297 mm x 420 mm

A4 210 mm x 297 mm

- Diagrams

(1) Single line diagrams

(2) Circuit diagrams

(3) Connection diagrams

(4) Block diagrams

(5) Logic diagrams

(6) Process diagrams

(7) Terminal diagrams

(8) Protection Co-ordination diagrams

1.1 Drawings and data for approval

The Contractor shall supply four (4) paper copies each of at least the drawings and data listed below, for approval by The Authority, within sixty calendar days after the date of effectiveness of the Contract.

(1) Complete substation arrangement drawings showing the details of equipment layout.

(2) Foundation frame plans with fastening details. Earthing arrangement and access points to earthing bus. Details of conduit/bushing for control wiring between cubicles.

(3) Detail drawings and specifications for all equipment to be supplied including the characteristic curves of current transformers.

(4) Complete internal connection and elementary diagrams (AC, DC schematic), of control and protection for circuit-breaker operating mechanism and auxiliary equipment, power requirements for all operating coils, motors, electrically operating devices, including drawing list, legend, bill of materials.

(5) Complete interlocking scheme of the whole switchgear.

(6) Qualifications and previous field experience of operators for cable termination kits installation.

(7) All other drawings considered necessary for the installation, operation and maintenance of the switchgear equipment.

Generally, if no more details are required, one approved copy of each drawing/document will be returned to the Contractor within forty-five (45) calendar days after receipt by The Authority. If The Authority requires additional information, the Contractor cannot regard the lost time as a reason for extending the delivery time without penalty.

When the drawings have been returned for correction, the Contractor shall make the necessary revisions on them and shall submit the corrected drawings and data for approval within thirty (30) calendar days.

Any manufacturing done before approval of the drawings and data, will be at the Contractor's risk. The Authority shall have the right to require the Contractor to make any changes in the design which may be necessary in the opinion of The Authority, to make the equipment conform to the requirements and intent of this Contract Documents without additional cost to The Authority. Approval of the Contractor's drawings shall not be held to relieve the Contractor of any part of his obligation to meet all of the requirements of this Contract Documents or of the responsibility for the correctness of his drawings.

1.2 Final approved drawings

The Contractor shall furnish six (6) paper copies each and one (1) transparent reproducible copy

1.3 Asbuilt drawings

The Contractor shall furnish four (4) paper copies each and three (3) soft copies (Autocad R-14 or PDF file) in CD-ROM copies.

1.4 Three (3) sets of instruction book and two(2) CD-ROM copies for installation, operation, and maintenance of switchgears.

1.5 Three (3) sets of instruction book and two(2) CD-ROM copies for installation, operation, maintenance of all instruments, meters, switches, indicators, alarms, and protective devices.

1.6 Reports of type tests and routine tests of the switchgear and two(2) CD-ROM copies.

2. The Bidder has to prove that the type of switchgears has been in field operation under tropical conditions for at least three (3) years by submission of reference lists and certificates issued by public utilities.

APPENDIX 1

SWICHGEAR DESIGN AND PERFORMANCE CRITERIA

The switchgears shall have the following design and performance criteria, or better:

	Description		22 kV
1	Rated normal current, at special site and service conditions:		
	- for main bus bar	A	2,000
	- for incoming feeder	A	2,000
	- for outgoing feeder	A	600/300
	- for bus section circuit breaker	A	2,000
	- for capacitor bank	A	300
	- for station service transformer	A	6
2	Rated short time withstand current	kA	25
3	Rated peak withstand current	kA	63
4	Rated duration of short circuit	sec	1
5	Degree of protection for control unit and auxiliary equipment	-	IP4X
6	Degree of protection for cubicle and between compartments	-	IP4X
7	Power supply voltage for closing and tripping coils	VDC	125
8	Power supply voltage for DC control circuit	VDC	125
9	Power supply voltage for AC control circuit (AC auxiliary supply)	VAC	230
10	Nominal voltage	kV	22
11	Maximum voltage rating	kV	24
12	Power frequency	Hz	50
13	Number of phases	-	3
14	Power frequency withstand voltage	kV	
	- Phase to earth and between phase		50
	- Across open switching device and isolate distance		60
15	Lightning impulse withstand voltage	kV	
	- Phase to earth and between phases		125
	- Across open switching devices and isolated distance		145
16	Applicable standard	-	IEC 62271-200

APPENDIX 2

INSTRUMENT TRANSFORMER RATINGS

Voltage Transformers

22 kV Metal Clad AIS	Ratio	Core No.	Class	Burden	Voltage factor
Voltage Transformer for Busbar	$22/\sqrt{3}:/0.11/\sqrt{3}$ kV $22/\sqrt{3}:/0.11/\sqrt{3}$ kV	1 2	0.5 3P	50 VA 50 VA	1.9 30 s

Current transformers

22 kV Metal Clad AIS	Ratio	Core No.	Class	Burden
Current Transformer for Incoming feeder	1,800-1,500-900/1 A 1,800-1,500-900/1 A 1,800-1,500-900/1 A 1,800-1,500-900/1 A	1 2 3 4	5P20 0.5 5P20 5P20	20 VA 20 VA 20 VA 20 VA
Current Transformer for Outgoing feeder	600-300/1 A 600-300/1 A	1 2	0.5 5P20	20 VA 20 VA
Current Transformer for Busbar	1,800-1,500-900/1 A 1,800-1,500-900/1 A	1 2	5P20 0.5	20 VA 20 VA
Current Transformer for Capacitor bank	300/1 A 300/1 A	1 2	0.5 5P20	20 VA 20 VA

Note:

See relevant drawing and diagram

APPENDIX 3

CONTROL, PROTECTION AND MEASURES

1. General conditions

1a Scope

The control and protection switchboard shall be designed for the control and protection as indicated by the drawings and as specified herein. Protective relays and their associated auxiliary relays shall perform the functions as shown on the drawing entitled: "Protective Device Functions", for each substation. The Contractor shall furnish any necessary control and protection functions indicated, mounted and wired as required, whether such devices are itemized herein or not.

Any modifications to the arrangement indicated or arrangement of equipment not shown shall be subject to the approval of the Authority.

The protection system of the substations 115kV and MV is based on the principle of local back-up. In some other terms, any fault occurring anywhere on an outgoing line, transformer or on the busbar should be detected and cleared locally by the relays and circuit breakers located in the substation concerned, before the distance or back-up relays located in the second zone, and controlled by the adjacent substation can be operated. This should be the case under normal operating conditions or in the event of the failure of one element of the protective chain i.e. the failure of a relay, circuit breaker, circuitry instrument, battery.

1b Reference Standards

All equipment, materials, fabrication and testing under this Specification shall conform to the latest applicable standard specifications and codes contained in the following list, or to equivalent applicable standard specifications and codes established and approved in the country of manufacturer of the equipment. Where standards are mentioned by name, equivalent applicable standards may be used.

IEC 60068-2-1	Environmental testing-Part 2-1: Tests – Tests A : Cold
IEC 60068-2-2	Environmental testing-Part 2-2: Tests – Tests B : Dry heat
IEC 60068-2-6	Environmental testing-Part 2-6: Tests – Tests Fc : Vibration (sinusoidal)
IEC 60068-2-27	Environmental testing-Part 2-27: Tests – Tests Ea and guidance : Shock
IEC 60068-2-78	Environmental testing-Part 2-78: Tests – Tests Cab : Damp heat, steady state
IEC 60255-151	Measuring relays and protection equipment - Part 151: Functional requirements for over/under current protection
IEC 60255-27	Measuring relays and protection equipment - Part 27: Product safety requirements

IEC 60255-26	Measuring relays and protection equipment - Part 26: Electromagnetic compatibility requirements
IEC 60870-5-103	Telecontrol equipment and systems – Part 5-103 : Transmission protocols – Compassion standard for the informative interface of protection equipment
IEC 60947-1	Low-voltage switchgear and controlgear – Part 1: General rules
IEC 60947-7-1	Low-voltage switchgear and controlgear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors
IEC 61000-4-2	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test
IEC 61000-4-3	Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test
IEC 61000-4-4	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Section 4 : electrical fast transient/burst immunity test, Basic EMC Publication
IEC 61000-4-5	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test

Any details not specifically covered by these standards shall be subject to the approval of Authority. In the event of contradictory requirements between such standards and this Specification, the terms of the Specification shall govern.

1c Site and service conditions

The equipment shall be capable of operating at its full ratings under site and service conditions as mentioned below.

The switchgear room has no air conditioning system.

Seismic activity:	None
Maximum wind speed:	(≈100 km/h)
Maximum recorded rainfall:	250 mm/day
Number of days with thunderstorm:	100 days/year
Average rainfall:	20 mm/day
Mean maximum annual relative humidity:	94%
Mean minimum annual relative humidity:	79%
Minimum daily relative humidity:	17%
Maximum temperature of surfaces exposed to sunbeam:	80°C
Mean minimum daily temperature:	24°C

Maximum ambient temperature:	40°C[1]
Minimum ambient temperature:	11°C

[1] According to IEC 62271-1 over 40°c will be possible under special requriement.

1c.1 General design

1c.1.1 Details of switchboard construction

Each control switchboard, each control and protective relay switchboard, each protective relay switchboard and each interposing relay cabinet, shall consist of an assembly made from not less than No. 3.0 mm leveled sheet steel and formed steel members as required to form a rigid self-supporting structure. No butt surface joints shall be made on the outside surfaces of switchboards and cabinets. No holes or fasteners shall be visible as viewed from the front of the panels. Switchboards and cabinets shall be designed to have bottom sheets and each bottom sheet shall be provided with gland plate which shall be made of a non-magnetic metal. Each gland plate shall be provided with adequate quantity of holes for control cable entrance from underneath the switchboard and cabinet. They shall be furnished with channel bases. The front and rear panels of the switchboards and the cabinets shall have bent angle or flange edges with an outside radius not exceeding 10 mm.

The construction details of the switchboards shall be as shown on Drawing No. OOT10N.

Finished panel surfaces shall be free from waves, bellies, or other imperfections. Exterior and interior surfaces shall be cleaned by sanding and steam cleaning, ground smooth, filled, primed, sanded and shall be finish-painted inside and outside with RAL 7032.

1c.1.1.1 Control switchboards

Each control switchboard shall be of the enclosed type.

Each enclosed switchboard assembly shall consist of basic panel assemblies, and necessary bolted-on floor channels, top sheets, and rear enclosure covering the back. Access to each switchboard section shall be provided by two hinged flat rear doors. The access doors shall be equipped with locks, latches, fully concealed hinges and handles.

Both sides of each control switchboard shall be enclosed.

End trims of the two end sections shall be readily removable so as to permit future control boards to be installed at both ends.

Mounting brackets as required shall be arranged on the rear of panels for mounting auxiliary equipment. They shall be located to allow access to the back of the equipment mounted on the front of the panels.

If the auxiliary equipment mounted on the brackets prevent access to the rear of the equipment on the front of the panels, then mounting brackets shall not be acceptable and the auxiliary equipment shall be mounted on hinged panels instead.

The enclosed switchboard panel size shall be 1,000 mm deep. The height, channel base, and panel width shall be as indicated on the drawings entitled: "Control Switchboard and Swing Rack type Protective relay Switchboard Equipment Layout" for 115 kV Breaker and a Half (with / without transformer) Substation.

The detail of each enclosed switchboard shall be as shown on Drawing No. OOT10N.

All control, selector, recloser cutoff and other switches shall be of the direct control type without using any interposing relays.

There shall be furnished in the control switchboard one fluorescent lamp, mounted and wired inside the top of the switchboard for interior lighting and controlled by a cutoff switch on the hinged rear door, so that the panel light is automatically extinguished when the door is closed. One duplex receptacle outlet of single-phase, 2-pole, 3-wire grounded type 15A at 250 V shall be furnished mounted and wired in a convenient location near the hinged rear door. The light and duplex receptacle outlet shall be connected to the 230 V, single-phase, 50 Hz, with grounded wire, AC source furnished by the Authority.

Each basic panel assembly for the control switchboard shall be a self-contained unit with factory wiring complete to conveniently located terminal blocks for the incoming cables. Each shall have vertical side members, which include vertical raceways and raceway covers for factory wiring, and shall be bolted to the right and left sides of the basic panel. These side members shall provide separate raceways to house, protect, and conceal the incoming cables and interpanel leads. Terminal blocks shall be furnished and mounted in vertical rows on both sides of the basic panel assembly.

Suitable wire slots with rubber bushings in vertical rows on both sides of the basic panel assembly near terminal blocks shall be provided for outgoing leads.

Each basic panel assembly shall be readily removable without disturbing the control switchboard assembly.

Each control switchboard shall be designed to provide cable entrance at the bottom of the switchboard in accordance with the requirements of Clause 1c.1.1

1c.1.1.2 Swing rack type switchboards

Each switchboard shall be of the swing rack type, consisting of a swing rack assembly, top sheet and rear enclosure covering the back and ends of the entire structure. Each cabinet shall have a front cover door equipped with a glass window for viewing all targets and indications. The cabinet door shall be equipped with locking handle, latches, fully concealed hinges, and complete with screened louvers at the top and bottom.

The cabinet door shall be hinged on the right hand side, front view. The relay rack assembly shall be hinged on the left hand side, front view.

Swing rack type switchboards shall have two types: one type shall be the control and protective relay switchboard and the other type shall be the protective relay switchboard.

Each control and protective relay switchboard shall be provided with conventional bay control consisting of breaker discrepancy control switch, synchronizing selector switch, recloser cutoff discrepancy control switches for 115 kV motor operated disconnect switches, electrically operated ground semaphore switches, light boxes for indicating bus and line energized and symbols and mimic buses. One annunciator assembly and one numerical power meter shall be provided for each bay control. There shall be digital bus voltmeter (s) provided for each main bus. This conventional bay control complete with symbols and mimic buses shall be as indicated on the drawing entitled: “Control and Protective Relay Switchboard Equipment Layout” for each substation. All conventional bay control switches shall be indirect control by using interposing relays to accomplish the control functions of the substation.

All other cutoff and pushbutton switches for auxiliary tripping and lockout relays for transformer and bus differential and breaker failure protection and all reset pushbutton functions shall be of the direct control type without using the interposing relays.

Each protective relay switchboard shall be used in conjunction with the control switchboard in Article 1c.1.1.1 and as indicated on the drawing entitled: “Control Switchboard and Swing Rack Type Protective Relay Switchboard Equipment Layout” for 115 kV Breaker and a Half (with / without transformer) Substation, and shall also be used with the swing rack type control board as indicated on the drawing entitled: “Control and Protective Relay Switchboard Equipment Layout” for 115 kV Substation Connected by Tie Line. All other cutoff, pushbutton switches shall be the same type as the preceeding paragraph.

Each cabinet shall be designed for mounting standard 19-inch wide rack-mounted relays.

Each relay rack assembly shall be arranged to swing through not less than 150 degrees from closed position to allow easy access to the back of the equipment mounted on the rack and to the interior of the cabinet.

Each switchboard shall be provided with a vertical wiring duct complete with a cover for factory wiring and a vertical raceway and a raceway cover to house, protect, and conceal the incoming cables. The vertical wiring duct and the vertical raceway shall be arranged as shown on Drawing No. OOT10N. Terminal blocks shall be furnished and mounted in vertical rows on the back inside the switchboard and located between the wiring duct and the raceway as shown on the above drawing. All wiring which connects to the external circuits shall terminate on these terminal blocks. Provision shall be made for interconnection of wiring between switchboard sections.

Mounting brackets, as required, shall be arranged for mounting and wiring auxiliary equipment. They shall be located to allow access to terminal blocks mounted on the back inside of the switchboard.

Each switchboard shall be designed to provide cable entrance at the bottom of the switchboard in accordance with the requirements of Clause 1c.1.1

Panel openings of the swing rack assembly not utilized by equipment shall be covered by cover plates.

The switchboard size shall be 800 mm wide, 610 mm deep and the height shall be 2,300 mm plus a 40 mm channel bases.

There shall be furnished in the control and protective relay switchboard and the protective relay switchboard one fluorescent lamp for each switchboard, mounted and wired inside the top of the switchboard for interior lighting and controlled by a cutoff switch on the hinged rear door, so that the panel light is automatically extinguished when the door is closed. One duplex receptacle outlet of single-phase, 2-pole, 3-wire grounded type 15A at 250 V shall be furnished mounted and wired in a convenient location near the hinged rear door. The light and duplex receptacle outlet shall be connected to the 230 V, single-phase, 50 Hz, with grounded wire, AC source furnished by the Authority.

1c.1.1.3 Interposing relay cabinets

Each interposing relay cabinet shall be provided with the interposing relays for substation control and protection functions. All relays shall be furnished complete with integral accessories, mounted and completely wired.

In general, control signals to the switchyard shall be first connected to the interposing relays before being connected to the relevant switchyard equipment.

The interposing relays shall be furnished mounted and wired with sufficient quantities to fulfil the requirements of substation control, indication, and protection functions as specified. Not less than 10 per cent spare of each function of interposing relays shall be furnished and mounted inside the cabinet, however the minimum of two spare relays shall be furnished and mounted for each function of the relays. The coils shall be suitable for continuous duty at their normal operating voltage. All contacts shall be of the renewable type with ample current-carrying and interrupting capacity for the application, and shall withstand at least 10 A at 1 second, 5 A at continuous duty, and be capable of interrupting 0.3 A of inductive current (L/R $\leq$40 ms) in a 125 V DC control circuit.

Where necessary, interposing relay shall be of the latched-in type especially for those concerning the mode selection functions.

Interposing relays shall be of the highly insulated type capable of withstanding 5 kV positive or negative pulses applied across the coils and between the coil terminals and ground with the contact assemblies bonded to ground.

Interposing relay cabinets shall be furnished and designed in accordance with Drawing No. OOT10N Each cabinet shall be an assembly enclosed at top and sides and shall have front and rear access doors for access to both sides of the center mounting plate. Interposing relays shall be mounted on both sides of this center plate. The front and rear shall each be provided with one hinged flat door and the rear shall be provided with two hinged flat rear doors. Access doors shall be equipped with locks, latches and fully concealed hinges.

Each cabinet shall be 915 mm wide, 1,000 mm deep and the height shall be 2,300 mm plus a 40 mm channel base.

Each cabinet shall have vertical side members, which include vertical raceways and raceway covers for factory wiring, and shall be bolted to the right and left sides of the cabinet. These side members shall provide separate raceways to house, protect, and conceal the incoming cables and interpanel leads.

Terminal blocks shall be furnished and mounted in vertical rows on both sides of the cabinet. The number of vertical rows and the arrangement of terminal blocks shall be in accordance with the Drawing No. OOT10N. All wiring which connects to the external circuits shall terminate on these terminal blocks.

Each cabinet shall be designed to provide cable entrance at the bottom of the cabinet in accordance with the requirements of Clause 1c.1.1.There shall be four (4) cable glands: two cable glands at the right side and other two at the left side of each interposing relay cabinet as indicated on the Drawing No. OOT10N

1c.1.1.4 Hinged synchronizing panels.

Each hinged synchronizing panel shall be fabricated from not less than 2.5 mm leveled sheet steel and shall be approximately 200 mm wide, 600 mm high and 200 mm deep. If specified, each hinged synchronizing panel shall be furnished and shall constitute a part of each control switchboard or control and protective switchboard assembly. Each shall be designed to swing back in line with the other panels when not in use to present straight line appearance. Each shall be readily removable and re-installed when future control board installation is required. The rear sheet shall be readily removable for access to the instruments and wiring in the panel.

- One -Twin indicating voltmeter, 0-150 V scale, 150 V coil, 50 Hz, 144 mm square face, for incoming and running potential.
- One -Twin indicating frequency meter, 48-52 Hz scale, 115 V, 144 mm square face, for incoming and running frequency.
- One -Synchroscope, 144 mm square face.
- Two -Synchronizing lamps, 15 W each, clear, to be connected to indicate synchronism.

1.c.1.1.5 Drawings and data requirements

The Contractor shall submit for approval the following drawings and data, sufficient to demonstrate fully that the equipment to be furnished shall conform to the requirements and intent of this Specification.

- <u>Metering and Relaying Diagrams</u>. The metering and relaying single line diagrams of each substation are included in this Specification. The Contractor shall supply single line diagrams showing conformity with the specified requirements indicating clearly changes necessitated by the proposed equipment.
- <u>Three Line Diagrams</u>. Each three line diagram shall show voltage and current connections to all metering and relaying equipment.
- <u>AC Schematic Diagrams</u>. All diagrams shall show AC connections such as AC supply to all metering and relaying equipment, synchronizing schematic diagrams, etc.
- <u>DC Schematic Diagrams</u>. All diagrams shall show the DC wiring for control, indication, annunciation, protection, etc., arranged in a schematic form and shall include the necessary wiring of all power circuit breakers that received a trip signal from the protective relays that are listed in the drawings, "Protective Device Functions", for each substation. On each schematic diagram where the main relays or auxiliary relays are shown, all contacts for indicated relays shall show the detailed functions of the contacts to be used, including the reference drawing near the relevant relays.

  For the annunciator, the Contractor shall furnish enough information in detail to understand complete operation of the annunciator system. It shall be furnished with a description of the operation of each component and an explanation of the operational sequence of each component in regard to the overall annunciator scheme. All components shall show internal schematic diagrams and circuit board illustrations.

- Logic Diagrams. Logic diagrams shall show details of the logic control circuits for each individual control and protection equipment.
- Wiring Diagrams. Wiring diagrams shall show connections from point to point for all control board equipment. All the wiring connections to the equipment on any one panel shall be shown on the same drawing. Inter-panel connections shall be properly identified on both the incoming and outgoing panel drawings.

  Wiring list or tabular type wiring diagrams shall not be accepted.
- Control, Selector, Cutoff and Pushbution Switches-Contact Tabulation Diagrams. Contact tabulation diagrams of control and other switches shall show terminal arrangement, escutcheon plate and contact tabulation. On each schematic diagram where switch contacts are shown, switch position tabulations for the indicated switches shall be included somewhere on the same drawing.
- Nameplate Schedule Diagrams. A nameplate schedule diagram for each substation shall show designations on all nameplates. The wording of each nameplate designation may be revised to satisfy physical limitations subject to the approval of the Authority.
- Annunciator Schedule Diagrams. An annunciator schedule diagram for each substation shall show annunciator designations for all the annunciator points including spares provided. The wording of each annunciator designation may be revised to satisfy physical limitations subject to the approval of the Authority.
- Equipment Layout Diagrams of Switchboards and Cabinets. Each equipment layout diagram shall show dimensions, location, and general layout of all panels and all equipment to be located on the panels.
- Switchboard and Cabinet Construction. The Contractor shall provide for approval the general assembly drawings including dimensions, details of arrangement plan and section and floor plan complete with anchor both setting plan.

The equipment as indicated on the control switchboards, protective relay switchboard, control and protective relay switchboards and the interposing relay cabinets, shall cover only the major equipment. It is to be understood that, all other associated auxiliary equipment and accessories, although not indicated on the drawings entitled: “Control Switchboard and Protective Relay Switchboard Equipment Layout, Control and Protective Relay Switchboard Equipment Layout, and Interposing Relay Cabinet Equipment Layout”, but necessary for the complete and sound functions of the switchboards and cabinets as described in this Specification, and as generally accepted as the applicable standards, shall be furnished by the Contractor. The Bidder at the time of bidding shall, to the best of his knowledge, furnish the list showing quantity and details of all the equipment he intends to supply.

The switchboards and cabinets proposed shall give the best optimum result as called for in this Specification, and as basically required by standard electrical engineering practice.

The Contractor, after having finished the design of the switchboards and cabinets shall submit the Authority for approval all the design details including individual equipment of the switchboards and cabinets, and to all associated equipment in the substation, and showing overall functions of the schematic diagrams. The Authority shall then review the schemes, and should any proper functions required in this Specification or required for sound engineering practice of the switchboards and cabinets entail necessary modifications to the scheme or additional equipment other than those originally proposed by the Bidder at the time of bidding, the Authority will return the scheme to the Contractor to carry out the modification required without any extra charge to the Authority.

1c.1.1.6 Ground buses

A 6 mm by 25 mm cross-section bare copper ground bus shall be provided at the bottom of each switchboard panel and each cabinet, to which the metallic cases of meters, instruments, relays and grounding circuits of all other equipment shall be connected. The grounding buses shall be solidly bolted to the steel framework so as to make good electrical contact. Solderless lugs or terminals shall be provided on the ground buses for terminating No. 95-120 sq.mm. stranded copper ground cables from the substation grounding system.

1c.1.1.7 Wiring

All wiring used within the switchboards, interposing relay cabinets, shall meet the requirements of the APPENDIX 4: Small Wiring and NEMA standard Publication No. WC5-1992/ICEA S-61-402 and shall be rated 600V, tinned, stranded copper switchboard wire and polyvinyl chloride insulated. All hinged wiring shall be extra flexible. Internal wiring of each basic panel assembly and each cabinet shall be neatly and carefully installed in suitable wiring ducts with removable covers and complete to conveniently located terminal blocks for connecting to incoming and outgoing leads.

The terminal arrangement shall group all leads for each particular function to facilitate connections to the incoming and outgoing cables. The arrangement shall be subject to the approval of the Authority.

Wiring between inter-panel shall be made and routed through vertical raceways of the switchboards and cabinets. Such wiring shall also be terminated and reconnected in terminal blocks in order to permit convenient separation of individual panels or cabinets.

All incoming and outgoing cables shall enter the switchboards and the cabinets through cable slots in the floor underneath the switchboards and the cabinets.

Splices or tee connections shall not be permitted in control wiring or instrument leads.

Any control boards or cabinets that are split for shipment shall have terminal blocks adjacent to the split and shall be provided with wiring required to interconnect the split units.

1c.1.1.8 Indicating lamps

All indicating and pilot lamp assemblies shall be of the light-emitting diode (LED), complete with integrally mounted resistors, The indicating light assemblies shall be suitable for use with 125 VDC, switchboard type with color caps. The color caps shall be red, green, white, blue or yellow as required. All lamp bulbs shall be interchangeable, and shall be replaceable from the front of the panels.

1c.1.1.9 Light boxes

Each light box, for indication of line or bus to be energized, shall be of switchboard type. Each light box shall have a white translucent nameplate with machine-engraved, black lettering illuminated by backlighted with two LED lamps parallel together. Each nameplate shall be engraved in accordance with the drawing entitled : "Nameplate Schedule Diagrams".

Each light box shall be 25 mm. high by 50 mm wide.

All LED lamps shall be interchangeable, and shall be replaceable from the front of the panels.

1c.1.1.10 Test switches

Test switches shall be of the separate type as specified. Separate test switches shall be of the switchboard, back-connected type, finished in dull black for front-of-panel mounting. All test switches shall be arranged to isolate completely the instruments from the instrument transformers and other external circuits and provide means for testing either from an external source of energy or from the instrument transformers by means of multiple test plugs which shall be provided for the purpose. A sufficient number of test plugs to make a complete test on one meter or instrument shall be furnished for each type of test switch. All test switches shall be arranged so that the current transformer secondary circuits cannot be open-circuited in any position while the test plugs or cover plugs are being inserted or removed.

Test switches and multiple test plugs shall be ABB, flexitest switches, type FT-1 or equivalent.

1c.1.1.11 Terminal blocks

The switchboards and interposing relay cabinets shall be provided with terminal blocks for termination of all wiring devices mounted in the switchboards and cabinets and all external circuits.

Terminal blocks shall be of non-flammable, non-hygroscopic insulating material, rated for 600 V and conform to IEC 60947-7-1 and IEC 60947-1 standards. Except as otherwise specified, terminal blocks shall be furnished with two sizes; one size shall accept the conductor of 1.5 to 4.0 sq.mm, the other one shall be sized to accept the conductor of 2.5 to 6.0 sq.mm. Insulating barrier between adjacent terminal shall be integral part of the terminal block. Terminals shall have adequate current carrying capacity. All terminal blocks and terminations shall be grouped according to circuit functions. Each terminal block shall have removable white marking strip for marking circuit designation. One spare blank marking strip shall be furnished with each terminal block. The terminal blocks shall be well arranged in order that they permit safe wiring works on any terminal while all adjacent terminals are live.

The terminal blocks provided for CT circuit shall be of spring loaded screw-on type or spring loaded type and they shall be provided with sliding switch bridge and test socket screws.

The terminal blocks provided for control, protection circuits and other circuits shall be of screw-on type. It shall be designed in such a way that after the terminal block is unscrewed, the wire is still engaged to the terminal block. All CT and PT wires, as well as control and protection circuits shall be terminated with blade type or ring type of cable lugs.

The arrangement of all terminal blocks shall be such that incoming and outgoing leads can be easily arranged for connections to terminals. Terminal blocks shall be located so that the accessibility to them will not be lessened by interference from structural members or panel instruments. Ample space shall be provided to terminal blocks for termination of all external circuits.

1c.1.1.12 Nameplates

Nameplates shall be furnished and mounted by the Contractor. Each assembly, each piece of equipment mounted on an assembly, and each power and control circuit shall be provided with a nameplate. All nameplates shall be of laminated plastic material, black on the surface with a white internal layer. Lettering shall be machine-engraved into the nameplate to form white letters against a black background. All panel mounted nameplates shall be in accordance with the respective drawings showing nameplate schedule. A sample nameplate, showing the style of engraving to be used shall be submitted to the Authority for approval. Nameplate engraving shall be subject to the approval of the Authority.

1c.1.1.13 Symbols and mimic buses

All symbols, devices and painted mimic buses, 10 mm in width, shall be provided on control switchboard and control and protective relay switchboard to form single line diagrams which will simulate actual electrical connections as indicated on the drawings entitled “Control Switchboard and Protective Relay Switchboard Equipment Layout" and "Control and Protective Switchboard Equipment Layout". Mimic disconnect devices for ground switches shall be electrically operated to automatically position themselves in accordance with their respective ground switches. The mimic buses shall be painted on the front of the panels with lacquer or enamel. Color of mimic buses shall be as follows :

115 kV	-	Light Orange
33 kV	-	Dark Green
22 kV	-	Blue

1c.1.1.14 Control, selector, cutoff and pushbutton switches

The control, selector, cutoff and pushbutton switches shall be of the multistage voltage type, rated 600 V, continuous duty, for both AC and DC services. Each contact shall be of the readily renewable, self-cleaning type and shall be of the wipe type. A rectangular front-of-the-panel escutcheon plate shall be furnished and engraved showing the switch positions of control, selector, cutoff and pushbutton switches. The switch identification shall be engraved on the escutcheon plate, or if necessary, on a separate adjacent nameplate furnished by the Contractor.

Details of individual switch shall be as described below :

- Breaker Discrepancy Control Switches (BDCS) Each breaker discrepancy control switch shall be of the momentary contact, and shall also be engraved "on" and "off". Each switch shall include integrally mounted with the light-emitting diode complete with a series resistor.
- Discrepancy Control Switches for 115 kV Motor Operated Disconnect Switches (DSDCS) Each discrepancy control switch shall be of the momentary contact type, and shall also be engraved "On" and "Off". Each switch shall include integrally mounted with the light-emitting diode complete with a series resistor.
- Synchronizing Selector Switches (SS) Each synchronizing selector switch shall be of the maintained contact type, three-position "Automatic" "Normal" "Manual", complete with a key used as a handle, removable at "normal" position only to ensure that on one set of potentials can be applied to the synchronizing equipment at any one time.
- Recloser Cutoff Switches (79CO) Each recloser cutoff switch shall be of the momentary contact type, three position " on" "normal" "off" with spring return to the normal position, with fixed, modern, oval black handle. Each switch shall be complete with an indicating red-light-emitting diode complete with integrally mounted resistor.
- Transformer Differential Cutoff Switches (87T-CO) Each transformer differential cutoff switch shall be of the maintained contact type, two-position "on" "off", with fixed, modern,

oval black handle. Each cutoff switch shall be complete with an indicating red light-emitting diode complete with an integrally mounted resistor.

- Bus Differential Auxiliary Tripping and lockout Relay Cutoff Switches (86B-CO) Each differential auxiliary tripping and lockout relay cutoff switch shall be of the maintained contact type, two-position "on" "off", with fixed, modern, oval black handle. Each cutoff switch shall be complete with an indicating red light-emitting diode complete with an integrally mounted resistor.
- Breaker Failure Cutoff Switch (50BF-CO) Each breaker failure shall be of the maintained contact type, two-position "on" "off", with fixed, a modern, oval black handle. Each cutoff switch shall be complete with an indicating red light-emitting diode complete with an integrally mounted resistor.
- Pushbutton Switches (PB) Each pushbutton switch shall be of the heavy duty type and constructed for definite over-travel in both directions. Each shall be dust-proof, fully shrouded to prevent accidental operation.
- Line Current Differential Cutoff Switch (87L-CO) Each line current differential cutoff switch shall be maintained contact type, two-position, "on" "off" with fixed, modern, oval black handle. Each cutoff switch shall be complete with an indicating red-light-emitting diode complete with integrally mounted resistor.
- Direct Transfer Trip Cutoff Switch (86TT-CO) Each direct transfer trip cutoff switch shall be maintained conted type, two-position, "on" "off" with fixed, modern, oval black handle. Each switch shall be complete with an indicating red-light-emitting diode complete with integrally mounted resistor.

All switch shall be rated 20A, and shall be of the direct control switch function type without using the interposing relays. These switches shall be for use with the control switchboards in clause 1.4.1.1, and all cutoff and pushbutton switch functions for transformer protection, bus protection, breaker failure protection, auxiliary tripping and lockout relay contacts and relay resetting which are mounted on the "Control and Protective Relay Switchboards" and "Protective Relay Switchboards". These switches shall also be for use with the "Swing Rack Type Control Board" for 115 kV substation connected by tie line.

The total number of contacts and total number of contact tabulations shall be adequate for their required functions but minimum number of contacts and contact tabulation shall be at least as indicated on the Dwg. NO. OOT15N sheet #1 of #2.

In case of conventional control and protection are combined in the same switchboard, there shall be included with control switch functions, symbols and mimic buses, an annunciator assembly, and metering equipment for each bay in addition to the protective relaying system which is indicated on the drawing entitled: "Control and Protective Relay Switchboard" for each substation. The breaker discrepancy control switch, discrepancy control switch for 115 kV motor operated disconnect switch, synchronizing selector switch and recloser cutoff switch shall be the same as described above except that each switch shall be rated 10A and shall be of the indirect control switch function type and shall be accomplished the switch functions by using the interposing relays.

The total number of contacts and total number of contact tabulations shall be adequate for their required functions but minimum number of contacts and contacts tabulations shall be at least as indicated on the Dwg. NO. OOT15N sheet #2 of #2.

If the schemes for control, protection, and other equipment as proposed by the Contractor and approved by the Authority, required additional contacts than those listed in this Specification and shown in the above drawing (OOT15N sheet #1 and sheet #2) the Contractor shall furnish these extra contacts and contact tabulations without additional cost to the Authority.

1c.1.1.15 Digital voltmeters

Each voltmeter shall be flushmounted, back connected, dustproof, fully tropicalized, digital switchboard type for mounting one a steel panel. Each meter shall be suitable for operation with the instrument transformers shown on the drawing under both normal and short circuit conditions.

Each meter shall be for measuring the 115 kV line voltage with 3 CVT's (or 3 VT's) or 115 kV bus voltage with 1 CVT (or VT) as required and as specified for each substation. For measuring 115 kV line voltage, there shall be 3 CVT's (or 3 VT's) for each line except that the bus voltage, there shall be 1 CVT (or 1 VT) connected with bus phase "B" and ground. Although the measuring of the bus voltage shall be phase-to-ground, the reading voltage displaying on the meter shall indicate phase-to-phase voltage.

Except as otherwise specified, the digital meters shall be approximately 96 mm x 48 mm.

Each digital voltmeter shall have the following characteristics and requirements:

Alphanumeric display	:	4 digits, red, Light-Emitting Diode (LED)
CVT (or VT) ratio for each bus	:	$115000/\sqrt{3}$: 115 V // $115\sqrt{3}$
Decimal point	:	adjustable at front panel
Power supply	:	230 V, 50Hz, single-phase, grounded wye

1c.1.1.16 Digital power meters

Each power meter shall be flush mounted, back connected, dustproof, fully tropicalized, digital switchboard type for mounting on a steel panel. Each meter shall be suitable for operation with the instrument transformers shown on the drawing under normal and short circuit conditions.

Each power meter shall be capable of measuring and monitoring all electric quantities of the power system.

Each meter shall have the following characteristics and requirements:

Alphanumeric display	:	LCD with back lighting illumination
Parameter Setting	:	by a keypad on the front panel and complete with communication port
Power System	:	Three-phase, Three wire and Three-phase, Four wire (Balanced and Unbalanced loads)
Current input	:	1 A and 5 A
Voltage input	:	110 V and 115 V (Line-to-Line Voltage)
CT and CVT or VT Ratio	:	programmable
Measurement/Display	:	1) rms phase voltage, Line-to-ground (Va, Vb, Vc, Vaverage)
	:	2) rms line voltage, Line-to-line (Vab, Vbc, Vca, Vaverage)
	:	3) rms phase current (Ia, Ib, Ic, Iaverage)
	:	4) active power (Pa, Pb, Pc, Ptotal)
	:	5) reactive power (Qa, Qb, Qc, Qtotal)
	:	6) apparent power (Sa, Sb, Sc, Stotal)
	:	7) import and export active energy (kWhtotal)
	:	8) power factor (PFa, PFb, PFc, PFtotal)
	:	9) frequency
	:	10) others (if any)

Accuracy Class

- rms phase voltage	:	0.5% of reading + 0.05% of FS
- rms line voltage	:	0.5% of reading + 0.05% of FS
- rms phase current	:	0.5% of reading + 0.05% of FS
- active power	:	0.5% of reading + 0.05% of FS
- reactive power	:	1.5% of reading + 0.05% of FS
- apparent power	:	0.5% of reading + 0.1% of FS

- import and export active energy	:	0.5% of reading + 0.05% of FS
- power factor	:	1.5% of reading
- frequency	:	0.05% of reading
Maximum demand	:	phase current (Ia, Ib, Ic), total active power (Ptotal), total reactive power (Qtotal) and total apparent power (Stotal), every 15 minute
Communication interface	:	RS-485 port
Power supply	:	125 VDC and 230 V, 50 Hz, single-phase
Insulation test voltage one minute	:	2 kV (rms)
Operating temperature	:	$0^{o}C$ to $50^{o}C$

Each digital power meter shall include the followings:

(1) Instruction manual

(2) Software package (s) for setting parameters and readout data via communication port.

Any features and necessary components to accomplish the necessary functions of the digital power meter shall be provided as required by the meter functions, whether such features or devices are not itemized herein or not.

1c.1.1.17 Annunciators

Each annunciator system shall be of the solid-state type consisting of an annuciator with input/output and an annunciator horn relay. Each annunciator horn relay shall be wired to initiate the common horn. One common horn shall be furnished for each substation. The annunciator system shall operate from DC source with rated voltage 125 VDC.

Each annunciator system shall be compact and integrally mounted in a dustproof, back connected, flush-mounted switchboard type cabinet. Each annunciator shall have 8 alarm points including push buttons for the following functions: “Silence the alarm”, “Acknowledged”, “lamp reset” and “lamp test”. Each alarm point shall be provided with a light-emitting diode and shall have a nameplate, writing with black letters. Each alarm point shall be designed to operate either with field contact that closed for alarm or open for alarm.

Automatic acknowledge timer and push button switch shall be installed at bus section cubicle.

A red group pilot lamp for indication of annunciator operation and a white indicating light assembly for monitoring availability of annunciator potential shall be furnished with each annunciator system. They shall be suitable for mounting on the control board panel face.

The alarm horn shall be of the vibrating type, and shall be suitable for surface mounting inside the switchboard.

Each horn shall be furnished, mounted and wired inside the switchboard as specified and wired complete with a horn switch with 125 VDC rating and shall be also be mounted and wired inside the switchboard.

All signal inputs and outputs of annuciator modules shall be provided with optical couplers and RC filter circuits for high voltage surge protection.

Each annunciator shall be provided with a self-supervision system for continuously monitor the hardware and the software of the unit. The self-supervision shall also monitor and supervise the operation of the power supply module.

Each annunciator assembly shall be equipped with a serial interface at the rear port to provide communication with the remote computerized control system.

Each shall be provided with an event register, which stores at least last five events in chronological order. The event register can be read and displayed on the front panel or via the serial interface.

Each power supply shall be of the DC-to-DC converter regulated type and designed to protect it from high voltage and surge and to provide transient surge isolation between the station battery and the sensitive electronic components of the annunciator system. Each power supply shall be provided with necessary equipment to protect it from overloads that occur on the output side of the power supply. Each power supply shall include input reversed polarity protection and overvoltage and short circuit protection on the logic voltage supply. In the event of a short circuit on the power supply output, no damage will occur to the power supply.

Each annunciator system shall be designed for continuous operation at any voltage from 80 per cent to 120 per cent of rated voltage as specified and at a range of ambient temperatures of 10°C to 50°C and 0 to 94% humidity.

The annunciator operational sequence shall be manual lamp reset type and shall conform to the following table:

Designated event	Visual		Audible
	Annunciator lamps	Group pilot lamp	
Normal	Off	Off	Off
Alert	Bright flashing	On	On
Acknowledged (Horn Reset)	Steady On	Off	Off
Return to Normal	Steady On	Off	Off
Return to Alert before Acknowledge	Bright flashing	On	On
Acknowledged (Horn Reset)	Steady On	Off	Off
Reset	Off	Off	Off
Functional (Lamp test)	Bright flashing	On	On

Each annunciator shall be designed so that the closing of a trouble contact shall flash the annunciator lamp, light the group pilot lamp and sound the alarm.

The operator shall then be able to silence the alarm, stop flashing and extinguish the group pilot lamp by pressing the horn reset pushbutton and extinguish the annunciator lamp by pressing the lamp reset pushbutton, provided the trouble contact has been opened.

Operation of the lamp reset pushbutton shall not cause the alarm to sound. Release of the pushbutton shall not cause the alarm to sound again whether or not any trouble contacts are still closed. Operation of an annunciator lamp shall not interfere with or cause false operation of any other annunciator lamp whether operated simultaneously or in sequence.

Wrong operation of any pushbutton shall not cause malfunction to the correct operation of the system.

Operation of the test pushbutton shall simultaneously simulate inputs and exercise the logic of each alarm point.

1c.1.2 Protection

Protective relays shall operate in conjunction with a CSCS equipment.

Protective relays shall be of numerical type. Auxiliary ones such as undervoltage, trip circuit supervision etc… could be of electromechanical or static technology.

The substation is organized with a centralized control building for the whole of site.

All equipment of 115/MV substation will be fed by 125 VDC supply. All the equipment shall operate satisfactorily and shall not be subject to deterioration in the range of 80 to 110% of the nominal supply voltage.

For the lines, a full scheme numerical distance protection shall be furnished to provide the primary pilot protection scheme for all substations, except the switching substations, which shall be protected by a line current differential primary pilot protection.

The backup protection for both types of primary pilot relaying, shall each be a directional overcurrent protection. They shall be directional phase and ground overcurrent relays for protection of phase and ground faults.

The transformers will be protected by numerical differential relay of the numerical type including restricted earth fault protection.

The busbar will be protected by a differential relay of the numerical type protection, including breaker failure protection.

Equipment shall be protected against electrical and electro-magnetic disturbance and shall particularly comply with IEC 60255-5 and IEC 60255-22 standards.

Protective Relays shall be selected and provided among the following manufacturers:

- ABB (Sweden or Switzerland or Finland)
- Areva (Alstom) (Germany or U.K.)
- Siemens (Germany)
- SEL (U.S.A.)

1c.2 Detailed requirements

These requirements shall be considered as a minimum to be satisfied.

The protective relay shall be of the numerical type with a documented past service period of not less than two years.

The protection system for transmission lines shall take into consideration the grounding network practice of the project. All transformers (Dyn or Yyn vector group) are solidly grounded on MV network, meanwhile PEA will improve in the future the low-resistance grounding method by the addition of a resistance in the neutral connection.

The system objective maximum fault clearance times are as follows :

100 ms: maximum fault clearing time of 1st step of distance protective relay

100 ms: maximum fault clearing time of busbar protection

In the event of a failure to interrupt fault current by the line Circuit breaker, the breaker failure must trip all the necessary adjacent circuit breakers within 250 ms starting from the primary protection release the trip command.

1c.2.1 Documentation

The supply shall include, whether explicitly mentioned or not, all elements and drawings necessary to co-ordinate and ensure the correct function of the referred protection in compliance with the specifications.

In addition to all components the Contractor shall supply the necessary documents, calculations and settings, related to the relays and to the primary network, to prove the correct function of the protection equipment according to the specifications.

1c.2.2 Equipment structure

The different components shall be implemented to satisfy the following general requirements:

- Protective relays shall be suitable for operation in the local climate condition,
- Protective relays shall not be responsive to mechanical shocks,
- Parts installed in the open air shall be protected against sun radiation, humidity and dust,
- Protective relays and associated auxiliary equipment shall be of standard construction,
- Protective relays shall be supplied by an experienced and reliable manufacturer,
- Protective relays shall be fitted into protection boards as specified elsewhere,
- Applicable type test certificates in accordance with IEC international standards shall be submitted,
- Insulation of all the related circuits shall comply with IEC60255 and shall not be less than 2 kV for all the interfaces,
- Static and microprocessor based devices shall be tested on all interfaces, except serial communication ports according to IEC60255-22-3,
- Protection class of the enclosure for all relays or protection systems shall not be inferior to IP52, when finally installed,
- Relay equipment shall be arranged to produce a perfect contact,
- For each relay circuit, power supply shall be provided with DC/DC converter,

- Miniature circuit breakers shall be provided with each control circuit for both AC and DC control circuits, each miniature circuit breaker shall be equipped with two electrically separated normally closed control for alarm at the annunciator and at CSCS.
- Protection equipment shall be designed not to produce any overvoltages in case of switching of contacts at secondary AC and/or DC control or supervisory alarm circuits,
- Internal auxiliary relays, switches, terminals, push buttons, etc., shall be clearly identified by labels,
- Double stack terminals on the protection circuit will not be accepted,
- Terminal blocks shall include 20% spare of each type of terminal used (exception for test blocks).
- The contractual language i.e. English shall be used for setting and data input means as well as for the description of all the main relay interfaces.

Control circuits including potential and current transformer secondary circuits, batteries, DC controls, AC auxiliary power supplies, supervisory alarms and communication circuits connected to the function of the protection equipment shall be protected against conductive, electrostatic and electromagnetic influences of transients of neighbouring circuits.

Each protective relay shall provide the required number of electrically separate normally open contact adequately for it functions for tripping the breaker of all types of faults, initiating the breaker failure relaying, the annunciator, remote alarm at CSCS, blocking the breaker closing circuit and etc.

Both ends of each cable connecting relays to voltage and current transformer secondary circuits, batteries, DC control, AC auxiliary power, supervisory alarms, tripping and communication circuits, shall be marked with slip-over ferrules of different colours and numbering.

1c.2.2.1 Relay front design

The front of all protection relays shall be clearly marked with important information. Using the contractual language the function of the relay and the name of the protected feeder shall be clearly recognisable. Additional indicators on the front of the relay, with an adequate description in the contractual language, shall allow phase identification and type fault on every protection equipment as well as every operation step if more than one exists.

At all protection relays the actual setting at every part of the relay, the tripping alarm as well as all the supervisory and monitoring alarms, the latter for electronic relays, shall be clearly visible without opening the relays.

Indicators shall allow identification of the function activated, the alarm of the supervisory and monitoring of the protection relay as well as the alarm of the auxiliaries at the alarm boards. Each indicator, whether of the electrical or mechanical type, shall be capable of being reset by hand without opening the relay.

Each cubicle where protective relay shall be located shall be illuminated internally for maintenance purposes, and the lamp shall be controlled by the door.

1c.2.2.2 Bay Control Unit (BCU)

All binary signals to CSCS system shall be furnished to provide electrically separate normally contacts.

All protective relaying cases shall be fully independent and monitored by a bay controller processed by microprocessor based system, preferably one processor for each bay using one communication interface which will be connected to the CSCS system.

1c.2.2.3 I/O Interface

All signals shall be processed by the CSCS from the Centralized Control Unit (CCU). Refer to specification Computer – Based Substation Control System.

1c.2.2.4 Trip circuit

All the relays used for tripping shall still operate if the DC supply voltage is equal to 80% of the rated voltage

The entire control and signalling circuits of the CBs shall be continuously supervised in both opened and closed CB positions. The design of this supervision shall prevent the CB to trip in case of failure of any component of the referred supervision circuit.

No time delay for the tripping contacts will be accepted. Master trip relays shall have a maximum tripping time equal to 10 ms.

The tripping contacts of protective relays without autoreclosing shall be self reset when no further fault conditions are present, whereas the signalling and block of closing order to the CB remains until the operator resets the relay manually. An exception shall be made for the event recorder signalling contacts.

All trips due to substation internal faults shall result in a lock-out (i.e. Busbar protection, transformer differential, Buchholz etc.). Trips due to external faults (i.e. line faults, backup earth-fault) shall not cause lock-out.

A cut-off switch shall be provided on tripping circuit of each protective relay (main or back-up) associated with differential busbar or differential transformer protection (breaker failure included). Position of this switch shall be monitored by CSCS system.

All tripping control circuits for the CB shall be interrupted for the qualitative and quantitative tests. These circuits shall be located at the same test block provided to test the relay with currents and/or voltages.

1c.2.2.5 Instrument transformers

If modules of relays connected to the CT's current circuits can be removed, the design of these parts shall prevent an open circuit at the secondary side of the CT's in any case.

All current transformer and voltage transformer wirings, entering the control and relay panel, shall terminate directly on terminal blocks. The type and design of these terminal blocks shall be approved by the Authority.

The terminal block shall be in accordance with the requirements of Clause 1.4.1.11.

The characteristics of current transformers for the protection described in these specifications are the minimum requirement to be fulfilled.

Before manufacturing of the current transformers, the Contractor shall submit for approval a verifiable calculation based on the design short circuit of the substation using a time constant approximate 45 ms for the network. This is necessary to demonstrate that the offered protection shall be stable for faults outside it's zone, shall trip within the required tripping time and shall have enough sensitivity to work together with the offered CT's.

This requested calculation shall define the maximum admissible CT rated output, knee point voltages for all taps, enabling changes of the current transformers without additional costs to the Authority.

1c.2.2.6 Wiring, setting and testing

The Contractor shall supply, before elaborating the wiring diagrams, block diagrams in one drawing for each type of feeder protection. These block diagrams shall include schematic information concerning trip circuits, control circuits, secondary circuits of voltage and current transformers with polarity marks, DC power supply, supervisory alarms and teleprotection circuits, etc. These block diagrams shall be updated during the factory test, erection and commissioning phases.

The protection system shall be completely wired, tested and inspected at the factory before shipment.

Wiring used within the switchboard shall conform to NEMA standard and shall be in accordance with the requirements of Clause 1c.1.1.7 and **APPENDIX 4**: Small Wiring

The only work necessary to be performed at site shall be the connection of the external devices, the commissioning procedure and the site tests.

Test devices shall be provided for relay test facilities. Each test device shall be furnished with each relay and arranged to isolate completely the relay from instrument transformers and other external source of energy or from instrument transformers by means of multipole test plugs which shall be provided for the purpose. A sufficient of number of test plugs to make a complete test on one relay shall be furnished for each type of test device. All test devices shall be arranged so that the current-transformer secondary circuits cannot be open-circuited in any position while test plugs are being inserted or removed.

It shall be possible to perform complete test of a protective relay, interposing relays, if any, and circuit breaker by injection of analogue values through the test blocks, without disconnecting any wire or connector.

1c.2.2.7 DC-Supply

The power supply shall be based on 125 V lead-acid station battery.

All relays shall be equipped with a self monitoring alarm system, especially for DC supply and abnormal level of stabilised DC voltages but not necessarily limited to only these two. The DC supply of all the protection relays and communication shall be monitored by means of an auxiliary contact of the related mini CB's which will provide an alarm in case of fault on the DC supply.

The DC supervision relays shall indicate a delayed, independent and separate alarm for each supervisory relay and also a local and remote alarm in case of a missing DC supply and DC/DC converter failure of a protective relay DC supply.

1c.2.2.8 Requirement for Numerical Protective Relays

- **Hardware and Software Requirement**

  Necessary hardware and software for commissioning shall be provided. All cables between the PC, test equipment and protection shall be supplied.

  The software manuals shall give clear details of every action to be performed in its use. The handling of the numerical relays by the service personnel shall be possible without manual.

  A protocol with the parameter settings and addresses shall be supplied for each relay including drawing as well as a proposed programme of alarms and output contacts.

  A copy of the setting shall be placed after the commissioning on the protection board, with the addresses, labels and parameters finally set on the relays.

  Addresses and input values for the binary I/O, LEDs and command relays shall be included on the drawings for the specific uses of the relays on this project.

  Hardware and software used for the setting, and configuration of the protective relay in all its aspects shall be included. A numerical protective relay without the appropriate software will not be accepted.

  Main protective functions according to software library in each numerical protective relay shall be configured and standardized by relay manufacturers, relay suppliers or panel builders including additional functions and logic diagram for details design criteria to required. Any software modification at site to meet the Authority's functions shall not be accepted by the Authority. All main and backup protective functions of multi-function relays shall be configured and activated by relay factory or panel builder factory before delivery the relays to site work. The activated protective functions shall be ready to use and work properly anytime even they are not used at the present time. The re-configured additional required relay functions at site shall not be accepted by the Authority.

The numerical protective relay supplied shall have a documented service experience in plants or substations of at least two years, including hardware, software, transportation, installation, commissioning, etc.

The features of the numerical relays to be supplied shall include:

- Programmable scheme logic
- Remote setting/interrogation
- Serial communication interface
- Time-tagged event/disturbance record
- Measured quantities displayed
- Self-monitoring (Hardware/Software)

All main protection relays shall have 4 setting groups. Backup overcurrent protection relays shall have at least two setting groups.

- **Interface Requirements**

All features of the relay (relay setting, configuration, etc) shall be accessed through a Front Panel User interface provided. The user shall be allowed to navigate around the menu by using arrow keys or push buttons.

All numerical relays shall be delivered with a serial interface for the PC (located on the front panel) and one additional interface for the integrated substation control System. In case of numerical relays it shall be possible to set the parameters from a remote control centre by modem and also be able to request data from the relays. Through the serial interface the PC shall be able to retrieve the following minimum information, archive set or modified.

Communication with CSCS will be based upon IEC IEC60870-5-103.

Proprietary or other standardized widespread protocols are acceptable, since interoperability with the system is guaranteed. Interfacing devices shall be prohibited.

For numerical relays which are not manufactured by the company providing the CSCS, the interoperability with the CSCS will have to be clearly demonstrated.

The protection scheme(s) shall include all hardware and software to allow remote setting/configuration/fault analysis from :

- A dedicated PC or laptop, with a direct link to the relay
- From a remote access facility (from the manufacturer's office, or from an engineering department). These latter facilities shall be conveniently secured.

The main requirements applicable to communication with the relay shall be the following :.

On and Off line communication

- Relay Settings
- Relay configuration (I/Os, programmable scheme logic, fault recording programming…)
- Switching of setting group
- Extract disturbance records
- Access to relay monitored parameters

Access to relay display and setting parameters will be keyed by different authorization levels (password).

The parameter setting of the relay shall be remotely controlled from the station control level.

- **Disturbance records requirements**

The relay shall include an internal disturbance recorder, with sufficient analog channels to record three-phase currents and/or three-phase voltages, residual current and/or residual voltage depending on the relay model. Main protective relays shall have capacity to record at least 16 logic channels and backup protective relays shall have capacity to record at least 8 logic channels. The internal disturbance recorder shall have the capability to store at least the last 5 disturbance records with a minimum total storage capacity of 3 seconds (typical). This records shall be stored in the relay memory, backed by a battery or non-volatile memory. Battery low voltage alarm facility shall be provided for monitoring of status of the battery.

For all main protective relays the channels and the trigger source shall be configurable, and triggering by external equipment shall be possible.

Records shall be saved in files of COMTRADE format and could be extracted from remote communication and processed on the CSCS engineering workstation

1c.3 115kV dedicated protection

In addition to dedicated protection devices described below, auxiliary tripping relays and auxiliary tripping and lockout relays (94P, 94L, 94BU, 94BF, 86T, 86B, 86BF, 86L) shall be provided with transformer protection, bus protection, direct transfer tripping and breaker failure protection, distance relay, current differential relay, backup protection.

Each auxiliary tripping and lockout relay shall be of the high-speed type, DC voltage operated, electrical reset with cut-off contact provided to interrupt the operating coil. All contacts shall be electrically separate contacts and rated to carry 30A, 300V, for 3 seconds, 5A, 300V, continuous, and be capable of interrupting of 0.2A of inductive current (L/R ≤40 ms) in a 125 V DC control circuit. These contacts shall be used for tripping, lockout the circuit breakers, initiating the breaker failure relaying, the annunciator, remote alarm at CSCS and etc.

Loss of DC control circuit shall be monitored by loss-of-potentiala DC alarm relay. (27XB, 27XR). Each relay shall be provided with an auxiliary relay, standard speed with slow dropout characteristics. Each auxiliary relay shall be furnished with two (2) electrically separated normally closed contacts. These contacts shall dedicated to:

- initiate the annunciator
- initiate CSCS.

These relay shall also be furnished with two (2) electrically separated normally open contacts for future use.

Similarly, loss-of-AC control supply shall also be monitored by a loss-of alarm relay (27 XM). Each relay shall also provide the contacts for alarms similar to loss-of-DC alarm relay.

1c.3.1 Line protection

1c.3.1.1 Line differential protection (87 L)

The required current differential protective relay shall be fully numerical and suitable for 2 terminals lines and/or line-cable.

Each line current differential relay shall be used as primary pilot protection and with a dedicated fiber optical cable as a communication link to permit high speed simultaneous intertripping of the breakers at both ends of the line. The reclosing of the line shall be done through a sychrocheck relay.

The backup protection of the line shall be protected by a directional phase and ground overcurrent relays with at least four (4) inverse time curves and one (1) definite time characteristics.

In case of fault on the protected feeder, the protection shall send an intertrip order to the remote terminal to ensure fault clearing at both ends of the protected line.

In case of the line is fed from a breaker and a half switching station, the protective relay shall be provided with separate inputs for each set of line CT's. Stub protection function shall be provided in this case and shall be based on low impedance biased differential protection principle.

In certain cases, the line differential protection may be connected where line CT ratios at either end of the protected line are different. A CT correction factor shall then be provided. CT saturation shall not result in any relay misoperation for internal or external faults.

The relay shall fulfill the following requirements:

- A phase segregated current differential, providing high speed and selective detection of all type of faults, including resistive faults,
- Dual redundant signalling channels allowing segregation of the protection signals,
- Dual slope percentage bias restraint, tripping characteristic, ensuring stability for through fault conditions with both slope settable,
- The relay shall be designed to work within the signaling bandwidth of a basic 56/64 kbp/s pulse code modulated channel (PCM) , or via electrical interfaces conform to ITU-T G.821 standard. If a dedicated fiber optic cable does not make the link between the 2 relays, the contractor shall make sure that the relay communication requirement is consistent with the substation's telecommunication facilities and with the telecommunication network they are connected to.
- The configuration and setting of the relay shall be possible from the front panel interface, or by remote communication means.
- Freely configurable intertripping signals shall be provided which can be transmitter over the protection communication channel from one end of the line to the other.

The recloser (79) and check synchronism (25 & 27/59) function shall be selectable for the following modes in the same time

- Live bus/dead line
- Dead bus/live line
- Live bus/live line
- Voltage difference
- Frequency difference
- Angle difference

The recloser shall be activated by the internal protection and/or by all external protection order.

High speed and delayed single or three-phase cycle followed by minimum 1 low speed cycle shall be possible.

The dead time setting range shall be adjustable approximately between 0.2 to 2.0 seconds. The reclaim time setting range shall be adjustable between 1 to 300 seconds.

In the event that the reclosing relay is used with a synchro-check relay or voltage check relay, the reclosing relay shall be capable of completing its reclosing cycle with a maximum time delay of 5 seconds imposed by the synchronism-check relay or voltage check relay.

If the reclosing relay is not inherently capable of operating with a supplemental device with a 5-second pick-up then one extra timer shall be provided for this purpose.

Each reclosing relay may be combined with synchro-check relay.

The synchronism-check relay shall ensure that reclosure will proceed only if the synchronism conditions are met, line voltage and bus voltage are in normal condition, at the same frequency, equal and in-phase. Closing angle and operation times shall be independently adjustable. The synchrocheck relay operation shall be initiated by the reclosing relay.

A control cutoff switch (87L-CO) with separate red indicating light (LED) shall be provided with each set of relays to segregate the auxiliary tripping relay (94L) from the line current differential relay. In addition to the above requirement, a direct transfer trip cutoff switch (86 DTT-CO) shall be provided to segregate the auxiliary tripping and lockout relay (86L) and shall also initiate the transfer trip relay (DTT) for sending the signal to trip the remote end line via the optical fiber cable.

Internal Disturbance recorder : in case of fault the relay shall able to store four cycles of pre-fault and at least seven cycles of post-trip data. This includes as well the voltages and currents as internal relay information. Each event shall be tagged with date and time and stored in a non-volatile memory in chronological sequence.

In addition the relay will comprise:

- Communication channel supervision,
- Continuous self monitoring with watchdog contact.

1c.3.1.2 Distance Protection (21/21 N) and Direction Overcurrent Protection (67/67N)

The design of this protection device shall fulfil at least the following requirements:

Each distance relay shall be of the full scheme and numerical type. Each relay line terminal shall utilize a distance relay as a pilot protection for all combinations of phase faults and ground faults. Each distance relay system shall be designed for use with a teleprotection equipment to permit high speed simultaneous intertripping of the circuit breakers at both ends of the line. The communication link shall be by means of a fiber optical cable. The pilot tripping and reclosing schemes shall be in accordance with the requirements of Clause 3.1.1.

The directional phase and ground overcurrent relays shall be of the numerical type and shall be used as a backup protection. Each relay system shall be provided with at least four (4) Inverse Time Curves and one definite time characteristic. Each directional unit shall be voltage polarized which shall be incorporated in each relay system.

At least four (4) Number of zones distance stages with impedance set polygon characteristics for forward and reverse measurement shall be implemented.

Each distance relay shall be suitable for protection of long or short overhead line or cable, double circuit lines, heavily loaded line, and with line weak infeed.

The time delay for each zone shall be independent, and the operating time of the relay shall be less than 25 ms.

To ensure correct measurement under earth fault conditions, the relay shall be earth compensated with both residual and a angular compensation for the proposed scheme OHL or cable.

VT or CVT supervision shall be included for monitoring the VT or CVT secondary voltage and to detect low voltage or a blown-fuse in VT or CVTcircuit or all left open fuses of voltage supply to the relay system.

VT supervision will block the trip of the distance protection. The logic for this feature if based on zero component voltage and current shall not be influenced by magnetising inrush current during energization of power transformers.

The power swing-blocking feature shall be able to block one, two, three or all zones. Power Swing Blocking function shall be overridden under the presence of an earth fault.

Each distance relay shall operate properly with high values of source impedance. It shall be capable of measuring all faults with minimum fault current of 0.2 time of rated current. The maximum continuous operating current rating of the distance relay shall not be less than 2.0 times of rated current. The measuring element shall be adjustable between 0.01 to 150 ohm per phase with 1A current rating and 115 V secondary voltage rating.

In any substation where there are more than one transmission lines in parallel, effective means for fault detection shall be provided for each distance relay with either one or all the lines in operation.

The required distance relay shall be suitable for operation with capacitive voltage transformers.

CT saturation shall not result in any relay misoperation for internal or external faults.

The relay shall not misoperate for current reversals that may occur during the clearing of external faults.

System logic for switch onto fault protection (SOTF) shall be implemented in the distance relay. The SOTF feature shall be for a settable time 0 to 1 sec (remain for a time not exceeding 0.5 sec) after the relay detects the local circuit has closed. This feature will block the autoreclosure scheme and the tripping will trip instantaneously regardless of whether the fault is located at the near end or the remote end of the line. Any starting, measuring via distance comparators or any current level detector, will initiate the tripping in this logic.

Stub protection function shall be provided for One and Half substation arrangement. This feature shall be used to protect the remaining live portion of a primary circuit on which an disconnector has been opened.

A logic for teleprotection schemes shall be regarded among the following topics according to the scheme used:

- Permissive underreach Transfer Trip (PUTT),
- Permissive overreach Transfer Trip (POTT),
- Zone 1 extension,
- Blocking Overreach scheme. (BOR)

The logic scheme of the supplied teleprotection logic shall be submitted in block diagrams with clear indication of the send logic, trip logic, open terminal end and weak end logic.

Reclosure and Check Synchronism functions

The recloser (79) and check synchronism (25 & 27/59) functions shall be selectable for the following modes in the same time:

- Live bus/dead line
- Dead bus/live line
- Live bus/live line
- Voltage difference
- Frequency difference
- Angle difference

The recloser shall be activated by the internal protection and/or by all external protection order,

High speed and delayed single or three phase cycle followed by minimum 1 low speed cycle shall be possible.

The dead time setting range shall be adjustable approximately between 0.2 to 2.0 seconds. The reclaim time setting range shall be adjustable between 1 to 300 seconds.

In the event that the reclosing relay is used with a synchro-check relay or voltage check relay, the reclosing relay shall be capable of completing its reclosing cycle with a maximum time delay of 5 seconds imposed by the synchrocheck relay or voltage check relay.

If the reclosing relay is not inherently capable of operating with a supplemental device with a 5-second pick-up then one extra timer shall be provided for this purpose.

Each reclosing relay may be combined with synchrocheck relay.

The synchronism check shall ensure that autoreclosure will proceed only if the synchronism conditions are met, line voltage and bus voltage are in normal condition, at the same frequency, equal and in-phase. Closing angle and operation times shall be independently adjustable. The synchro-check relay operation shall be initiated by the reclosing relay.

The recloser shall be coordinated with the line differential protection’s recloser so that for a fault on the line, a single reclosing cycle is initiated. As a consequence, both reclosers may work on a parallel basis (with the first acting recloser inhibiting the remaining one), or with a master/follower configuration.

- **Fault Locator**

  The distance from the relaying point to the fault location will be measured and displayed (in km) by the incorporated fault locator units. The algorithm in this case shall take into consideration the pre-fault load current.

- **Disturbance Recorder**

  In case of fault the internal Disturbance Recorder shall record and store four cycles of pre-fault and at least seven cycles of post-trip data. This includes as well the voltages and currents as internal relay information. Each event shall be tagged with date and time and stored in a non volatile memory in chronological sequence.

  Integral user interface shall allow easy access to analogue fault data and numerical input or output status.

  The EEPROM shall be a non-volatile area of the memory, and will fulfil the storage and maintain the information within it even if the DC supply is removed. This area of the memory shall be copied to the working RAM after a DC power up, but only written to and read from, if setting changes are updated or a fault condition occurs.

  The synchronisation from a common remote clock and locally through the substation control unit by means of a general synchronising signal or by a manual menu guided instruction shall be possible.

1c.3.1.3 Backup protection (67-67N)

Phase and ground directional overcurrent relays shall be used to provide backup protection in conjunction with the primary protection in Clause 3.1.1 and 3.1.2 for transmission lines against phase and ground faults. Each directional unit shall be voltage-polarized.

The voltage-polarizing source shall be drawn from auxiliary transformers (included in the relay) connected to line VT or CVT. At least 4 Inverse Time curves (IEC 60255) and 1 definite time shall be provided. Each relay shall have a current setting range of 0.1-2.5 In and shall be used with 1 A. rated secondary current CT.

Operation indicator with reset pushbutton shall be incorporated in each directional overcurrent phase and ground faults protection for indication of the relay operation.

1c.3.1.4 Tripping and interposing supervision relay (95)

Supervision relay shall be used for monitoring important control and signalling circuit such as circuit breaker or disconnector circuits. The supervision relay shall be able to detect interruptions, too high resistances cause by galvanically bad connections, increased transfer resistance in the contacts, welding of the control contact, loss of control voltage and failure of the relay itself.

1c.3.1.5 Voltage circuits failure (27)

The fuse failure relay shall monitor the output of voltage transformer and will block the trip of distance protectionand give an alarm in case of VT fuse failure. The 3-phase voltage shall be monitored.

1c.3.1.6 Transformer Protection 115 /MV

The protection of power transformer can be divided into two main groups able to detect:

- Internal faults, such as Short-circuit between windings, short-circuit between turns, Ground faults, Tap changer failure and transformer tank oil leaks.
- External faults, such as Power system phase faults, Power system ground faults, Overload and Overexcitation.

The main protection scheme required for power transformer internal phase and ground faults shall be based on a differential protection relay. The detection of short-circuits between turns shall be carry out by the use of a Restricted Earth fault protection. This function should be included in the differential protection relay.

As a standard protection fitted to all oil immersed transformers, a Buchholz relay will detect all insulation breakdowns inside the transformer tank, causing either the formation of gas or surges of oil flow from the tank to the expansion vessel.

All faults detected by these relays will trip the HV and MV circuit breakers.

The overcurrent protection relay shall be used as back-up protection for internal and external phase and ground faults.

- **Transformer Differential Protection (87 T – 64 REF)**

  The transformer differential protection relay required shall be of numerical type design with all main functions individually configurable by the user.

  A cut-off switch shall be provided on tripping circuit of each protective relay (main or back-up) associated with transformer differential protection (breaker failure included).

  Position of this switch shall be monitored by CSCS system.

  The protective relay required shall be a biased differential current type (87T)able to protect 2 winding transformer. Restricted Earth fault protection (64REF) shall be provided as part of the relay. The 64REF function shall be based on the high impedance circulating current principle with suitable non-linear resistor and stabilizing resistor. Internal vector group compensation and line current transformer ratio correction shall be performed through the dedicated software of the relay. No interposing relays shall be accepted by the Authority.

The Internal Disturbance and Events recorder shall be able to measure and store Three voltage and Three current by winding. In addition, analogue channels shall be provided to measure and store fault current in the neutral(s). The relay shall be able in case of tripping events to store the input data for 1 s with 2 periods pre-fault data.

The Internal Disturbance and Events recorder shall provide the possibility of external binary signal acquisition for the purpose of indication and fault recording (Buchholz, O/C, E/F). Each event shall be tagged with date and time and stored in a non-volatile memory in chronological sequence.

The numerical relay shall be controlled by self-control routines (e.g. every 10 s) to avoid false function and to permit early detection of any fault inside the relay.

- **Back-up Protection (50/51, 50G/51G)**

The overcurrent protection device installed on both sides of the transformer and neutral connection, as a back-up protection, shall be numerical independent relay elements able to measure phase and ground faults.

At least one Definite Time and four selectable Inverse Time curves for the phase and ground elements shall be provided according to IEC60255-3

- Standard inverse curve,
- Very inverse curve,
- Extremely inverse curve,
- Long time inverse curve
- Definite time ,

All setting will be entered by means of a built-in keypad or external portable computer.

All logic events and analogue information shall be stored in memory and shall be transferred to the CSCS or PC for post analysis.

In the front of the relay at least 3 LED’s shall be able to indicate the following functions: Trip, alarm, warning, healthy.

- **Static voltage regulator control relay (90)**

The tap changer operation shall be controlled automatically by voltage regulating relay, continuously monitored and initiated the tap changer mechanism. The relay shall have the following facilities:

- Integral line drops compensation.
- Inverse or definitive time characteristics.
- In case of several transformers in parallel, reverse reactance or circulating current compensation shall be taken in consideration.

- Under voltage, over voltage and over current supervision
- Alarms

- **Mechanical Functions**

  Following functions are the minimum to be provided: Buchholz alarm, Buchholz trip, oil flow operated, oil pressure relief device of the OLTC, temperature monitor thermometer, thermal replica and magnetic type oil level.

  All necessary tripping relays associated with the transformer, should be provided e.g

  - Buchholz protection,
  - Transformer pressure relief device
  - Transformer sudden pressure relay
  - LTC diverted switch pressure relief device
  - LTC diverted switch sudden oil flow

  Winding temperature sensors. Operating signal of these different sensors and protections shall be routed to the binary inputs of the main integrated Differential protection.

1c.3.1.7 Busbar Protection (87B)

Each busbar shall be protected by a low impedance numerical busbar protection, designed for high-speed and selective protection of busbar installation. The hardware shall be based on a central unit communicating to various line units through optic fiber. No hardwiring/analog interfacing between units shall be accepted so as to minimize any potential interference with substation environment. In case of busbar fault, the protection shall trip and lockout all breakers which connected with the faulty bus, on both sides of the transformer and trip and lock-out the bus coupling breakers.

The protection scheme shall include an integrated check zone feature with independent fault criteria detection. The check zone operation principle is independent from isolator status. Tripping takes place only if zone and check zone detectors are operating simultaneously.

The protection shall be suitable for use on a bus with up to all connected feeders and shall have the following properties:

- High sensitivity and selectivity for internal faults and high stability for external faults,
- All three-phase shall have the same pickup setting for the different current. This is to ensure the same sensitivity for all three-phases,
- Phase-to-phase and phase-to-ground faults in solidly grounded system or resistance grounding.
- The protection shall be able to operate on CT's having a wide range of different ratio,
- The function of the protection shall be blocked if a measuring circuit is faulty,

- Except on PEA special request, no special performance for CT's supplying the protection shall be required,
- Tripping time less than 20 ms,
- Event recorder with resolution of not more than 1 ms shall be provided,
- Self checking and supervision shall be continuously monitored,
- Extension of busbar protection shall be possible, and the protection cubicle provided shall already be wired for the entire substation.

A cut-off switch shall be provided on tripping circuit of each protective relay (main or back-up) associated with differential busbar (breaker failure included).

A control switch (87CO) with a separate red indicating lamp (LED) shall be provided with each set of relays to segregate the auxiliary tripping and lockout relay from the differential relays as necessary to prevent false tripping due to the bypassing of the current transformers. The busbar differential relay shall be provided with a supervision unit, which shall be used to detect an unbalance current, or voltage in the differential measuring circuit due to spill current or open CT circuits.

The red lamp (LED) shall light to indicate that the trip circuit from the differential relays to the auxiliary tripping relay is open.

Each busbar differential relay shall be furnished with three (3) electrically separate normally open contacts in addition to those required by the bus differential protection scheme.

1c.3.1.8 Breaker failure protection (50BF)

The breaker failure protection will be separated or integrated in the other protective relaying system as required, and shall be of numerical type design with functions individually configurable by the user.

The breaker failure protection for breaker and a half bus with or without transformer shall be of the separated type.

In case of currents sensing elements (buchholz) are not available, external signal inputs performed via binary inputs shall be incorporated in a tripping logic using auxiliary control of the CB.

The relay shall be sensitive to detect fault 0.2 to 2 times of the rated current, adjustable in steps of less than to 01 times of this currents.

A breaker failure relaying shall be provided for each circuit breaker.

All protection relays of the dedicated feeder shall initiate the breaker failure relaying in case of fault.

Lockout relays shall be provided to prevent reclosure, either manual or automatic, until lockout relays are reset.

Breaker failure Protection components shall be as follows:

- **Current Detector Relays (50BF).**

  Current detector relays shall be of numerical type, non-directional instantaneous overcurrent relays with fast-resetting time of less than 12.5 milliseconds when the current drops to 90 per cent of the pickup. Each shall contain either two-phase units with 0.2-1.6A pickup range and one ground unit with 0.05-0.4A pickup range or three-phase units with 0.2-1.6A pickup ranges.

  A control switch (50BF-CO) with a separate red indicating lamp (LED) shall be furnished with each set of the relays, to segregate the auxiliary tripping and lockout relay from the current detector relay.

- **Breaker Failure Timers (62BF).**

  Breaker failure timers shall be adjustable for use with current detector relay above. The setting range shall be from 0.05 to 1.0 seconds in step of not more than 10 ms.

1c.4 MV Dedicated Protection

Each MV switchgear shall be designed for the control, metering, protection and annunciation. The switchgear shall also furnished all information to the remote control location for Substation Computer-based Control System (CSCS) via CSCS equipment which are incorporated in each switchgear section.

1c.4.1 Outgoing feeder

Each outgoing feeder shall contain the following metering and relaying systems:

- 3 phases with instananeous and time-delayed units overcurrent protection, using 3 independent stages $\left(\frac{50}{51}\right)$,
- 1 Ground Fault with instantaneous and time-delayed units Overcurrent protection, using 3 independent stages $\left(\frac{50G}{51G}\right)$,
- 1 Reclosing relay having a minimum of 4 shots (79),
- 1 Breaker failure relaying sytem,
- 1 Event and disturbance recorder,
- 1 Metering system,

shall be fully integrated.

The phase and ground overcurrent protective relays and breaker failure current detector relay shall be of numerical type design.

At least one Definite Time and four selectable Inverse Time curves for phase and ground elements shall be provided according to IEC60255-3

- Normally inverse curve,
- Very inverse curve,
- Extremely inverse curve,
- Long time inverse curve
- Definite time

All setting shall be entered by means of a built-in keypad or external portable computer. Comprehensive data accumulated in the memory for post fault analysis shall be retrieved through the serial interface into a personal computer.

In the front of the relay at least 3 LED's shall be able to indicate the following functions: Trip, alarm, warning, healthy.

The protection of all outgoing feeders shall be provided with a Local on-off function that can be operated from HMI.

a) The reclosing function shall be initiated by both Overcurrent and Earth Fault protections.

   The reclosing relay shall be capable of performing 4 (four) different shots, associated with 4 independent times.

   - 1st shot instantaneous
   - 2nd shot selectable 0.1 to 10 s
   - 3rd shot selectable 0.2 to 60 s
   - 4th shot selectable 0.2 to 120 s

   Dead time and reclaim times shall be adjustable.

b) Each under frequency relay shall be furnished to perform the load shedding scheme. Each relay shall be provided with four steps frequency settings by using a selector switch, 5 position, "OFF", "step#1", "step#2", "step#3", and "step#4" for the purpose of tripping the outgoing feeders as required. The switch shall be engraved on the escutcheon plate with the following modes:

   OFF,
   ON 1 = f1
   ON 2 = f2
   ON 3 = f3
   ON 4 = f4

   It shall only be possible to set the position of the settable switch locally.

   The load shedding equipment shall not start the autoreclosing function. Restoration after load shedding sequence shall be done manually, by a function "UF step 1 to step 4 reset".

The setting range for each steps shall be comprised between 50 and 45 Hz in step of approximately 0.02 Hz.

Time delay to allow a co-ordination between the different steps, settable between 0.2 to 10 s for each step shall be provided.

Logic selectivity should be used wherever possible to reduce clearance time of fault.

The function shall be guaranteed with voltage levels of +10% to -40% of the rated voltage.

The function shall be blocked if the voltage is less than 60% of the rated voltage.

The accuracy of under/over frequency protection shall be 20 ms.

c) Breaker failure relay shall be initiated by protection relay, for each CB.

d) The current setting range shall be comprised between 0,1 to 1,3 In. Timer shall be adjustable between 0,05 s to 5 s. Metering, measuring active and reactive energies shall have an accuracy of 0.5 and 1% respectively.

e) In addition 1 undervoltage relay and 1 overvoltage relay (due to the presence of capacitor banks) shall be provided.

The setting range for both shall be 10 to 150 V by step of 0.5 V.

1c.4.2 Incoming feeders

Each incoming feeder and bus-section shall be protected by a three-phase with instantaneous and time-delayed overcurrent and a ground fault protection (50, 50G / 51 51G). These relays shall be identical as the aforementioned paragraph.

One set of instantaneous overcurrent (50 ARC) detector relays shall be provided to operate in conjunction with the arc detection protection as called for in the Specification 22 kV indoor switchgear

1c.4.3 Capacitor Bank feeder

Capacitor Bank feeder shall be protected by:

- 3 phases overcurrent protection,
- 1 Earth Fault Overcurrent protection,
- 1 Under and Overvoltage relay

The phase-to-phase and phase-to-earth Overcurrent protection, undervoltage and overvoltage relays shall be identical as those described in paragraph “outgoing feeder”

In case of overvoltage occurs to the capacitor banks over the presetting voltage value, the overvoltage (59) shall initiate the auxiliary tripping and lookout relay (86) to trip and block closing of the vacuum switches (or SF6 breakers) and also cutoff the VT supply to the power factor controller so that the power factor controller will return to it neutral stage for stopping the operation.

The neutral connections of the Double Star arrangement of the capacitor bank shall be monitored by one overcurrent relay (Unbalance protection) via a bushing current transformer (see Specification Shunt Capacitor Bank).The current unbalance relay (60) shall be furnished with two-stage operation : the first stage shall provide the alarm and the second stage shall provide contacts for tripping and alarm the capacitor bank switching device.

1c.5. Environmental Constraints and Electromagnetic Compatibility

1c.5.1 Environmental Data

1c.5.1.1 All the equipment supplied in the scope of this project shall be compliant with the environment constraints listed in this paragraph. Temperature requirements

Category	I	II	III
Rated operation range (1)	T1: +5°C T2: +40°C	T1: -10°C T2: +55°C	T1: -25°C T2: +70°C
Maximum operation limits (2)	T3: +5°C T4: +40°C	T3: -10°C T4: +55°C	TI: -25°C T2: +70°C
Relative humidity At + 23°C	75 %	80 %	90 %
Storage and transport conditions (3)	-40°C +70°C	-40°C +70°C	-40°C +70°C
Operation location example	Air conditioned room	Relay room	Outdoor equipment

The three above definitions are extracted from IEC60359.

(1) Operational range:

Range of values that can take an influence quantity when the prescriptions regarding the error determined in rated operating conditions are fulfilled.

(2) Maximum operation limits:

Range of values that can take an influence quantity beyond the rated range of operation, in which an equipment can still work without deterioration or degradation of its operating qualities when it works again at its rated conditions of operation.

(3) Storage:

Set of climatic conditions to which the equipment can be submitted, when not operating, without deterioration or degradation of its operating qualities when works again in its rated conditions of operation.

1c.5.1.2 Class of Equipment

The following description gives the class definition used in the next paragraphs (except the temperature related paragraph):

CLASS 1: Low-level electromagnetic radiation environment, such as levels typical of local radio/television stations located at more than 1 km and levels typical of low power transceivers.

CLASS 2: Moderate electromagnetic radiation environments, such as portable transceivers that can be relatively close to the equipment but not closer than 1m.

CLASS 3: Severe electromagnetic radiation environments, such as levels typical of high power transceivers in close proximity of the control equipment.

CLASS 4: Open class for situations involving very severe electromagnetic radiation environments. The level is subject to negotiation between the user and the manufacturer or as defined by the manufacturer.

According to these figures, the equipment to be supplied shall be compliant with tropical constraints.

TEST	METHOD	CLASS	SEVERITY
Cold	IEC60068-2-1	-	- 25°C / 96 h (storage) + 5°C / 96 h (in operation)
Dry heat	IEC60068-2-2	-	+ 70°C / 96 h (storage) + 70°C / 96 h (in operation)
Damp heat	IEC60068-2-78	-	+ 55°C / 95% / 96 h (storage) + 40°C / 93% / 96 h (in operation)

ELECTROMAGNETIC ENVIRONMENTAL STANDARDS

Isolation tests: voltage withstand

TEST	METHOD	CLASS	SEVERITY
Rated insulation voltage	IEC60255-5	-	500 VDC
Insulation impedance	IEC60255-5	-	100 MΩ

ISOLATION TESTS: DIELECTRIC WITHSTAND

TEST	METHOD	CLASS	SEVERITY
Rated insulation voltage	IEC60255-5	-	2 kV/50 Hz/1 mn

Isolation tests: impulse voltage withstand

TEST	METHOD	CLASS	SEVERITY
Unidirectional surge 1,2 / 50 µs (voltage) 8 / 20 µs (current)	IEC 61000-4-5 IEC60255-5	-	5 kV (supply) 5 kV (input/output) 1 kV (communication)

Immunity tests against radiated electromagnetic field disturbances

TEST	METHOD	CLASS	SEVERITY
Radiated electromagnetic field disturbance	IEC 61000-4-3 IEC60255-22-3	3	30 V/m (15 V/m for talky-walky frequencies)

Immunity tests against recurrent fast transient

TEST	METHOD	CLASS	SEVERITY
Electrical fast transient burst	IEC 61000-4-4	4	4 kV (supply) 4 kV (input/output) 4 kV (communication)

1 MHz damped oscillatory wave tests

TEST	METHOD	CLASS	SEVERITY
1 MHz damped oscillatory wave	IEC60255-22-1	3	2,5 kV CM (supply) 2,5 kV (input/output) 2,5 kV (communication)

Electrostatic discharge

TEST	METHOD	CLASS	SEVERITY
Electrostatic discharge	IEC 61000-4-2 IEC60255-22-2	4	15 kV contact

Mechanical shock

TEST	METHOD	CLASS	SEVERITY
Semi-sinusoïdal shock in operation	IEC60068-2-27	-	15 g / 11 ms 1 shock per sense and per axe

Fast transient tests for measuring relays with single input

TEST	METHOD	CLASS	SEVERITY
Fast transient disturbance test	IEC60255-3	3	2,5 kV CM (supply) 2,5 kV (input/output) 2,5 kV (communication)

Vibrations

TEST	METHOD	CLASS	SEVERITY
Sinusoidal vibrations (in operation)	IEC60068-2-6		10 to 55 Hz / 0,15 mm or 2 gn 2 hours per axe

1c5.1.3 Ventilation

The specified equipment shall be able to operate in normal continuous service without forced ventilation under the following environmental conditions. In order to increase the reliability a forced ventilation shall be included. In case of a failure of the forced ventilation equipment, an alarm shall be sent to the substation control unit.

The formation of condensed water on the circuit boards, modules, covering and in general in the apparatus shall be avoided.

All equipment covered by this specification shall be selected and especially treated, as required, for used in a tropical climate and for protection against fungus growth and corrosion during shipment and storage.

1c.5.2 Electromagnetic Environmental Precautions

The correct operation of the substation control system and protection equipment shall not be limited or restricted by environmental influences. Therefore the substation control system and protection equipment shall be designed to withstand the influence of :

- Switching operations in primary circuits
- Lightning stroke in HV line
- Lightning stroke in grounded component
- Switching operations in secondary circuits

- Faults occurring within or near the substation producing ground currents and ground potential rise
- Radio interferences produced by hand-held walkie-talkie type radio communication equipment (P = 2 Watt) in the frequency range 80/160/460 MHz at 30 cm distance

The measures to be taken to reduce EMI (electromagnetic interferences) are listed below:

Primary circuits

Most of the measures listed below are necessary to protect HV equipment but they have also a beneficial effect on interference to secondary circuits.

- Protection against lightning strokes
- Protection by lightning arrests
- Configuration of earthing systems
- Use of VT and CT with acceptable transient response

Secondary circuits

In secondary circuits the following measures shall be at least adopted to reduce EMI.

- Separation of the various circuits connected with devices having different degrees of interference level(power supplies, input and output network circuits, earth connections).
- Galvanic separation of the I/O signal circuits and of the auxiliary supply circuit lines with isolating relays, optodiodes, transformers, coupling condensers.
- Screens of the cables from switch bays shall not be laid to adjacent unshielded circuits.

Further following measures are to be taken in the installation:

- Separation (spacing out or different routes) of power circuits (e.g. a.c. power supply cables) from control cables.
- Separate cabling of the low frequency and high frequency circuits
- Earthing connection of equipment shall be kept as short as possible and generally separated from the cables. For HV equipment at least two connections are necessary.
- Increasing density of the earthing mat meshes where the occurrence of high transient current is more likely (lightning arresters, spark gaps, VT and CT).
- Impedance between equipment (VT and CT etc.) and the earth network shall be as low as possible.
- Cable route shall run as far as possible from and not parallel to busbars or power cables.
- The forward and return conductor of the same circuit shall run in the same cable.
- Twisted pairs or quad cables shall be adopted whenever possible (i.e. low current circuits and data lines).
- Screened cables shall run as close together as possible.

- DC auxiliary supply cables shall be laid in a radial configuration better than a ring.
- Screen of perfectly homogeneous with low resistance, protected of the external high frequency electric and magnetic field for the cables shall be provided.
- Screen of the cables shall have low coupling impedance within the interference frequency range.
- Earthing of the screen shall have very low impedance with adequate section minimum length and optimum contact arrangements.

1c.6 Factory tests

After the switchboard and cabinet structures shave been fabricated and all components assembled, the complete gear including instruments, relays and devices shall be given standard factory tets and all others the latest applicable standards. These tests shall include, but not be limited to, the following:

- Dielectric Tests
- Sequence Tests
- Check of Control Wiring
- Mechanical Tests

APPENDIX 4

SMALL WIRING

1. General conditions

1a Scope

This specification describes the requirements with which the manufacturer shall comply in order to supply 600 V multi-core control cable, copper conductor, flexible metallic sheath, non fuel base material insulated and non toxic, low smoke, halogen free (LSOH) material jacketed

1b Reference Standards

All equipment required within the scope of works shall conform as a basic requirement with the latest edition of the following standards:

IEC 60068	:	Environmental testing
IEC 60947-7-1	:	Low voltage switchgear and controlgear – Part 7-1: Ancillary equipment –Terminal blocks for copper conductors.
NEMA WC5/ICEAS-61-402	:	Thermoplastic-insulated wire and cable for the transmission and distribution of electrical energy
ASTM B3	:	Standard specification for soft or annealed copper wire
TIS 838	:	Standard for control cables

The latest edition of each standard shall mean the edition available on the date of signing the Contract.

1c Principal Requirements

1c.1 Service Conditions

Cable insulating material shall be suitable for installation in wet and dry locations.

1c.2 Site and Service Conditions

The equipment shall be capable of operating at its full ratings under site and service conditions as mentioned below.

The switchgear room has no air conditioning system.

Seismic activity:	None
Maximum wind speed:	(≈100 km/h)
Maximum recorded rainfall:	250 mm/day
Number of days with thunderstorm:	100 days/year
Average rainfall:	20 mm/day
Mean maximum annual relative humidity:	94%
Mean minimum annual relative humidity:	79%
Minimum daily relative humidity:	17%

Maximum temperature of surfaces exposed to sunbeam:	80°C
Mean minimum daily temperature:	24°C
Maximum ambient temperature:	40°C(1)
Minimum ambient temperature:	11°C
Maximum ambient temperature in trench for Control cables	65°C

(1) according to IEC 62271-1 over 40°C will be possible under special requirement.

1c.3 Design Requirements

The maximum continuous current-carrying capacity of each individual cable type and cross-section used shall be determined, taking into account Site conditions. The resulting load reduction factors are subject to the approval by the Authority.

The conductor cross-section of each cable shall be adequate to carry the fault currents determined by the relevant short-circuit protection device when operating under the specified load conditions, without deterioration of the dielectric properties. Calculation including the short-circuit calculations, shall form part of the documents to be supplied by the Contractor.

1c.4 600 V CONTROL CABLE AND 600 V SWITCHBOARD WIRE

1c.4.1 Control Cable

Construction

The general construction of the control cable shall be suitable for installation in wet and dry locations and shall be furnished with the characteristics described herein. The control cable shall meet the following specific requirements.

- Conductors The conductor shall be of soft or annealed uncoated copper wire and shall conform to ASTM B3. Concentric-stranded conductor shall conform to Table 2.
- Insulation The insulation shall be polyvinyl chloride suitable for use on a copper conductor with a maximum operating temperature not less than 75 °C
- The insulation thickness shall not be less than 1.14 mm (0.045 in).
- The insulation shall conform to Part 3 of ICEA Pub. No. S-61-402.
- Fillers. Fillers shall be used in the interstice of the multi conductor, cable where necessary to give the complete cable a substantially circular cross section.
- Wrapping. The cable shall be helically wrapped over the filler and copper shielding with 0.0254 mm (0.001 in) thickness non-hygroscopic mylar or polyester tape.

- Inner Jacket. Inner jacket shall be polyvinyl chloride or polyethylene of at least 1.14 mm(0.045 in) thickness and shall be applied over the wrapping
- Shielding. The shielding shall be annealed copper tape of suitable width and shall be helically applied over the inner jacket with a minimum 10% lap.
  The annealed copper tape shall be at least 0.1 mm (0.004 in) thickness and substantially free from burrs.
- Jacket. The jacket shall be of a black polyvinyl chloride jacket over the wrapping and shall comply in all respects with Part 4 of ICEA Pub. No. S-61-402.
- Circuit Identification. The assembly of conductors in cable composed of 12 conductors or less shall be in accordance with the combinations given in the Table 1. When more than one color is required, the base and tracer color coding shall conform to method 1, Part 5 of ICEA Pub. No. S-61-402.
- Spare Conductors. The minimum number of spare conductors in each control cable shall be as follows:

Conductor Number in Cable	Minimum Number of Spare Conductors
2	NIL
3	NIL
4	NIL
5	NIL
9	2
12	2

1c.4.2 Switchboard Wire

Construction

The Switchboard wire shall be suitable for installation in dry location especially for wiring used within the control switchboard or other substation equipment control cabinets.

- Conductors. The conductor shall be soft drawn or annealed tin-coated copper wire and shall conform to ASTM B3. Concentric-stranded conductor shall conform to Table 3.
- Insulation The insulation shall be polyvinyl chloride suitable for use on a copper conductor with a maximum temperature not less than 75 ^{o}C. The insulation thickness shall not be less than 1.14 mm (0.045 in) The insulation shall conform to Part 3 of ICEA Pub No. S-61-402.

Table 1 : Colors Sequence for Control Cables

Conductor Number	Background or Base Color	Tracer Color
1	Black	-
2	White	-
3	Red	-
4	Green	-
5	Orange	-
6	Blue	-
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White

Table 2 : Stranded Conductor for Control Cables

Conductor Size (sq.mm)	No of Strands	Nominal Strand Diameter (mm)	Approximate Overall Diameter (mm)
1.5	7	0.50	1.50
2.5	7	0.67	2.01
4	7	0.85	2.55
6	7	1.04	3.12

Table 3 : Switchboard Wire

Conductor Size (sq. mm.)	No of Strands	Nominal Strand Diameter (mm)	Approximate Overall Diameter (mm)
1.5	30	0.25	4.2
2.5	50	0.25	4.7
4.0	56	0.30	5.3
6.0	84	0.30	5.9

Table 5 : Colors circuit identification for switchboard wire

Color	Circuit identification
Red	Power circuit phase A
Yellow	Power circuit phase B
Blue	Power circuit phase C
Green	Neutral wire
Black	AC control circuit
Gray	DC control circuit
Green/Yellow	Grounding wire

1c.4.3 Conductors Sizes

All switchboard wires used within the control and protective relay boards or other control cabinet shall be tinned, stranded copper switchboard wire and shall meet the requirement of ICEA Pub. No. S-61-402.

1c4.3.1 Conductor Sizes for Control Cable

Each control cable conductor minimum sizes used for power supply and control circuits shall be as follows:

- Secondary current transformer circuits 4 sq.mm. (for CT_{sec} 1A)
- Secondary voltage transformer circuit 2.5 sq.mm.
- Substation equipment D-C or A-C Control circuits 4 sq.mm.
- Status and alarm circuit 1.5 sq.mm.
- Power supply circuit 4 sq.mm.

The voltage drop at the load for 2.3.1.5 shall not be more than 3%.

1c.4.3.2 Conductor sizes for Switchboard and Equipment Control Cabinet Wiring

Wiring used within the switchboards, and other equipment control cabinets shall have minimum sizes as follows:

- Secondary current transformer circuits 4 sq.mm. (for CT_{sec} 1A)
- Secondary voltage transformer circuits 2.5 sq.mm.
- Substation equipment D-C or A-C control circuits 2.5 sq.mm.

- Status and alarm circuits 1.5 sq.mm.
- Power supply circuits 4 sq.mm.

Calculation of secondary current circuits for Clauses 2.3.1.1 and 2.3.2.1 shall be submitted to the Authority for approval. The Authority shall review the calculation, if a larger size of control cable and switchboard wire are required for the proper functions of the protection, then the Contractor shall carry out to change the size of the control cable and switchboard wire without extra charge to the Authority.

1c.4.4 Metallic Shield

Metallic shield shall be made of copper tape for control cables.

As Metal Sheath Cables are installed, non magnetic metallic glands which effective earth the armour, are recommended for all cable entries. All joints in cables should be made in such a way as to prevent entry of vermins as well as to maintain the fire circuit integrity. The manufacturer shall have a tested joint system with test reports indicating compliance. Termination by crimping is recommended.

Metal shields of the control cables shall be grounded at both ends of each cable. Each end of the cable shield shall be welded to an insulated 600V, PVC, copper ground conductor with 6 sq.mm size and this conductor shall then be attached to the ground bus by a terminal lug provided inside of the equipment cabinets, instrument transformer junction boxes, and the switchboards.

Provision for sealing at each end of the cable shall be provided including wrapping over the connection of the shield and the insulated ground conductor by the PVC insulating tape.

1c.4.5 Cable and Wire Markings.

The following information shall be printed on the surface of the cable and wires:

- Name of manufacturer
- Size of cables and wires and number of conductors
- Type of insulation
- Voltage classification
- Date of manufacturer

1c.4.6 Cable Ends

An end cap shall be provided on the cable end to which special attention shall be paid to prevent penetration of moisture during transportation.

1c.4.7 Packing

All cables and wires shall be packed on reels. The reels shall be nonreturnable and shall be included in the prices of the cables and wires offered. The length of the cable and wire to be packed on each reel shall be as indicated below:

Control cables : 500 m + 0.5%

Switchboard wires : 100, 150 or 200 m + 0.5%

The following information shall be displayed:

- Name of manufacturer
- Size and number of conductors
- Type of insulation and voltage classification
- Length of cable
- Reel number and other suitable indentification for reel and reel size.
- Date of manufacture
- Total weight

1c.5. TERMINATION AND LABELING

For all terminations of wires and cables the insulation shall be neatly stripped without nicking the strands of the conductors.

Each cable end shall be equipped with compression cable lug. Cable lugs for power cables shall be of adequate size.

Cable shall be firmly fixed on metallic supports.

Brass cable gland shall be used.

Cable glands or clamps shall be fitted in all cases to prevent stresses on conductors or terminals. It is important that the sealing compound and sleeving used in terminations is selected to suit the service conditions under which the cable is to operate.

No terminations will be accepted, if the insulation readings, 24 hours after making off, is less than 100 megaohm using a standard 500 V or 1,000 V “Megger” (cables only).

Some slack cable in a loop or other suitable form is to be provided in a convenient place in the runs, where required.

Designation of each end of cable conductor or switchboard wire shall be marked with source and destination terminal name.

Each terminal shall carry a letter or number marking. Terminals shall be numbered on the terminal block in chronological order, from left to right and from bottom to top.

Dividers shall be provided to separate incomings. In addition, provision of a side marking shall allow identification of the cable arriving from the outside. Terminal covers with dividers shall be fitted onto power terminal blocks.

The wiring shall be arranged so as to avoid masking the distinctive markings of functional elements.

Wiring drawings for control and relay panels shall show wire and cable terminations for external wiring.

The ends of each cable core and all secondary panel wiring shall be fitted with white ferrules marked by printed black numbers, with the identification being the same as for the relevant terminals. Both ends of each cable shall be marked with terminal destination, including cubicle name, equipment name and pin number.

In case different terminal boards are arranged close to each other, the numbers on the ferrules shall contain the terminal board denomination and the terminal number. The ferrules shall be fitted in such a way, that they cannot become detached when the wire is removed from the terminal. All internal wiring shall enter the terminal block from one side only.

The moisture and oil-resisting insulation material shall have a gloss finish.

All wiring used within the equipment control cabinets switchboards, and interposing relay cabinets shall meet the requirements of this Specification.

1c.6 INSTALLATION

1c.6.1 General requirements

The Contractor shall perform all relevant design and dimensioning of the complete cable systems and prepare the cable installation drawings with cable routing, connection diagrams and cable lists, details, etc.

All secondary wiring shall be arranged and protected to prevent damage it by arcing or by mechanical effects.

Power supplies for all control circuits of switchboard mounted devices, all control cabinet mounted devices, VT secondary circuits, and any other individual control circuits shall each be protected and provided with a miniature circuit breaker connected to isolate the devices from power supplies in the tripped or open position. The miniature circuit breakers shall be located within the switchboards or cabinets. Engraves nameplates shall be installed beside each set of the miniature circuit breaker for identification.

Each miniature circuit breaker shall be equipped with two electrically separated normally closed contacts: one for initiating the annunciator on the switchboard panel and the other shall be wired to the CSCS for alarm.

Wiring shall be neatly run, bundled or in rigid PVC wire-ways filled to not more than 70%.

Different functions of service, such as VT and CT circuits, tripping and annunciation shall not be routed in the same cable.

Control cables and high voltage power cables shall not use the same route.

Low voltage power cables and control cables shall be adequately spaced.

The installation of wiring shall take into account stresses due to vibration and the proximity of elements dissipating heat.

The Contractor shall ensure that all cabinets of the same type are wired in an identical manner.

All necessary precautions shall be taken to minimize inductive and capacitive coupling between different types of circuit.

Special precaution shall be taken to ensure, that no magnetic circuit is formed around single-core cables laid in single or trefoil formation, or around any cable liable to carry unbalanced currents.

The wiring shall be laid in ridged plastic ducts with slotted lateral openings. The conductors placed in the ducts shall have sufficient extra length. The fill factor for ducts shall not exceed 70%. The plastic material shall be sturdy and shall allow the ducts to withstand the impact resistance tests on apparatus with a reinforced enclosure. Burning of the plastic material through exposure to flame shall not spread beyond the combustion zone once the flame has been removed.

Splices or tee connections shall not be permitted in control wiring or instrument leads. Terminal blocks shall be used for all terminations

The cut end of cables shall be treated to prevent seepage of water into the cable. When unreeling cable from the cable drums, special care shall be taken to prevent damage to the cables. When moving the cover of the drum, care shall be taken to prevent damage to the cable sheath.

The Contractor shall provide all necessary materials for installation of the cables, such as grounding lead wires, compression type terminals, metal fitting, bolts and nuts including cable identification and felt packing to be inserted between cables and cleats.

Cables installed on cable racks, shall be firmly fixed to the cable rack at suitable intervals by plastic cable ties or equivalent.

All cables shall be provided with cable support.

During installation, care shall be taken not to damage the outer sheath of all wires and cable. Cables damaged during installation shall be repaired or replaced to PEA satisfaction at no additional charge.

1c.6.2 Connections

In low voltage equipment, there are many connections, and faults caused by them play a major part in declining reliability of equipment. For each wire no intermediate connection is allowed between terminal blocks or equipments. It shall therefore be necessary to guarantee reliability of components used and to take care in their installation.

- Crimping

  This type of connection shall be made with specially designed equipment for the type of crimping required.

  Crimping of two conductors in the same cable lug or in the same terminal end shall be prohibited.
- Connection by Coiled Wire (Wire Wrapping).

  This connection technique requires use of a special tool and shall be implemented following good trade practice (choice of post, device, etc.)
- Screw-Type Connection

  The design of the various elements shall guarantee against any accidental unscrewing.

  The tightening of conductors shall guarantee a low contact resistance and secure attachment of the conductor, without damaging it.
- Clip Connection

  The quality of this type of connection depends largely on the quality of the components used; the Contractor shall indicate their characteristics.
- Connection by Connectors

  The connectors installed in humid premises or outdoors shall have the following characteristics:
  - quality and protection of electrical contacts for low currents (gold on nickel),
  - watertight against dripping from whatever direction,
  - withstand to 100% environment (relative humidity),
  - corrosion resistant material ("Marine" bronze).

  The connection of connectors shall be carried out by qualified personnel.

  The guarantee of effective watertightness of the cable-connector assembly shall require the installation on each cable of a heat-shrinking cap, with epoxy resin injection in the hollow parts.

  Each end of conductor of control cable and switchboard wire shall be provided with ring-tongue terminal lug to avoid CT open-circuited due to a loose screw.

1c.6.3 Terminal-Terminal Blocks

All electrical connections from equipment to the outside shall be via terminal blocks. These terminal blocks shall be positioned vertically on both sides of the frame and in the lower part of cubicles or accessories.

The terminals shall be installed on metal "support plates" which serve as both the mount and the securing device of the assembly.

Each bank of terminals shall be blocked off at the each end by a fixed stop.

Terminals with clamping screws in direct contact with the conductor are not acceptable.

Terminal for CT circuit shall be of the short-link type.

Terminals blocks shall be grouped by category:

X1 - For annuciator circuit

X2 - For indicator circuit

X3 - For control and auxiliary relay circuit

X4 - For VT circuit

X5 - For DC auxiliary supply

X6 - For CSCS circuit

X7 - For AC auxiliary supply

X8 - For Capacitor bank

X9 - For CT circuit

For each category, terminal blocks shall be provided with 20% spare terminals.

Insulating barriers shall be provided using separators to avoid any short-circuits. Terminals shall be sized according to the conductors to be connected (8 mm pitch terminals with 4 mm test cells or 6 mm pitch terminals with 2 mm test cells).

Each terminal shall carry a printed letter or number marking. Terminals shall be numbered on the terminal block in chronological order, from left to right and from bottom to top.

Dividers shall be provided to separate incomings. In addition, provision of a side marking shall allow identification of the cable arriving from the outside. Terminal covers with dividers shall be fitted onto power terminal blocks.

1c.6.4 Test Boxes

1c.6.4.1 Verification of Measuring and Protection Devices.

Test block boxes shall be used to verify the essential circuits of protection and metering devices, since they facilitate inspection operations without affecting the safety of the assembly. They shall allow simultaneous measurement of currents and voltages feeding these protection systems and shall cancel all functions, except alarms and indications, during tests.

Protection systems mounted in cubicles shall always be fitted with these boxes to facilitate their testing using suitable testing sets.

These boxes shall always admit a current of 30 A, withstanding over-currents from major faults - over-currents which are fully transmitted by current reducers.

Depending on the complexity of the diagrams or the verifications to be performed, the terminal boxes may correspond either to each set of instrument transformers, or to a measurement unit or specific protection unit.

The various circuits may be tested in operation.

1c.6.4.2 Voltage and Current Test

Boxes used for testing shall be closed by a cover, allowing continuity of the circuits.

These boxes shall not break the circuits when the cover is removed. For CT circuit, short circuit facilities shall be provided.

These boxes shall be flush mounted.

The maximum acceptable intensity shall always be 30 A. The dielectric strength testing voltage shall be 2000 V - 50Hz.

The various elements comprising these boxes shall be protected from environmental factors, in compliance with IEC publication number 60068.

Sockets shall include an orientation pin to avoid any connection errors.

The various position and combination of these pins shall be proposed by the Contractor.

By-pass of the "voltage" circuits on the terminal block shall be possible.

Screw-type connection shall be used.

"Current" circuits shall always be connected using round centrally drilled cable lugs.

1c.6.4.3 Associated Testing Equipment.

The Contractor providing the elements fitted with test boxes shall also provide equipment for testing the circuits.

Connection sockets with leads shall be provided.

1c.6.4.4 Installation.

All the test boxes installed shall be of the same type.

1c.7 CABLE LAYING

The Contractor shall select the most suitable cable routes and raceways, ensuring a minimum of interference with other installations.

Routing shall be as short as possible, and shall pass through reserved areas free of any components, screws and bolts; in the proximity of removable or adjustable elements, wires shall be effectively protected.

As appropriate for the various locations the cables shall be installed in cable ducts, raceways, conduit or tray systems, cable trenches, etc., or laid directly in the ground.

Cables running inside buildings or concrete trenches shall be laid on trays. The trays shall be of adequate strength and size to carry the specified number of cables, provide 25% spare capacity. The design of such trays shall include a safety factor to avoid permanent distortion, when supporting erection staff during cable installation. The trays shall be of suitable aluminium alloys or hot-dip galvanized steel standard materials.

Cable trays shall normally be of the ladder-type consisting of bars with rungs, evenly spaced (maximum 300 mm) according to requirements. Perforated, covered metal trays shall be used in highly polluted or otherwise endangered surroundings. All trays shall be rigidly fixed on supporting steel structures, masonry or galvanized racks. Cable trays arranged one above the other shall be at least 200 mm apart in case of power cables and 150 mm in case of control cables.

Earthing cable of the same size the one used for grounding grid shall be laid along cable tray and fixed as shown on corresponding drawing.

Cables laid on trays or racks shall be properly fixed or clamped. Supports and racks shall be arranged to facilitate removal or replacement of cables.

Cables branched from general raceways and directed to the relevant equipment shall be suitably protected, where required, over their entire lengths by e.g. galvanized steel conduits sealed at their ends against ingress of water. Conduits shall be fixed on steel structures, brickwork or be embedded in concrete floors or walls according to field requirements.

Conduits embedded in concrete or block-work shall be of a suitably rigid PVC-type. Cables laid outdoors, across roads in concrete or foundations shall run in hard PVC plastic pipes buried in ground at a depth of not less than 600 mm or embedded in concrete foundations at suitable depth.

The cross-sectional area of such ducts shall be utilized to 50% only. Pipe ducts shall terminate in concrete draw pits before entering buildings. Draw-pits shall be provided where required to facilitate cable installation.

Cables on brick walls or similar civil structures can be installed in conduits (galvanized steel conduits within the reach of persons or erection/maintenance devices, PVC conduits in other areas) or in pre-fabricated installation channels made of galvanized sheet metal or plastic.

Unarmored cables shall be properly protected against mechanical damage, where leaving ducts or covered trenches and the like.

Fire-partitions shall be provided where cables are passing through different fire zones or where entering cubicles and panels.

Pulling, fixing and terminating of cables shall be strictly in accordance with the manufacturer's instructions, using the recommended tools and appliances.

APPENDIX 5

Generic I/O Requirements for CSCS

Table A-1.1 through A-1.11 list the quantities of I/O points required for each type of substation power device that will be monitored and/or controlled by the CSCS and the DMS. For some devices, the quantify of I/O points varies depending on the substation configuration. In cases where the I/O point count varies with substation configuration, separate I/O point lists are provided for each configuration. Each of these tables contains the following information:

1. Description of each required I/O point
2. Engineering units for analog points
3. English-language descriptor for status and control points
4. Total quantity of each type of point

For ac analog points, the total quantity of points is categorized into normal current inputs (0-1 amp or 0-5 amp), voltage inputs (0-110 V AC) and fault current inputs (if any)

For status inputs, the total quantity of points is categorized as follows:

1. Regular (i.e. not Momentary Change Detect) Status Inputs
    a. Two-state, single-contact inputs (SC-2S)
    b. Two-state, double-contact inputs (DC-2S)
    c. Two-state but slowly change (slow DC-2S)
    d. Three-state Status (DC-3S)
2. Momentary Change Detect (MCD) points
    a. Two-state, single-contact inputs (SC-2S)
    b. Two-state, double-contact inputs (DC-2S)
    c. Three-state Status (DC-3S)

For control points, the total quantity of points is categorized into regular (on/off) control outputs and raise/lower control outputs.

Table A-1.1

I/O POINT COUNTS FOR

22 kV VACUUM CB INDOOR TYPE METAL-CLAD SWITCHGEARS, SINGLE BUS CONFIGURATION

1.1.1 INCOMING LINE

Control Outputs:

	System Bay Name	Point Name		Digital Output	Raise/Lower	Setpoint	Remark
1	22 kV S/S Inc_	_BVB-01 Open Command		1			
2	22 kV S/S Inc_	_BVB-01 Close Command		1			
			Control Output Totals	2	0	0	

Analog Points:

	System Bay Name	Point Name	Units	Type of Analog Input		Remark
				Current	Voltage	
1	22 kV S/S Inc_	Current Phase A	amps	1		
2	22 kV S/S Inc_	Current Phase B	amps	1		
3	22 kV S/S Inc_	Current Phase C	amps	1		
4	22 kV S/S Inc_	Current Harmonic Phase A	amps	--	--	Calculated point for direct ac inputs
5	22 kV S/S Inc_	Current Harmonic Phase B	amps	--	--	Calculated point for direct ac inputs
6	22 kV S/S Inc_	Current Harmonic Phase C	amps	--	--	Calculated point for direct ac inputs
7	22 kV S/S Inc_	Fault Current Phase A	amps	1		
8	22 kV S/S Inc_	Fault Current Phase B	amps	1		
9	22 kV S/S Inc_	Fault Current Phase C	amps	1		
10	22 kV S/S Inc_	Voltage A-B	kV		1	
11	22 kV S/S Inc_	Voltage B-C	kV		1	
12	22 kV S/S Inc_	Voltage C-A	kV		1	
13	22 kV S/S Inc_	Active Power	MW	--	--	Calculated point for direct ac inputs
14	22 kV S/S Inc_	Reactive Power	MVAR	--	--	Calculated point for direct ac inputs
15	22 kV S/S Inc_	Power Factor	%	--	--	Calculated point for direct ac inputs
			Analog Point Totals	6	3	

Status Points:

				Regular Points				MCD Points			
	System Bay Name	Point Name	Descriptor	SC-2S	DC-2S	DC-2S SLOW	DC-3S	SC-2S	DC-2S	DC-3S	Remark
1	22 kV S/S Inc_	O/C Relay Phase A	Trip/Normal	1							
2	22 kV S/S Inc_	O/C Relay Phase B	Trip/Normal	1							
3	22 kV S/S Inc_	O/C Relay Phase C	Trip/Normal	1							
4	22 kV S/S Inc_	E/F Relay	Trip/Normal	1							
5	22 kV S/S Inc_	O/C or E/F Time Delay	Trip/Normal	1							
6	22 kV S/S Inc_	O/C or E/F Inst	Trip/Normal	1							
7	22 kV S/S Inc_	U/F Relay Step 1	Trip/Normal	1							
8	22 kV S/S Inc_	U/F Relay Step 2	Trip/Normal	1							
9	22 kV S/S Inc_	U/F Relay Step 3	Trip/Normal	1							
10	22 kV S/S Inc_	U/F Relay Step 4	Trip/Normal	1							
11	22 kV S/S Inc_	U/F Relay	Enable/Disable		1						
12	22 kV S/S Inc_	Arc Detection System	Operated/Normal	1							
13	22 kV S/S Inc_	MW/MVar Recorder	Fail/Normal	1							
14	22 kV S/S Inc_	Under/Over Voltage	Alarm/Normal	1							
15	22 kV S/S Inc_	_BVB-01 Open/Closed Status	Open/Closed	1							
16	22 kV S/S Inc_	_BVB-01 Time Delay (CB Fail)	Trip/Normal	1							
17	22 kV S/S Inc_	E/F Relay Status	On/Off		1						
18	22 kV S/S Inc_	50 BF Status	On/Off		1						
19	22 kV S/S Inc_	DC-Supply Control Circuit	Fail/Normal	1							
20	22 kV S/S Inc_	_BVB-01 Withdraw. Unit Status	In/Out Service			1					
21	22 kV S/S Inc_	_BVB-01 Trip Ckt.Supervision	Fail/Normal	1							
22	22 kV S/S Inc_	_BVB-01 Spring Charge	Fail/Normal	1							
23	22 kV S/S Inc_	_BVB-01 LV. Connector Pulled	Alarm/Normal	1							
24	22 kV S/S Inc_	_BVB-01 Control Set on	Local/Remote		1						
25	22 kV S/S Inc_	_BVG-01 Open/Closed Status	Open/Closed		1						
			Status Point Totals	19	5	1	0	0	0	0	

Table A-1.1

I/O POINT COUNTS FOR

22 kV VACUUM CB INDOOR TYPE METAL-CLAD SWITCHGEARS, SINGLE BUS CONFIGURATION

1.1.2 OUTGOING LINE

Control Outputs:

	System Bay Name	Point Name		Digital Output	Raise/Lower	Setpoint	Remark
1	22 kV S/S Out_	_VB-01 Open Command		1			
2	22 kV S/S Out_	_VB-01 Close Command		1			
3	22 kV S/S Out_	Auto Reclosing ON Command		1			
4	22 kV S/S Out_	Auto Reclosing OFF Command		1			
			Control Output Totals	4	0	0	

Analog Points:

	System Bay Name	Point Name	Units	Type of Analog Input		Remark
				Current	Voltage	
1	22 kV S/S Out_	Current Phase A	amps	1		
2	22 kV S/S Out_	Current Phase B	amps	1		
3	22 kV S/S Out_	Current Phase C	amps	1		
4	22 kV S/S Out_	Current Harmonic Phase A	amps	--	--	Calculated point for direct ac inputs
5	22 kV S/S Out_	Current Harmonic Phase B	amps	--	--	Calculated point for direct ac inputs
6	22 kV S/S Out_	Current Harmonic Phase C	amps	--	--	Calculated point for direct ac inputs
7	22 kV S/S Out_	Fault Current Phase A	amps	1		
8	22 kV S/S Out_	Fault Current Phase B	amps	1		
9	22 kV S/S Out_	Fault Current Phase C	amps	1		
10	22 kV S/S Out_	Active Power	MW	--	--	Calculated point for direct ac inputs
11	22 kV S/S Out_	Reactive Power	Mvar	--	--	Calculated point for direct ac inputs
12	22 kV S/S Out_	Power Factor	%	--	--	Calculated point for direct ac inputs
			Analog Point Totals	6	0	

Status Points:

	System Bay Name	Point Name	Descriptor	Regular Points				MCD Points			Remark
				SC-2S	DC-2S	DC-2S SLOW	DC-3S	SC-2S	DC-2S	DC-3S	
1	22 kV S/S Out_	O/C Relay Phase A	Trip/Normal					1			
2	22 kV S/S Out_	O/C Relay Phase B	Trip/Normal					1			
3	22 kV S/S Out_	O/C Relay Phase C	Trip/Normal					1			
4	22 kV S/S Out_	E/F Relay	Trip/Normal					1			
5	22 kV S/S Out_	O/C or E/F Time Delay	Trip/Normal					1			
6	22 kV S/S Out_	O/C or E/F Inst	Trip/Normal	1							
7	22 kV S/S Out_	U/F Relay Step 1	Trip/Normal	1							
8	22 kV S/S Out_	U/F Relay Step 2	Trip/Normal	1							
9	22 kV S/S Out_	U/F Relay Step 3	Trip/Normal	1							
10	22 kV S/S Out_	U/F Relay Step 4	Trip/Normal	1							
11	22 kV S/S Out_	U/F Relay Trip Selection	Off, On1, On2, On3, On4, On5				1*				* DC-6S
12	22 kV S/S Out_	Auto Recl On/Off Status	On/Off		1						
13	22 kV S/S Out_	Auto Recl In Progress Status	InProgress/Normal					1			
14	22 kV S/S Out_	Auto Recl Lock Out Status	Lockout/Normal	1							
15	22 kV S/S Out_	Arc Detection System	Operated/Normal	1							
16	22 kV S/S Out_	_VB-01 Open/Closed Status	Open/Closed						1		
17	22 kV S/S Out_	_VB-01 Withdraw. Unit Status	In/Out Service			1					
18	22 kV S/S Out_	_BVB-01 Time Delay (CB Fail)	Trip/Normal	1							
19	22 kV S/S Out_	E/F Relay Status	On/Off		1						
20	22 kV S/S Out_	50 BF Status	On/Off		1						
21	22 kV S/S Out_	DC-Supply Control Circuit	Fail/Normal	1							
22	22 kV S/S Out_	_VB-01 Trip Ckt.Supervision	Fail/Normal	1							
23	22 kV S/S Out_	_VB-01 Spring Charge	Fail/Normal	1							
24	22 kV S/S Out_	_VB-01 LV. Connector Pulled	Alarm/Norm	1							
25	22 kV S/S Out_	_VB-01 Control Set on	Local/Remote		1						
26	22 kV S/S Out_	_VG-01 Open/Closed Status	Open/Closed		1						
			Status Point Totals	12	5	1	1	6	1	0	

Table A-1.1

I/O POINT COUNTS FOR

22 kV VACUUM CB INDOOR TYPE METAL-CLAD SWITCHGEARS, SINGLE BUS CONFIGURATION

1.1.3 BUS SECTION

Control Outputs:

	System Bay Name	Point Name		Digital Output	Raise/Lower	Setpoint	Remark
1	22 kV S/S BS__	BVB-_ Open Command		1			
2	22 kV S/S BS__	BVB-_ Close Command		1			
			Control Output Totals	2	0	0	

Analog Points:

	System Bay Name	Point Name	Units	Type of Analog Input		Remark
				Current	Voltage	
1	22 kV S/S BS__	Current Phase A	amps	1		
2	22 kV S/S BS__	Current Phase B	amps	1		
3	22 kV S/S BS__	Current Phase C	amps	1		
4	22 kV S/S BS__	Fault Current Phase A	amps	1		
5	22 kV S/S BS__	Fault Current Phase B	amps	1		
6	22 kV S/S BS__	Fault Current Phase C	amps	1		
			Analog Point Totals	6	0	

Status Points:

				Regular Points				MCD Points			
	System Bay Name	Point Name	Descriptor	SC-2S	DC-2S	DC-2S SLOW	DC-3S	SC-2S	DC-2S	DC-3S	Remark
1	22 kV S/S BS__	O/C Relay Phase A	Trip/Normal	1							
2	22 kV S/S BS__	O/C Relay Phase B	Trip/Normal	1							
3	22 kV S/S BS__	O/C Relay Phase C	Trip/Normal	1							
4	22 kV S/S BS__	E/F Relay	Trip/Normal	1							
5	22 kV S/S BS__	O/C or E/F Time Delay	Trip/Normal	1							
6	22 kV S/S BS__	O/C or E/F Inst	Trip/Normal	1							
7	22 kV S/S BS__	BVB-_ Open/Closed Status	Open/Closed		1						
8	22 kV S/S BS__	BVB-_ Withdraw. Unit Status	In/Out Service			1					
9	22 kV S/S BS__	_BVB-01 Time Delay (CB Fail)	Trip/Normal	1							
10	22 kV S/S BS__	E/F Relay Status	On/Off		1						
11	22 kV S/S BS__	50 BF Status	On/Off		1						
12	22 kV S/S BS__	DC-Supply Control Circuit	Fail/Normal	1							
13	22 kV S/S BS__	Arc Detection System	Operated/Normal	1							
14	22 kV S/S BS__	BVB-_ Trip Ckt.Supervision	Fail/Normal	1							
15	22 kV S/S BS__	BVB-_ Spring Charge	Fail/Normal	1							
16	22 kV S/S BS__	BVB-_ LV. Connector Pulled	Alarm/Normal	1							
17	22 kV S/S BS__	BVB-_ Control Set on	Local/Remote		1						
			Status Point Totals	12	4	1	0	0	0	0	

Table A-1.1

I/O POINT COUNTS FOR

22 kV VACUUM CB INDOOR TYPE METAL-CLAD SWITCHGEARS, SINGLE BUS CONFIGURATION

1.1.4 BUS VT

Analog Points:

	System Bay Name	Point Name	Units	Type of Analog Input		Remark
				Current	Voltage	
1	22 kV S/S BUS No._	Voltage A-B	kV		1	
2	22 kV S/S BUS No._	Voltage B-C	kV		1	
3	22 kV S/S BUS No._	Voltage C-A	kV		1	
4	22 kV S/S BUS No._	Voltage Harmonic A	kV	--	--	Calculated point for direct ac inputs
5	22 kV S/S BUS No._	Voltage Harmonic B	kV	--	--	Calculated point for direct ac inputs
6	22 kV S/S BUS No._	Voltage Harmonic C	kV	--	--	Calculated point for direct ac inputs
			Analog Point Totals	0	3	

Table A-1.1

I/O POINT COUNTS FOR

22 kV VACUUM CB INDOOR TYPE METAL-CLAD SWITCHGEARS, SINGLE BUS CONFIGURATION

1.1.5 STATION SERVICE TRANSFORMER

Status Points:

	System Bay Name	Point Name	Descriptor	Regular Points				MCD Points			Remark
				SC-2S	DC-2S	DC-2S SLOW	DC-3S	SC-2S	DC-2S	DC-3S	
1	22 kV S/S TS_	T_VS-01 Status	Open/Closed		1						
2	22 kV S/S TS_	T_VS-01 Withdraw Status	In/Out Service			1					
3	22 kV S/S TS_	HRC 01 Fuse	Alarm/Normal	1							
4	22 kV S/S TS_	T_VG-01 Open/Closed Status	Closed/Open		1						
			Status Point Totals	1	2	1	0	0	0	0	

Table A-1.1

I/O POINT COUNTS FOR

22 kV VACUUM CB INDOOR TYPE METAL-CLAD SWITCHGEARS, SINGLE BUS CONFIGURATION

1.1.6 CAPACITOR BANK

Control Outputs:

	System Bay Name	Point Name	Digital Output	Raise/Lower	Setpoint	Remark
1	22 kV S/S C1_	_CVB-01 Open Command	1			
2	22 kV S/S C1_	_CVB-01 Close Command	1			
3	22 kV S/S C1_	Cap Bank on Auto	1			
4	22 kV S/S C1_	Cap Bank on Manual	1			
5	22 kV S/S C1_	Step 1 On Command	1			
6	22 kV S/S C1_	Step 1 Off Command	1			
7	22 kV S/S C1_	Step 2 On Command	1			
8	22 kV S/S C1_	Step 2 Off Command	1			
9	22 kV S/S C1_	Step 3 On Command	1			
10	22 kV S/S C1_	Step 3 Off Command	1			
		Control Output Totals	10	0	0	

Analog Points:

	System Bay Name	Point Name	Units	Type of Analog Input		Remark
				Current	Voltage	
1	22 kV S/S C1_	Current Phase A	amps	1		
2	22 kV S/S C1_	Current Phase B	amps	1		
3	22 kV S/S C1_	Current Phase C	amps	1		
4	22 kV S/S C1_	Fault Current Phase A	amps	1		
5	22 kV S/S C1_	Fault Current Phase B	amps	1		
6	22 kV S/S C1_	Fault Current Phase C	amps	1		
7	22 kV S/S C1_	Reactive Power	Mvar	--	--	Calculated point for direct ac inputs
			Analog Point Totals	6	0	

Status Points:

	System Bay Name	Point Name	Descriptor	Regular Points SC-2S	DC-2S	DC-2S SLOW	DC-3S	MCD Points SC-2S	DC-2S	DC-3S	Remark
1	22 kV S/S C1_	O/C Relay Phase A	Trip/Normal	1							
2	22 kV S/S C1_	O/C Relay Phase B	Trip/Normal	1							
3	22 kV S/S C1_	O/C Relay Phase C	Trip/Normal	1							
4	22 kV S/S C1_	E/F Relay	Trip/Normal	1							
5	22 kV S/S C1_	O/C or E/F Time Delay	Trip/Normal	1							
6	22 kV S/S C1_	O/C or E/F Instantaneous	Trip/Normal	1							
7	22 kV S/S C1_	DC Supply Control Circuit	Fail/Normal	1							
8	22 kV S/S C1_	Step 1 On/Off Status	On/Off		1						
9	22 kV S/S C1_	Step 2 On/Off Status	On/Off		1						
10	22 kV S/S C1_	Step 3 On/Off Status	On/Off		1						
11	22 kV S/S C1_	Arc Detection System	Operated/Normal	1							
12	22 kV S/S C1_	_CVB-01 Open/Closed Status	Open/Closed		1						
13	22 kV S/S C1_	_CVB-01 Withdraw Unit Stat	In/Out Service			1					
14	22 kV S/S C1_	_CVB-01 Time Delay (CB Fail)	Trip/Normal	1							
15	22 kV S/S C1_	50 BF Status	On/Off		1						
16	22 kV S/S C1_	_CVB-01 Trip Ckt.Supervision	Fail/Normal	1							
17	22 kV S/S C1_	_CVB-01 Spring Charge	Fail/Normal	1							
18	22 kV S/S C1_	_CVB-01 LV. Connector. Pulled	Alarm/Normal	1							
19	22 kV S/S C1_	_CVB-01 Control set on	Local/Remote		1						
20	22 kV S/S C1_	_CVG-01 Open/Closed Status	Open/Closed		1						
21	22 kV S/S C1_	Auto/Manual Control Switch	Auto/Manual		1						
22	22 kV S/S C1_	Step 1 Unbalance Relay	Operated/Normal	1							
23	22 kV S/S C1_	Step 2 Unbalance Relay	Operated/Normal	1							
24	22 kV S/S C1_	Step 3 Unbalance Relay	Operated/Normal	1							

Status Points (Cont.):

				Regular Points				MCD Points			
	System Bay Name	Point Name	Descriptor	SC-2S	DC-2S	DC-2S SLOW	DC-3S	SC-2S	DC-2S	DC-3S	Remark
25	22 kV S/S C1_	Step 1 Overvoltage Relay	Trip/Normal	1							Operated by Overvoltage
26	22 kV S/S C1_	Step 2 Overvoltage Relay	Trip/Normal	1							relay connected with the
27	22 kV S/S C1_	Step 3 Overvoltage Relay	Trip/Normal	1							SWGR bus to trip and
28	22 kV S/S C1_	Internal fault of VCB 1	Operated/Normal	1							lockout all vacuum switches
29	22 kV S/S C1_	Internal fault of VCB 2	Operated/Normal	1							or SF 6 breakers of each
30	22 kV S/S C1_	Internal fault of VCB 3	Operated/Normal	1							capacitor bank
31	22 kV S/S C1_	Step 1 DC supply control circuit	Fail/Normal	1							
32	22 kV S/S C1_	Step 2 DC supply control circuit	Fail/Normal	1							
33	22 kV S/S C1_	Step 3 DC supply control circuit	Fail/Normal	1							
			Status Point Totals	24	8	1	0	0	0	0	

APPENDIX 6

22 kV Switchgear Bill of Material (BOM)

Item	Description	Unit(s)	Type/ Model	Manufacturer/ Country	Quantities(Each cubicle)							
					I	O	C	BS	SST/LB	SST/CB	BR	VT(If any)
1.	Cubicle	Set(s)			1	1	1	1	1	1	1	1
2.	Busbar	Lot(s)			1	1	1	1	1	1	1	1
3.	Busbar Support	Lot(s)			1	1	1	1	1	1	1	1
4.	3 Phase 22 (33) kV Power Cable Connections	Circuit(s)			2	2	2	-	2	2	-	-
5.	3 Phase Bushing Spouse	Set(s)			2	2	2	2	2	2	-	1
6.	3 Phase Capacitive Voltage Detector (CVD)	Set(s)			1	1	1	-	1	1	-	-
7.	3 Phase Indicating Lamp For CVD	Set(s)			1	1	1	-	1	1	-	-
8.	3 Phase Vacuum Circuit Breaker (VCB)	Set(s)			1	1	1	1	-	1	-	-
9.	VCB Auxiliary Contact	Lot(s)			1	1	1	1	-	1	-	-
10.	VCB Truck or Rack Status Auxiliary Contact	Lot(s)			1	1	1	1	-	1	-	-
11.	VCB Operation Counter	Set(s)			1	1	1	1	-	1	-	-
12.	VCB Operating Mechanism	Set(s)			1	1	1	1	-	1	-	-
13.	VCB Tripping Coil	Set(s)			1	1	1	1	-	1	-	-
14.	VCB Closing Coil	Set(s)			1	1	1	1	-	1	-	-
15.	VCB Anti Pumping Circuits	Set(s)			1	1	1	1	-	1	-	-
16.	VCB Plug In Auxiliary Contact (If any)	Lot(s)			1	1	1	1	-	1	-	-
17.	3 Phase Load Break Switch (LBS)	Set(s)			-	-	-	-	1	-	-	-
18.	LBS Auxiliary Contact	Lot(s)			-	-	-	-	1	-	-	-
19.	LBS Truck or Rack Status Auxiliary Contact	Lot(s)			-	-	-	-	1	-	-	-
20.	LBS Operation Counter	Set(s)			-	-	-	-	1	-	-	-
21.	LBS Operating Mechanism	Set(s)			-	-	-	-	1	-	-	-
22.	3 Phase HRC Fuse with fuse holder	Set(s)			-	-	-	1(if any)	1	-	1(if any)	1
23.	3 Phase Earthing Switch	Set(s)			1	1	1	-	1	1	-	-
24.	Earthing Switch Auxiliary Contact	Lot(s)			1	1	1	-	1	1	-	-
25.	Earthing Busbar	Lot(s)			1	1	1	1	1	1	1	1
26.	3 Phase Three Position Switch (GIS only)	Set(s)			1	1	1	1	1	1	-	1
27.	Three Position Switch Auxiliary Contact (GIS Only)	Lot(s)			1	1	1	1	1	1	-	1
28.	Current transformer	Set(s)			3	3	3	3	-	3	-	-
29.	Voltage transformer	Set(s)			3(if any)	-	-	3(if any)	-	-	3(if any)	3
30.	Feeder Protection Relay (50/51), (50/51)N, 79, 50BF, 95	Set(s)			1	1	1	1	-	1	-	-
31.	Under Frequency, Under & Over Voltage Relay (81U), (27), (59)	Set(s)			-	-	-	1	-	-	1	-
32.	Aux. Trip and Lock Out Relay (86BF)	Set(s)			1	1	1	1	-	1	-	-
33.	Aux. Trip and Lock Out Relay (86T), (If any)	Set(s)			1	-	-	-	-	-	-	-
34.	Aux. Trip and Lock Out Relay (86ARC) (AIS Only)	Set(s)			1	1	1	1	-	1	-	-
35.	DC Under Voltage Relay (27X)	Set(s)			1	1	1	1	-	1	-	-
36.	Latching Relay for Auto Recloser On/Off	Set(s)			-	1	-	-	-	-	-	-
37.	Timer Relay For Spring Charge Fail	Set(s)			1	1	1	1	-	1	-	-
38.	Mechanical Latching Relay for extension Primary equipment's Auxiliary contact with coil cut-off contacts (if any)	Lot(s)			1	1	1	1	1	1		

Item	Description	Unit(s)	Type/	Manufacturer/	Quantities(Each cubicle)							
			Model	Country	I	O	C	BS	SST/LB	SST/CB	BR	VT(If any)
39.	Auxiliary Latching Relay	Lot(s)			1	1	1	1	1	1	1	1
40.	Auxiliary Control Relay	Lot(s)			1	1	1	1	1	1	1	1
41.	Arc Detection Monitor (AIS Only)	Lot(s)			1	1	1	1	1	1	1	1
42.	Arc Detection Sensor (AIS Only)	Lot(s)			1	1	1	1	1	1	1	1
43.	Current Sensing Unit For Arc Detection (AIS Only)	Set(s)			1	-	-	-	-	-	-	-
44.	Relay Test Block (1 set = 14 contacts)	Set(s)			1	1	1	2	-	1	1	-
45.	3 Phase Digital Multi Meter (If any)	Set(s)			1	1	1	1	-	-	-	-
46.	3 Phase Current Transformer (If any)	Set(s)			1	1	1	1	-	-	-	-
47.	3 Phase Voltage Transducer (If any)	Set(s)			1	-	-	1	-	-	1	3
48.	Watt Transducer (If any)	Set(s)			1	1	1	1	-	-	-	-
49.	VAR Transducer (If any)	Set(s)			1	1	1	1	-	-	-	-
50.	Recorder (If any)	Set(s)			2	1	1	1	-	-	-	1
51.	Metering Test Block	Set(s)			1	1	1	1	-	-	-	1
52.	MCB with auxiliary contact with 2NC	Lot(s)			1	1	1	1	1	1	1	1
53.	Fuse with fuse holder (If any)	Lot(s)			1	1	1	1	1	1	1	1
54.	Earthing Switch Semaphore	Set(s)			1	1	1	-	1	1	-	-
55.	VCB and LBS Truck or Rack Status Semaphore	Set(s)			1	1	1	1	1	1	-	-
56.	LBS status Indicator Semaphore	Set(s)			-	-	-	-	1	-	-	-
57.	LED Indicating Lamp	Lot(s)			1	1	1	1	1	1	1	1
58.	Mimic Diagrams	Lot(s)			1	1	1	1	1	1	1	1
59.	LED Line Lamp (Rectangular shape)	Set(s)			1	-	-	1	-	-	1	-
60.	Annunciator & Windows/Alarm point LED	Set(s)			1	1	1	1	-	1	1	-
61.	Horn relay	Set(s)			1	1	1	1	-	1	1	-
62.	Alarm horn (Siren)	Set(s)			-	-	-	1	-	-	-	-
63.	Horn Cut Off Switch	Set(s)			-	-	-	1	-	-	-	-
64.	Alarm Horn Cut Off Time Relay	Set(s)			-	-	-	1	-	-	-	-
65.	Push Button (If any)	Lot(s)			1	1	1	1	1	1	1	1
66.	Discrepancy Switch	Set(s)			1	1	1	1	-	1	-	-
67.	Remote/Local Selector Switch	Set(s)			1	1	1	1	-	1	-	-
68.	Auto Reclose On/Off Switch (79CO)	Set(s)			-	1	-	-	-	-	-	-
69.	CB Failure Cut Off Switch (50BF-CO)	Set(s)			1	1	1	1	-	1	-	-
70.	Under Frequency Selector Switch 5 position	Set(s)			-	1	-	-	-	-	-	-
71.	Under Frequency Cut Off Switch	Set(s)			1	-	-	-	-	-	-	-
72.	Set of Interlock (If any)	Set(s)			1	1	1	1	1	1	-	-
73.	Wire way	Lot(s)			1	1	1	1	1	1	1	1
74.	Wire marking for internal wiring	Lot(s)			1	1	1	1	1	1	1	1
75.	DIM (RTU for CSCS) (If nay)	Lot(s)			1	1	1	1	1	1	1	1
76.	Heater for high voltage compartments	Set(s)			3	3	3	3	3	3	3	3
77.	Thermostat or Heater Control Set	Set(s)			1	1	1	1	1	1	1	1
78.	Heater Control Switch Off-Auto-Manual	Set(s)			1	1	1	1	1	1	1	1
79.	Door Switch off Limit Switch	Set(s)			1	1	1	1	1	1	1	1
80.	Service Lighting (Fluorescent Lamp)	Lot(s)			1	1	1	1	1	1	1	1
81.	Terminal for CT Circuit internal wiring	Lot(s)			1	1	1	1	-	1	-	-
82.	Terminal for VT Circuit internal wiring	Lot(s)			1	1	1	1	1	1	1	1
83.	Terminal for Control Circuit internal wiring	Lot(s)			1	1	1	1	1	1	1	1

Item	Description	Unit(s)	Type/ Model	Manufacturer/ Country	Quantities(Each cubicle)							
					I	O	C	BS	SST/LB	SST/CB	BR	VT(If any)
84.	Terminal for CSCS internal wiring	Lot(s)			1	1	1	1	1	1	1	1
85.	Terminal Lug for internal wiring	Lot(s)			1	1	1	1	1	1	1	1
86.	CT Circuit Cable for internal wiring	Lot(s)			1	1	1	1	-	1	-	-
87.	VT Circuit Cable for internal wiring	Lot(s)			1	1	1	1	1	1	1	1
88.	CSCS Circuit Cable for internal wiring	Lot(s)			1	1	1	1	1	1	1	1
89.	Control Cable for internal wiring	Lot(s)			1	1	1	1	1	1	1	1
90.	Control Cable Support for internal wiring	Lot(s)			1	1	1	1	1	1	1	1
91.	Other Accessories to full function	Lot(s)			1	1	1	1	1	1	1	1

Note : ถ้าหน่วยจำนวนของอุปกรณ์ที่แสดงในตารางกำหนดเป็น Lot(s) หมายถึง จำนวนอุปกรณ์ที่จะใช้งาน ขึ้นอยู่กับการออกแบบใช้งานจริง

I = Incoming cubicle

O = Outgoing cubicle

BS = Bus section cubicle

SST/LB = Station service transformer cubicle with load break switch and HRC fuses

SST/CB = Station service transformer cubicle with vacuum circuit breaker

BR = Bus riser cubicle

VT = VT cubicle

APPENDIX 7

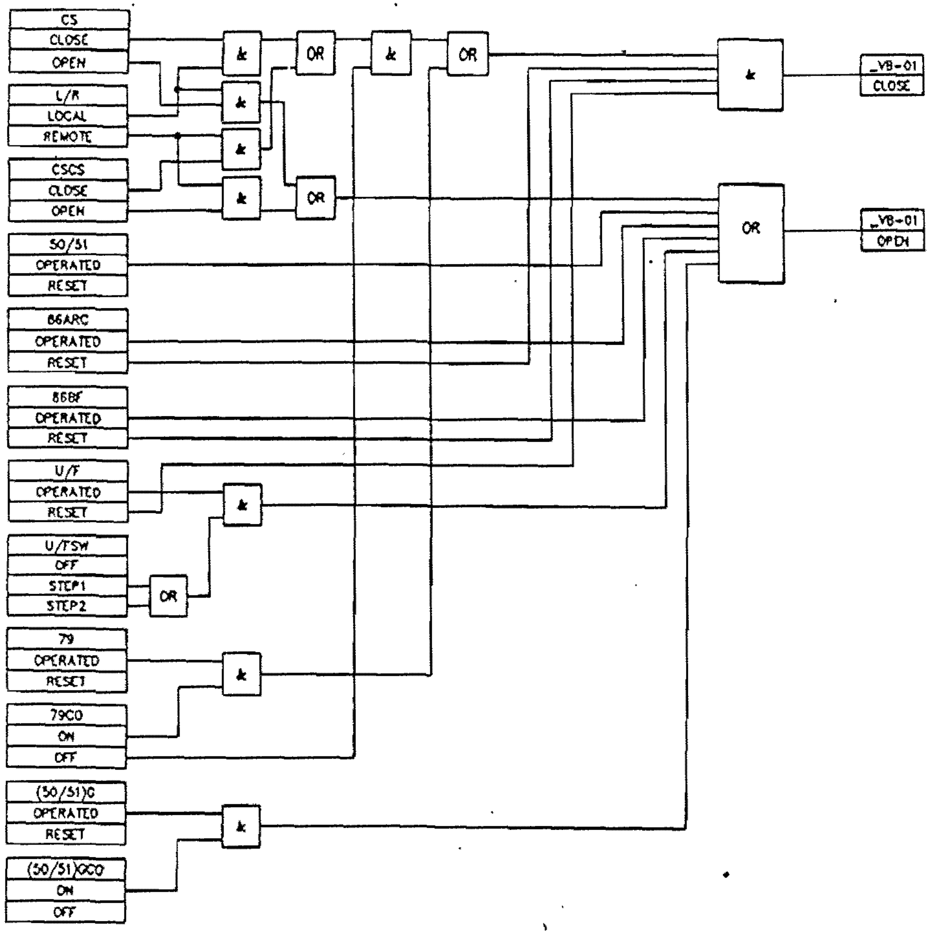
TYPICAL DESIGN CONTROL AND INTERLOCKING FUNCTION

- 22 kV AIR INSULATED SWITCHGEAR

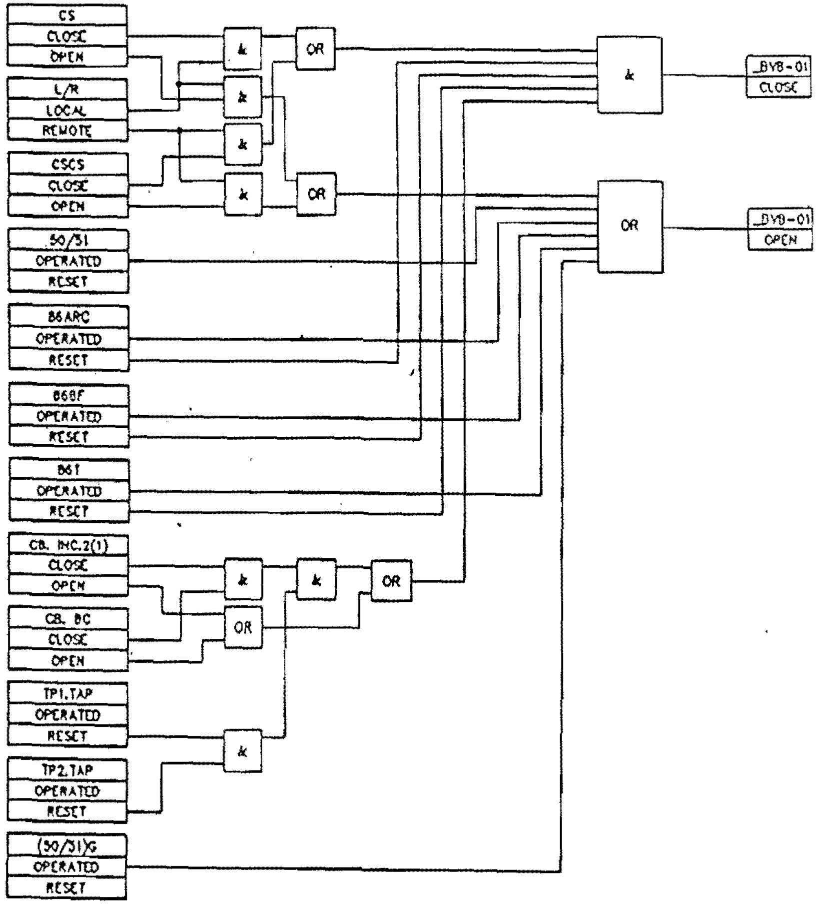
DWG. NO. PEA/ID.22&33-01 SHEETS 1, 2 AND 3 OF 3

- 22 & 33 kV SF6 GAS INSULATED SWITCHGEAR

DWG. NO. PEA/ID.22&33-02 SHEETS 1, 2 AND 3 OF 3



LOGIC DIAGRAM FOR OUTGOING PANEL CIRCUIT BREAKER



LOGIC DIAGRAM FOR INCOMING 1 (2) PANEL CIRCUIT BREAKER

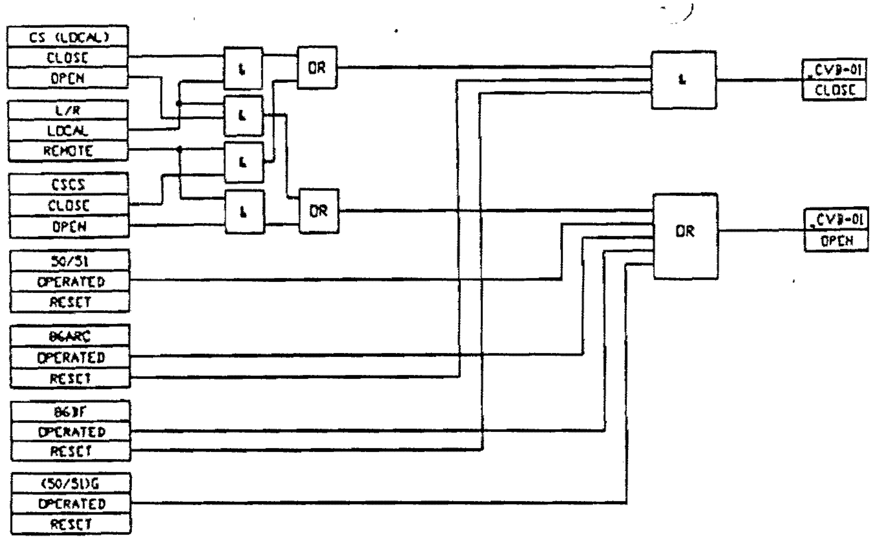
NOTE: AUTO RECLOSE RELAY (79) WILL BE INITIATED BY 51 OR 51G OPERATED

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
79	AUTO RECLOSE RELAY	PB	PUSH BUTTON SWITCH
79CO	AUTO RECLOSE ON/OFF SWITCH	CB.INC.1	CIRCUIT BREAKER INCOMING.1
50/51	PHASE OVER CURRENT RELAY	CB.INC.2	CIRCUIT BREAKER INCOMING.2
(50/51)G	GROUND OVER CURRENT OR EARTH FAULT RELAY	CB.BC	CIRCUIT BREAKER BUSCOUPLER
(50/51)GCO	GROUND OVER CURRENT OR EARTH FAULT ON/OFF SWITCH	CB	CIRCUIT BREAKER
86BF	BREAKER FAILURE AUXILIARY TRIPPING AND LOCKOUT	T/R	CIRCUIT BREAKER TRUCK OR RACK
86ARC	ARC DETECTION AUXILIARY TRIPPING AND LOCKOUT	TP1	POWER TRANSFORMER TP.1
86T	TRANSFORMER DIFF. AUXILIARY TRIPPING AND LOCKOUT	TP2	POWER TRANSFORMER TP.2
U/F	UNDER FREQUENCY RELAY	DS	115 kV DISCONNECTING SWITCH
U/FSW	UNDER FREQUENCY SELECTOR SWITCH	ES	EARTHING SWITCH
L/R	LOCAL/REMOTE SELECTOR SWITCH	LBSW	LOAD BREAK SWITCH
M/R	MAINTENANCE/REMOTE SELECTOR SWITCH	MAN	MECHANICAL MANUAL OPERATE
CS	DISCREPANCY CONTROL SWITCH		

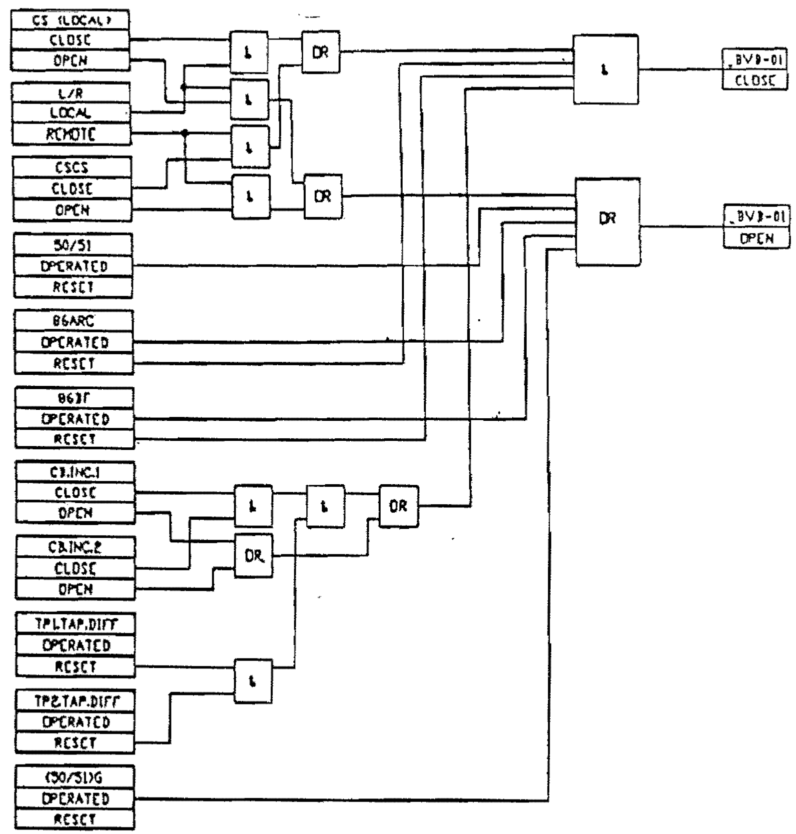
KEY TO SYMBOLS

1) OR - OR GATE
2) & - AND GATE
3) - DEVICE
4) - INPUT

กองอุปกรณ์ป้องกันและรีเลย์	การไฟฟ้าส่วนภูมิภาค	ใช้แทนแบบ ....
ผู้เขียน ..... ผู้สำรวจ ..... วิศวกร ..... หัวหน้าแผนก ..... ผู้อำนวยการกอง ..... ผู้อำนวยการฝ่าย	ผู้ว่าการ	ถูกแทนโดยแบบ .... เขียนเสร็จวันที่ 24/03/1999 แก้แบบวันที่ 24/03/1999 มาตราส่วน ....
รองผู้ว่าการฝ่ายเทคนิค	TYPICAL DESIGN CONTROL AND INTERLOCKING FUNCTION 22 KV AIR INSULATED SWITCHGEAR	DWG.NO. .... SHEET 1 of 3



LOGIC DIAGRAM FOR CAPACITIVE PANEL CIRCUIT BREAKER



LOGIC DIAGRAM FOR BUSCOUPLER PANEL CIRCUIT BREAKER

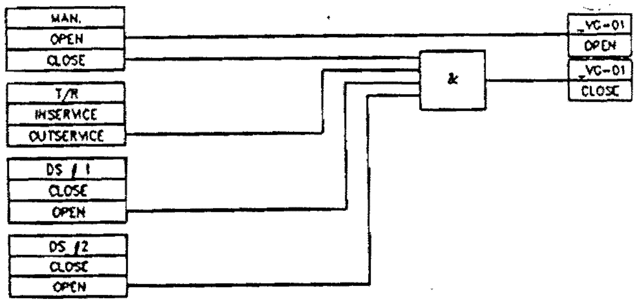
NOTE: AUTO RECLOSE RELAY (79) WILL BE INITIATED BY 51 OR 51G OPERATED

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
79	AUTO RECLOSE RELAY	PB	PUSH BUTTON SWITCH
79CO	AUTO RECLOSE ON/OFF SWITCH	CB.INC.1	CIRCUIT BREAKER INCOMING.1
50/51	PHASE OVER CURRENT RELAY	CB.INC.2	CIRCUIT BREAKER INCOMING.2
(50/51)G	GROUND OVER CURRENT OR EARTH FAULT RELAY	CB.BC	CIRCUIT BREAKER BUSCOUPLER
(50/51)GCO	GROUND OVER CURRENT OR EARTH FAULT ON/OFF SWITCH	CB	CIRCUIT BREAKER
86BF	BREAKER FAILURE AUXILIARY TRIPPING AND LOCKOUT	T/R	CIRCUIT BREAKER TRUCK OR RACK
86ARC	ARC DETECTION AUXILIARY TRIPPING AND LOCKOUT	TP1	POWER TRANSFORMER TP.1
86T	TRANSFORMER DIFF. AUXILIARY TRIPPING AND LOCKOUT	TP2	POWER TRANSFORMER TP.2
U/F	UNDER FREQUENCY RELAY	DS	115 KV DISCONNECTING SWITCH
U/FSV	UNDER FREQUENCY SELECTOR SWITCH	ES	EARTHING SWITCH
L/R	LOCAL/REMOTE SELECTOR SWITCH	LBSV	LOAD BREAK SWITCH
M/R	MAINTENANCE/REMOTE SELECTOR SWITCH	MAN	MECHANICAL MANUAL OPERATE
CS	DISCREPANCY CONTROL SWITCH		

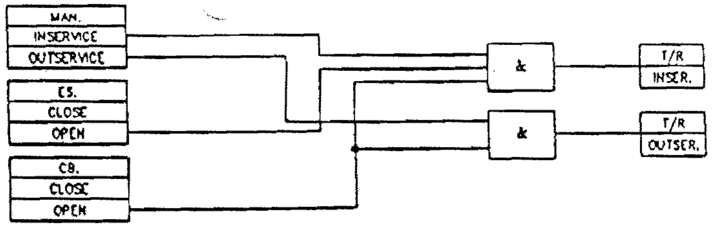
KEY TO SYMBOLS

1) OR - OR GATE
2) & - AND GATE
3) - DEVICE
4) - INPUT

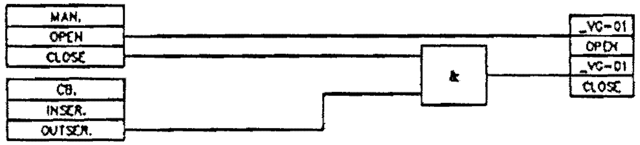
กองอุปกรณ์ป้องกันและรีเลย์	การไฟฟ้าส่วนภูมิภาค	ใช้แทนแบบ .... ถูกแทนโดยแบบ .... เขียนเสร็จวันที่ 24/03/1998 แก้แบบวันที่ 24/03/1998 มิติเป็น .... มาตราส่วน ....
ผู้เขียน ....มีขวัญ.... ผู้สำรวจ .... วิศวกร ....มีขวัญ.... หัวหน้าแผนก .... ผู้อำนวยการกอง .... ผู้อำนวยการฝ่าย	ผู้ว่าการ .... มาตรฐานการออกแบบ ระบบควบคุม และ ระบบป้องกันการทำงานผิดขั้นตอน ระบบตัดตอนระดับแรงดัน 22 กิโลโวลต์ ฉนวนอากาศ	
รองผู้ว่าการฝ่ายเทคนิค	TYPICAL DESIGN CONTROL AND INTERLOCKING FUNCTION 22 KV AIR INSULATED SWITCHGEAR	DWG.NO.PEA/ID.22A33/01 SHEET 2 of 3



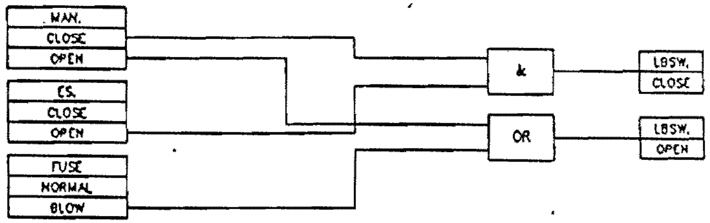
LOGIC DIAGRAM FOR INCOMING PANEL EARTHING SWITCH



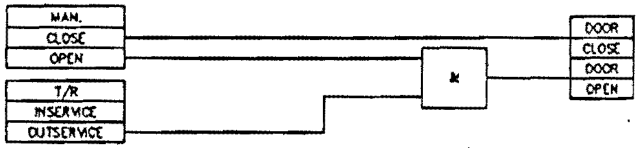
LOGIC DIAGRAM FOR EVERY PANEL TRUCK/RACK OF CIRCUIT BREAKER



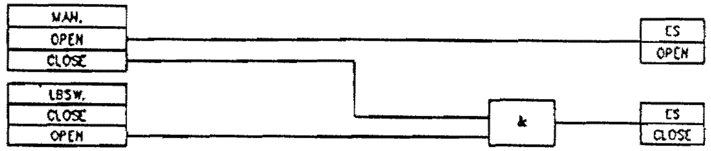
LOGIC DIAGRAM FOR OUTGOING PANEL EARTHING SWITCH



LOGIC DIAGRAM FOR STATION SERVICE TRANSFORMER PANEL LOAD BREAK SWITCH



LOGIC DIAGRAM FOR DOOR OF SWITCHING DEVICE COMPARTMENT



LOGIC DIAGRAM FOR STATION SERVICE TRANSFORMER PANEL EARTHING SWITCH

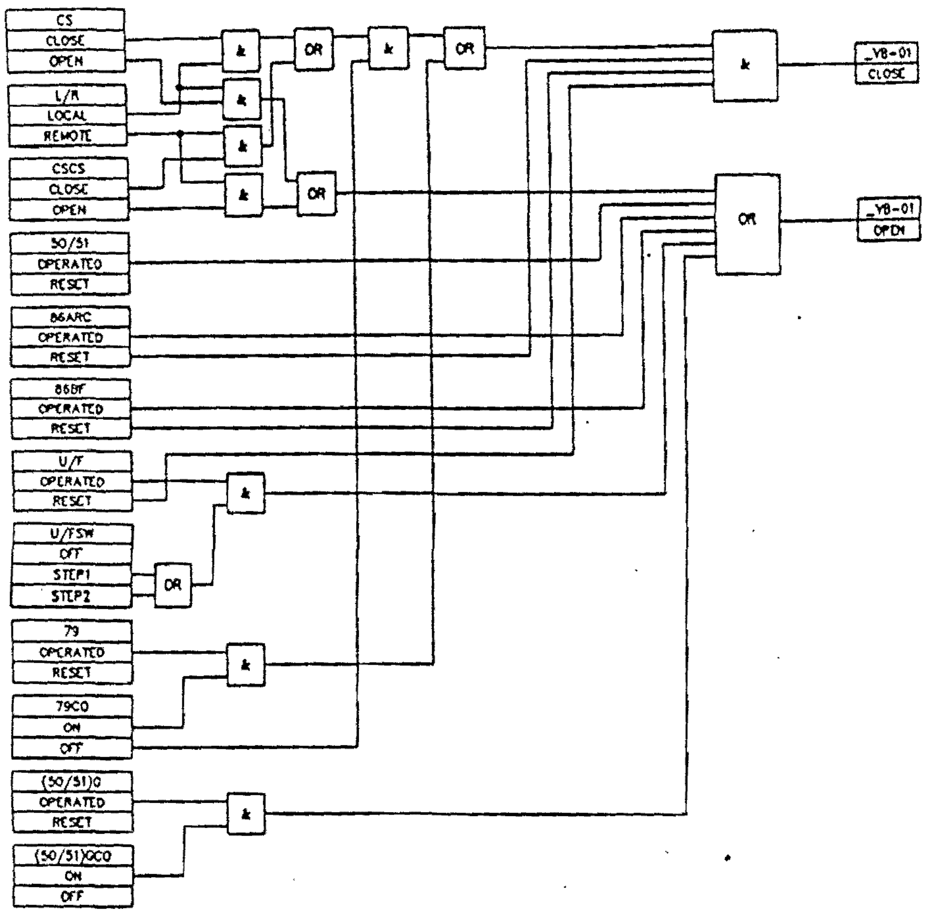
NOTE: AUTO RECLOSE RELAY (79) WILL BE INITIATED BY 51 OR 51G OPERATED

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
79	AUTO RECLOSE RELAY	PB	PUSH BUTTON SWITCH
79CO	AUTO RECLOSE ON/OFF SWITCH	CB.INC.1	CIRCUIT BREAKER INCOMING.1
50/51	PHASE OVER CURRENT RELAY	CB.INC.2	CIRCUIT BREAKER INCOMING.2
(50/51)G	GROUND OVER CURRENT OR EARTH FAULT RELAY	CB.BC	CIRCUIT BREAKER BUSCOUPLER
(50/51)GCO	GROUND OVER CURRENT OR EARTH FAULT ON/OFF SWITCH	CB	CIRCUIT BREAKER
86BF	BREAKER FAILURE AUXILIARY TRIPPING AND LOCKOUT	T/R	CIRCUIT BREAKER TRUCK OR RACK
86ARC	ARC DETECTION AUXILIARY TRIPPING AND LOCKOUT	TP1	POWER TRANSFORMER TP.1
86T	TRANSFORMER DIFF. AUXILIARY TRIPPING AND LOCKOUT	TP2	POWER TRANSFORMER TP.2
U/F	UNDER FREQUENCY RELAY	DS	115 KV DISCONNECTING SWITCH
U/FSW	UNDER FREQUENCY SELECTOR SWITCH	ES	EARTHING SWITCH
L/R	LOCAL/REMOTE SELECTOR SWITCH	LBSW	LOAD BREAK SWITCH
M/R	MAINTENANCE/REMOTE SELECTOR SWITCH	MAN	MECHANICAL MANUAL OPERATE
CS	DISCREPANCY CONTROL SWITCH		

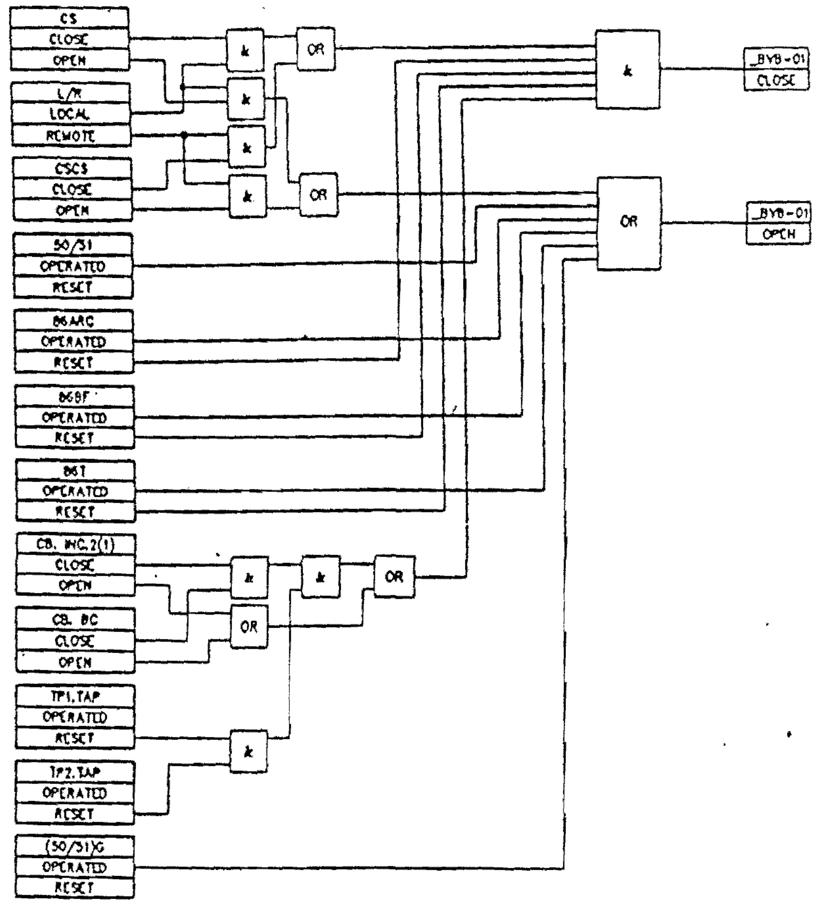
KEY TO SYMBOLS

1) OR - OR GATE
2) & - AND GATE
3) - DEVICE
4) - INPUT

กองอุปกรณ์ป้องกันและรีเลย์	การไฟฟ้าส่วนภูมิภาค	ใช้แทนแบบ ----------
ผู้เขียน ..... มีนนต์ ... ผู้สำรวจ ------------ วิศวกร ..... มีนนต์ ... หัวหน้าแผนก -------- ผู้อำนวยการกอง ------- ผู้อำนวยการฝ่าย -------	ผู้ว่าการ ----------------------------	ถูกแทนโดยแบบ -------- เขียนเสร็จวันที่ 24/02/2529 แก้แบบวันที่ 24/03/2529
	มาตรฐานการออกแบบ ระบบควบคุม และ ระบบป้องกันการทำงานผิดขั้นตอน ระบบสวิตช์เกียร์ระดับแรงดัน 22 กิโลโวลท์ ฉนวนอากาศ	มิติเป็น ---------- มาตราส่วน ----------
รองผู้ว่าการฝ่ายเทคนิค ----------------	TYPICAL DESIGN CONTROL AND INTERLOCKING FUNCTION 22 KV AIR INSULATED SWITCHGEAR	DWG.NO.PEA/ID.22A3301 SHEET 3 of 3



LOGIC DIAGRAM FOR OUTGOING PANEL CIRCUIT BREAKER



LOGIC DIAGRAM FOR INCOMING 1 (2) PANEL CIRCUIT BREAKER

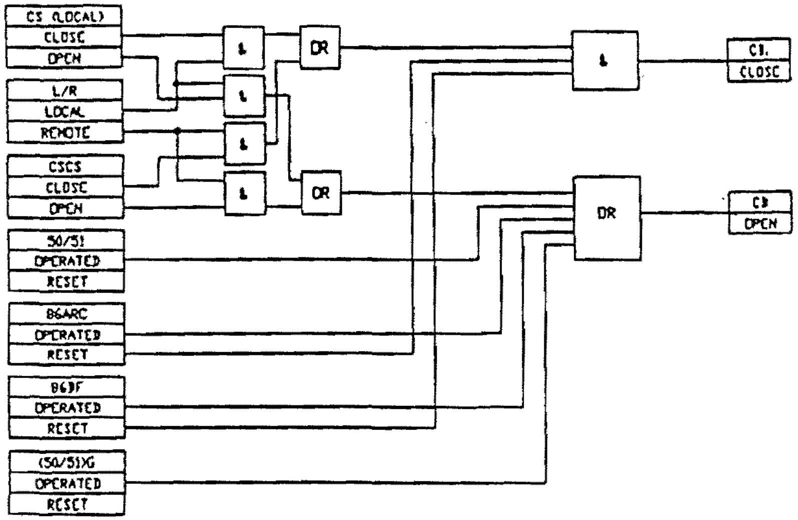
NOTE: AUTO RECLOSE RELAY (79) WILL BE INITIATED BY 51 OR 51G OPERATED

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
79	AUTO RECLOSE RELAY	PB	PUSH BUTTON SWITCH
79CO	AUTO RECLOSE ON/OFF SWITCH	CB.INC.1	CIRCUIT BREAKER INCOMING.1
50/51	PHASE OVER CURRENT RELAY	CB.INC.2	CIRCUIT BREAKER INCOMING.2
(50/51)G	GROUND OVER CURRENT OR EARTH FAULT RELAY	CB.BC	CIRCUIT BREAKER BUSCOUPLER
(50/51)GCO	GROUND OVER CURRENT OR EARTH FAULT ON/OFF SWITCH	CB	CIRCUIT BREAKER
86BF	BREAKER FAILURE AUXILIARY TRIPPING AND LOCKOUT	T/R	CIRCUIT BREAKER TRUCK OR RACK
86ARC	ARC DETECTION AUXILIARY TRIPPING AND LOCKOUT	TP1	POWER TRANSFORMER TP.1
86T	TRANSFORMER DIFF. AUXILIARY TRIPPING AND LOCKOUT	TP2	POWER TRANSFORMER TP.2
U/F	UNDER FREQUENCY RELAY	DS	115 kV DISCONNECTING SWITCH
U/FSW	UNDER FREQUENCY SELECTOR SWITCH	ES	EARTHING SWITCH
L/R	LOCAL/REMOTE SELECTOR SWITCH	LBSW	LOAD BREAK SWITCH
M/R	MAINTENANCE/REMOTE SELECTOR SWITCH	MAN	MECHANICAL MANUAL OPERATE
	DISCREPANCY CONTROL SWITCH		

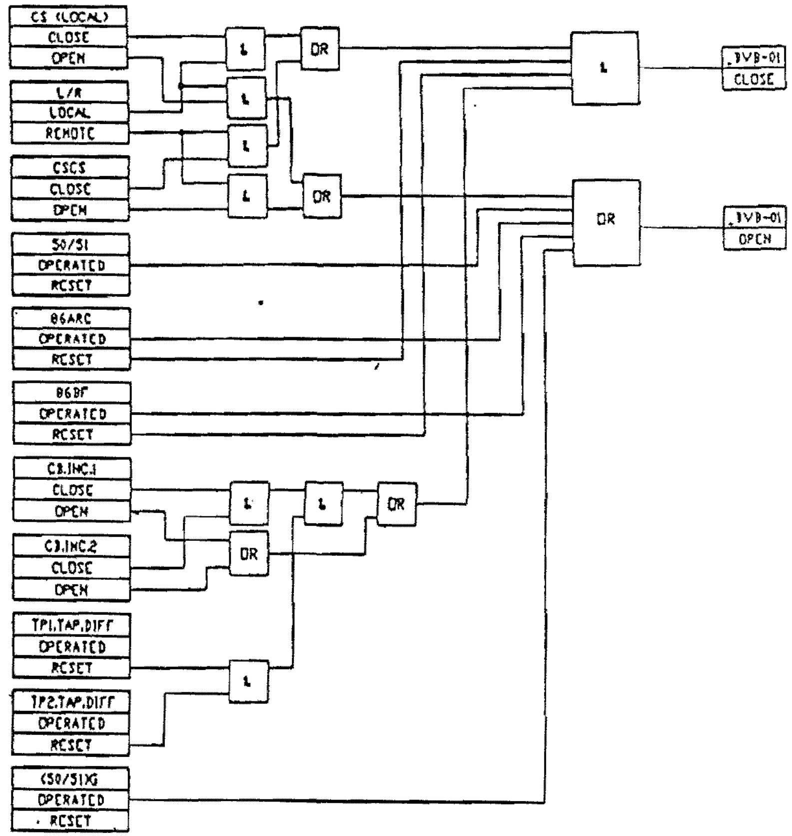
KEY TO SYMBOLS

1) OR - OR GATE
2) & - AND GATE
3) - DEVICE
4) - INPUT

กองอุปกรณ์ป้องกันและรีเลย์	การไฟฟ้าส่วนภูมิภาค	ใช้แทนแบบ ....
ผู้เขียน ..... [illegible] ...	ผู้ว่าการ	ถูกแทนโดยแบบ ....
ผู้สำรวจ		เขียนเสร็จวันที่ 24/02/2529
วิศวกร ..... [illegible] ...	มาตรฐานการออกแบบ ระบบควบคุม และ ระบบป้องกันการทำงานผิดขั้นตอน ระบบสวิตช์เกียร์ 22 และ 33 กิโลโวลต์ ฉนวนก๊าซ	แก้แบบวันที่ ..24/02/2529
หัวหน้าแผนก		[illegible] ....
ผู้อำนวยการกอง		มาตราส่วน ....
ผู้อำนวยการฝ่าย		
รองผู้ว่าการฝ่ายเทคนิค	TYPICAL DESIGN CONTROL AND INTERLOCKING FUNCTION 22 & 33 KV SF6 GAS INSULATED SWITCHGEAR	DWG.NO.PEA/ID.22&33/01 SHEET 1 of 3



LOGIC DIAGRAM FOR CAPACITIVE AND STATION SERVICE TRANSFORMER PANEL CIRCUIT BREAKER



LOGIC DIAGRAM FOR BUSCOUPLER PANEL CIRCUIT BREAKER

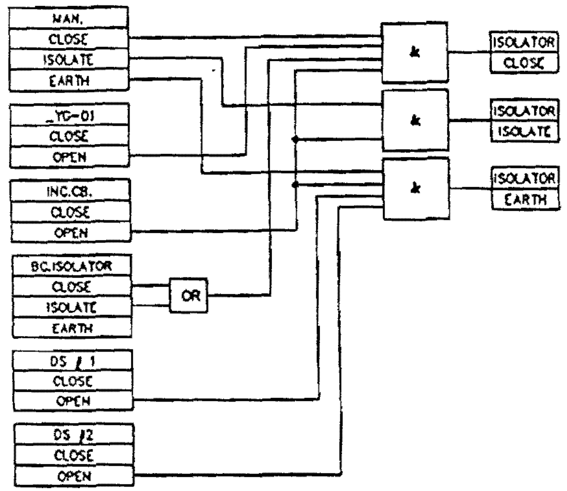
NOTE: 1.AUTO RECLOSE RELAY (79) WILL BE INITIATED WHEN 51 OR 51G OPERATED

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
79	AUTO RECLOSE RELAY	PB	PUSH BUTTON SWITCH
79CO	AUTO RECLOSE ON/OFF SWITCH	CB.INC.1	CIRCUIT BREAKER INCOMING.1
50/51	PHASE OVER CURRENT RELAY	CB.INC.2	CIRCUIT BREAKER INCOMING.2
(50/51)G	GROUND OVER CURRENT OR EARTH FAULT RELAY	CB.BC	CIRCUIT BREAKER BUSCOUPLER
(50/51)GCO	GROUND OVER CURRENT OR EARTH FAULT ON/OFF SWITCH	CB	CIRCUIT BREAKER
86BF	BREAKER FAILURE AUXILIARY TRIPPING AND LOCKOUT	ISOLATOR	THREE POSITION ISOLATING SWITCH
86ARC	ARC DETECTION AUXILIARY TRIPPING AND LOCKOUT	TP1	POWER TRANSFORMER TP.1
86T	TRANSFORMER DIFF, AUXILIARY TRIPPING AND LOCKOUT	TP2	POWER TRANSFORMER TP.2
U/F	UNDER FREQUENCY RELAY	DS	115 kV DISCONNECTING SWITCH
U/FSV	UNDER FREQUENCY SELECTOR SWITCH	OUT1(2)...	OUTGOING FEEDER 1(2)...
L/R	LOCAL/REMOTE SELECTOR SWITCH	CAP1(2)	CAPACITIVE PANEL 1(2)
M/R	MAINTENANCE/REMOTE SELECTOR SWITCH	TS1(2)	STATION SERVICE TRANSFORMER PANEL 1(2)
		MAN	MECHANICAL MANUAL OPERATE

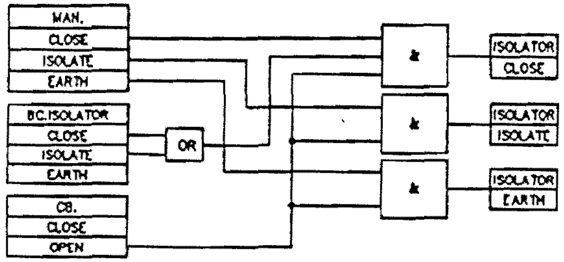
KEY TO SYMBOLS

1) OR - OR GATE
2) & - AND GATE
3) - DEVICE
4) - INPUT

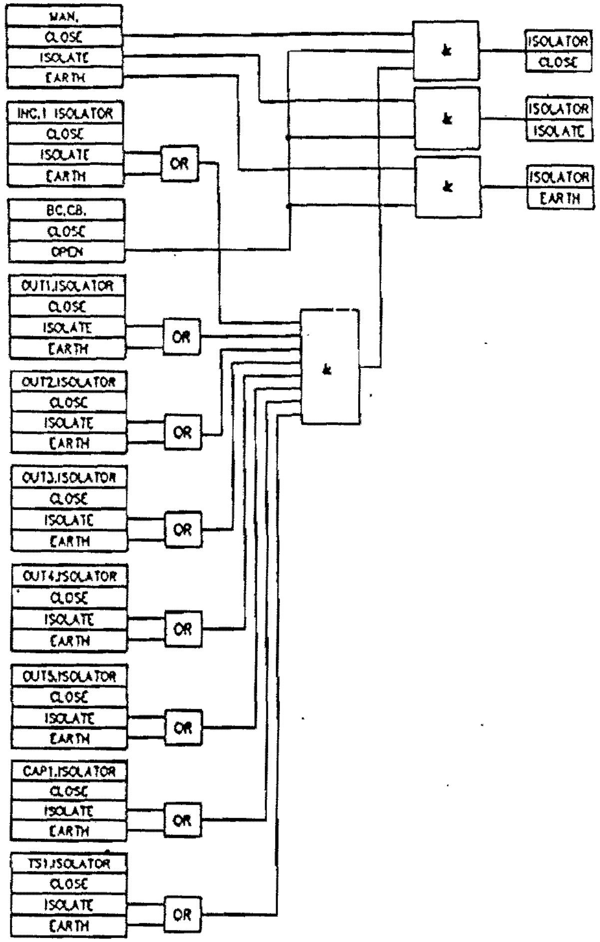
กองอุปกรณ์ป้องกันและรีเลย์	การไฟฟ้าส่วนภูมิภาค	ใช้แทนแบบ .... ถูกแทนโดยแบบ ....
ผู้เขียน ......มีชัย... ผู้สำรวจ .... วิศวกร ......มีชัย... หัวหน้าแผนก .... ผู้อำนวยการกอง .... ผู้อำนวยการฝ่าย	ผู้ว่าการ .... มาตรฐานการออกแบบ ระบบควบคุม และ ระบบป้องกันการทำงานผิดขั้นตอน ระบบตัดตอนระดับแรงดัน 22 และ 33 กิโลโวลต์ ฉนวนก๊าซ	เขียนเสร็จวันที่ 24/03/1998 แก้แบบวันที่ ..24/03/1998 มีเล่ม .... มาตราส่วน ....
รองผู้ว่าการฝ่ายเทคนิค	TYPICAL DESIGN CONTROL AND INTERLOCKING FUNCTION 22 & 33 KV SF6 GAS INSULATED SWITCHGEAR	DWG.NO.PEA/DD22AX001 SHEET 1 of 3



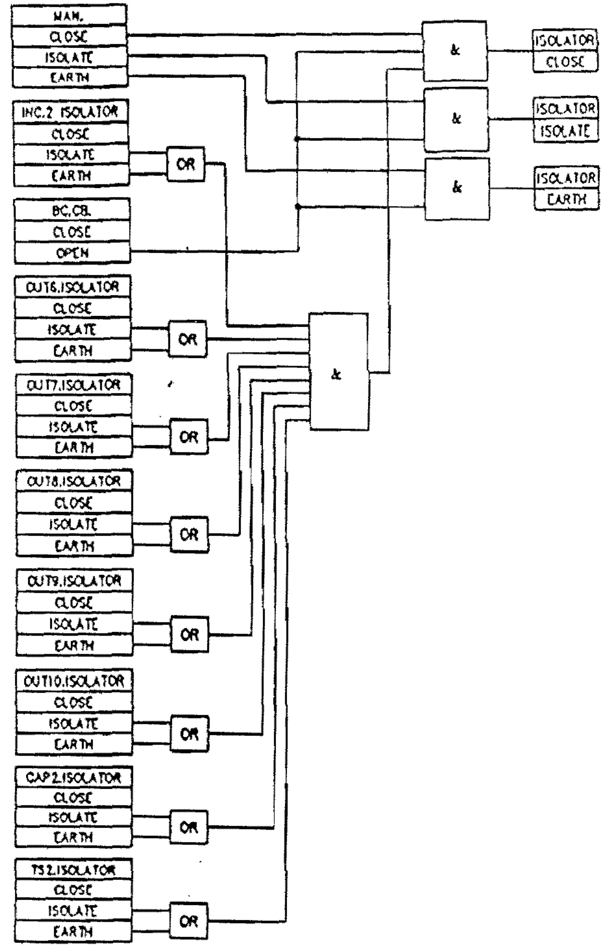
LOGIC DIAGRAM FOR INCOMING PANEL ISOLATOR/EARTHING SWITCH



LOGIC DIAGRAM FOR OUTGOING CAPACITIVE AND STATION SERVICE TRANS FORMER PANEL ISOLATOR/EARTHING SWITCH



LOGIC DIAGRAM FOR BUS COUPLER PANEL ISOLATOR/EARTHING SWITCH FOR BUS NO.2 SIDE



LOGIC DIAGRAM FOR BUS COUPLER PANEL ISOLATOR/EARTHING SWITCH FOR BUS NO.1 SIDE

NOTE: 1.AUTO RECLOSE RELAY (79) WILL BE INITIATED WHEN 51 OR 51G OPERATED

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
79	AUTO RECLOSE RELAY	PB	PUSH BUTTON SWITCH
79CO	AUTO RECLOSE ON/OFF SWITCH	CB.INC.1	CIRCUIT BREAKER INCOMING.1
50/51	PHASE OVER CURRENT RELAY	CB.INC.2	CIRCUIT BREAKER INCOMING.2
(50/51)G	GROUND OVER CURRENT OR EARTH FAULT RELAY	CB.BC	CIRCUIT BREAKER BUSCOUPLER
(50/51)GCO	GROUND OVER CURRENT OR EARTH FAULT ON/OFF SWITCH	CB	CIRCUIT BREAKER
86BF	BREAKER FAILURE AUXUARY TRIPPING AND LOCKOUT	ISOLATOR	THREE POSITION ISOLATING SWITCH
86ARC	ARC DETECTION AUXILIARY TRIPPING AND LOCKOUT	TP1	POWER TRANSFORMER TP.1
86T	TRANSFORMER DIFF. AUXUARY TRIPPING AND LOCKOUT	TP2	POWER TRANSFORMER TP.2
U/F	UNDER FREQUENCY RELAY	DS	115 kV DISCONNECTING SWITCH
U/FSW	UNDER FREQUENCY SELECTOR SWITCH	OUT1(2)....	OUTGOING FEEDER 1(2)....
L/R	LOCAL/REMOTE SELECTOR SWITCH	CAP1(2)	CAPACITIVE PANEL 1(2)
M/R	MAINTENANCE/REMOTE SELECTOR SWITCH	TS1(2)	STATION SERVICE TRANSFORMER PANEL 1(2)
DS	DISCREPANCY CONTROL SWITCH	MAN	MECHANICAL MANUAL OPERATE

KEY TO SYMBOLS

1) OR - OR GATE
2) & - AND GATE
3) - DEVICE
4) - INPUT

กองอุปกรณ์ป้องกันและรีเลย์	การไฟฟ้าส่วนภูมิภาค	ใช้แทนแบบ .... ถูกแทนโดยแบบ ....
ผู้เขียน ..... [illegible] ... ผู้สำรวจ .... วิศวกร ..... [illegible] ... หัวหน้าแผนก .... ผู้อำนวยการกอง .... ผู้อำนวยการฝ่าย	ผู้ว่าการ .... มาตรฐานการออกแบบ ระบบควบคุม และ ระบบป้องกันการทำงานผิดขั้นตอน [illegible] 22 และ 33 กิโลโวลต์ ฉนวนก๊าซ	เขียนเสร็จวันที่ 24/02/[illegible] แก้แบบวันที่ 24/02/[illegible] มีค่าเป็น .... มาตราส่วน ....
รองผู้ว่าการฝ่ายเทคนิค	TYPICAL DESIGN CONTROL AND INTERLOCKING FUNCTION 22 & 33 KV SF6 GAS INSULATED SWITCHGEAR	DWG.NO.PEA/[illegible] SHEET 3 of 3

APPENDIX 8

Lists of field tests

(For Turnkey Project)

Lists of field tests:

- **Individual tests**
- **Function tests**
- **Final tests**

This document describes the requirements for the field tests of 22 kV & 33 kV indoor switchgears at site prior to the acceptance. The Contractor shall perform the field tests according to the following:

Individual tests

1. Switchgear

1.1 Visual inspection (completeness of equipment and accessories, fastening of individual cubicles, etc.)

1.2 Conformity of assembly with drawings and instructions

1.3 Verification of wiring against drawings and specification

1.4 Construction check

1.5 Circuit-breaker test (see **3. Circuit-breaker**)

1.6 Disconnecting and earthing switch test (see **4. Disconnecting sw.**)

1.7 CT test (see **5. Current transformer**)

1.8 VT test (see **6. Voltage transformer**)

1.9 Phase arrangement check

1.10 Main circuit resistance measurement

1.11 Sequence test

1.12 Gas leakage test (GIS only)

1.13 Gas monitoring equipment test (GIS only)

1.14 Moisture content test (GIS only)

1.15 Dew point of SF_6 bottles test (GIS only)

1.16 SF6 gas purity test (GIS only), after filling

1.17 Insulation resistance test (5,000 VDC)

1.18 Power frequency withstand test (at 80% of routine test voltage)

1.19 Heater (including heating circuit) test

2. Station service transformer

2.1 Construction check

2.2 Insulation resistance test (5,000 VDC) including polarizing index of winding

2.3 Insulation resistance test of all accessories

2.4 Insulation power factor or loss tangent (δ) test (10 kV AC)

2.5 Ratio test

2.6 Inductance measurement

2.7 DC resistance measurement

2.8 Vector group check

2.9 AC excitation current test

2.10 Oil insulation test

3. Circuit-breaker

3.1 Construction check

3.2 Vacuum test

3.3 Insulation resistance test (5,000 VDC)

3.4 Insulation resistance test of all accessories

3.5 Contact resistance measurement

3.6 Timing test at rated voltage and minimum voltage close & trip

3.7 Measurement of initial charging time

3.8 Operation test including

(a) Local electrical testing of the closing and tripping of the circuit-breaker including interlocking operations

(b) Emergency trip test

(c) Position indicator and operation counter test

(d) The number of close and/or open operation

(e) Correctness confirmation of the spring charged indicator to indicate the state of energy stored in the spring

4. Disconnecting switch and earthing switch

4.1 Construction check

4.2 Insulation resistance test (5,000 VDC)

4.3 Insulation resistance test of all accessories

4.4 Contact resistance measurement

4.5 Operation test

(a) Close & open by manual

(b) Close & open by electrical

4.6 Mechanism (including mechanical interlock) check

4.7 All interlock check

4.8 Operating torque test

5. Current transformer

5.1 Construction check

5.2 Magnetization curve test

5.3 Insulation resistance test (high side 5,000 VDC, low side 500 VDC)

5.4 Ratio test

5.5 Polarity test

6. Voltage transformer

6.1 Construction check

6.2 Insulation resistance test (high side 5,000 VDC, low side 500 VDC)

6.3 Ratio test

6.4 Polarity test

7. Power fuse

7.1 Construction check

7.2 Operation check

7.3 Insulation resistance test (5,000 VDC)

8. AC & DC boards

8.1 Wiring check

8.2 Metering instrument test including tests of at least as specified elsewhere for relevant instrument

8.3 AC automatic change over switch operation check (for AC board)

8.4 DC automatic change over switch operation check (for DC board)

8.5 Insulation resistance test (500 VDC)

8.6 Molded case circuit-breaker characteristic test

8.7 Air circuit-breaker function test (if any)

8.9 Operation test

9. Battery charger

9.1 Insulation resistance test (500 VDC)

9.2 Operation test of voltage adjusting range (manual)

9.3 Operation test of load voltage compensator, rated current, etc.

9.4 Operation test of automatic float and boost charge setting

9.5 All alarm test

9.6 AC ripple test

9.7 Metering instrument test including tests of at least as specified elsewhere for relevant instrument

10. Battery set

10.1 Polarity check of each cell

10.2 Extra charging (0.1 ca according to charge characteristic from manufacturer)

10.3 Voltage, specific gravity and temperature test of each cell at the end of charging

10.4 Discharge characteristic test

11. Busbus connector and fitting

11.1 Contact resistance of connectors

11.2 Phase sequence (conformity with drawing) of bus

11.3 Tightness of bolts

12. High voltage power cable and terminator

12.1 Insulation resistance test (5,000 VDC)

12.2 DC high voltage test

13. Low-voltage cable and control cable

13.1 Insulation resistance test (500 VDC)

14. Protective device (Relay) and control panel

The test shall be performed according to the manufacturer's recommendation and as following:

14.1 Overcurrent function

- Minimum pick up test at least for five (5) tap settings
- Time characteristics test at maximum, central, minimum, and time dial
- Instantaneous unit test at at least for five (5) tap settings
- Indicating targets and seal-in operation test

14.2 Auto-reclosing function

- Reclosing time test at maximum, central, minimum, and service setting
- Reclaim time test at maximum, central, minimum, and service setting
- Lock out time test at maximum, central, minimum, and service setting
- Counter test

14.3 Under frequency load shedding function

- Minimum pick up test for at least for five (5) tap settings
- Time delay test at maximum, central, minimum, and service setting
- Indicating target and seal-in operation test

14.4 Under/ over voltage function

- Minimum pick up test for all setting
- Ratio characteristics test at maximum, central, minimum and service setting
- Indicating target and seal-in operation test

14.5 Breaker failure protection function

- Time accuracy test at maximum, central, minimum and service setting
- Indicating target and seal-in operation test

14.6 Arc detection system

- Operating time test
- Pick up light test (for light sensor of light type)
- Pick up current test (for current sensing unit of light type)
- Minimum pick up pressure test (for pneumatic type)

14.7 DC auxiliary relay

- Minimum pick up voltage test
- Pick up time test
- Dropped out time test

14.8 CT & VT circuit

- Connection check by using kick test and secondary injection
- Insulation resistance test (500 VDC)
- Burden measurement

14.9 Metering instrument

- AC indicating and recording ammeter and volt meter test
  - a) at 25%, 50%, 75%, 100% of full scale
  - b) response time test
- AC indicating and recording Watt / Var meter
  - a) at rated input voltage with 25%, 50%, 75%, 100% of rate input current
  - b) response time test
- AC current, voltage, Watt and Var transducers test (if any)
  - a) current input at 25%, 50%, 75% and 100% of rated input current
  - b) volt input at 25%, 50%, 75% and 100% of rated input voltage
  - c) Watt, Var input at rated input voltage with 25%, 50%, 75% and 100% of rated input current

Functional tests

1. Remote manual control for all remote manual functions of each equipment with has this requirement.
2. Function test (electrical and mechanical) of circuit-breaker, circuit-breaker truck/rack, earthing switch
3. Proper function of control, measuring and protective equipment including heating and lighting
4. All protective device functions at service setting test
5. Proper function of all interlocks
6. Sequence operation control of all relay contacts to actuate associated equipment by mean of secondary or primary injection test.
7. Recloser operations.
8. Protective operation of DC source.
9. Operation of annunciators and alarms.
10. Operation of lamp test circuit.

Final tests

1. Measurement of Insulation Resistance.

   Measurement of insulation resistance of the equipment shall be performed by 5,000 V insulation tester before and after energizing, under the following procedures :

   Insulation resistance (phase to phase and phase to ground) of the equipment shall be measured under the conditions that the 22 kV (or 33 kV) equipment are connected with the 22 kV (or 33 kV) system. In this case, the 22 kV (or 33 kV) circuit-breakers and disconnecting switches shall be closed for the test.
2. Energizing test.

   After completion of the measurement of insulation resistance mentioned above, AC energizing test shall be applied by the normal operating voltage of the existing power system for 24 hours in accordance with the following procedures:

   The AC energizing test for 22 kV (or 33 kV) equipment including the station service transformers shall be performed. Normal operating voltage shall be charged on the equipment and bus.

   During the test, the following shall be recorded or checked

   (a) The indicating value of meters mounted on the control panel shall be recorded on the test record sheet.

   (b) The current and voltage magnitude and phasing shall be checked at the relay test terminals in order to confirm correct connection of all AC secondary circuits.

3. Requirement for energizing test.

Power sources required for substation energizing shall be provided by The Authority. Connectors, lead wires and other materials required for the field tests shall be provided by The Contractor. The Contractor shall be responsible for providing all measuring instruments and tools required for the test.

APPENDIX 9

DESIGN DATA AND GUARANTEE

Instruction for filling the forms

1. The Authority has provided the application software stored in the recordable compact disc (CD-R) which is supplemented to this Invitation to Bid. Such application software is a tool facilitated Bidders for filling and printing-out all technical data required for this Invitation to Bid.
2. Such CD-R and all application software inside, are belonging to the Authority. Bidder return to the Authority on the bid opening date.
3. Bidders shall follow the instruction inside the CD-R for setting up the software.
4. Bidders shall fill all blanks of Design Data and Guarantee and List of supplier in this part as well as in other parts if required.
5. If any data are not applicable, the relevant blanks shall be filled with “NA”.
6. Bidders shall submit and include in the first envelope (Envelope I: Technical Proposal) of their bid, the filled design data and guarantee as well as list of suppliers in both printed-out document generated by the software and electronic data.
7. The electronic data shall be recorded in the CD-R of the Authority following the instruction inherent in the CD-R

Table of Contents

Design Data and Guarantee

Invitation to Bid No.:
Specification No.:M-8/2017
Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Switchboard – common features					
Manufacturer	-	-	-		
Country of origin	-	-	-		
Type/Model	-	-	-		
Type designation of switchgear (SWG)	-	Air insulated, or SF_6 gas insulated	SF_6 gas insulated		
Type designation of enclosure					
- Air insulated SWG.	-	Metal clad	-		
- SF_6 gas insulated SWG.	-	Metal-clad or Compartmented	Metal-clad or Compartmented		
Type designation of circuit-breaker					
- Air insulated SWG.	-	Withdrawing	-		
- SF_6 gas insulated SWG.	-	Non-withdrawable	Non-withdrawable		
Withdrawable circuit-breaker mounted on	-	Truck or Rack	-		
Nominal system voltage	kV	22	33		
Rated voltage	kV	24	36		
Rated frequency	Hz	50	50		

Invitation to Bid No.:
Specification No.:M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Insulation level					
- impulse withstand voltage	kV (peak)	125	170		
- one-minute power frequency withstand voltage	kV (r.m.s.)	50	70		
Rated peak withstand current	kV (peak)	63	63		
Rated short-time withstand current (1 s)	kA	25	25		
Thermal loss at full load per feeder	kW	-	-		
Rated normal current					
- main busbars					
a) at normal service conditions	A	-	-		
b) at special site and service conditions	A	2,000	1,250		
- incoming feeders					
a) at normal service conditions	A	-	-		
b) at special site and service conditions	A	2,000	1,250		
- busbar coupling					
a) at normal service conditions	A	-	-		
b) at special site and service conditions	A	2,000	1,250		
- outgoing feeders					
a) at normal service conditions	A	-	-		
b) at special site and service conditions	A	600	400		
- capacitor banks					
a) at normal service conditions	A	-	-		
b) at special site and service conditions	A	200	125		

Invitation to Bid No.:
Specification No.:M-8/2017
Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Main busbar cross-section area	mm^2	-	-		
Earth busbar cross-section area	mm^2	150	150		
Busbar material	-	Copper	Copper		
Type of busbar insulation	-	-	-		
Contact resistance of main circuit	Ω	-	-		
Busbar temperature rise on continuous operation at rated normal current	K	-	-		
Degree of protection of air insulated SWG for both enclosure and partition	IP…	IP4X/IP4X	-		
Degree of protection of SF_6 gas insulated SWG					
- SW_6 gas compartments	IP…	IP 65	IP 65		
- L. V. compartments	IP…	IP 4X	IP 4X		
Minimum sheet steel thickness (for AIS)					
- metal enclosure	mm.	2-3	-		
- metal partition	mm.	3	-		
Dimensions of switchboard cubicle (width x height x depth):					
- Incoming cubicle (IN)	mmxmmxmm	-	-		
- Bus section cubicle (BC)	mmxmmxmm	-	-		
- Outgoing cubicle (F)	mmxmmxmm	-	-		
- Capacitor bank cubicle (CC)	mmxmmxmm	-	-		
- Station service transformer unit cubicle (SS)	mmxmmxmm	-	-		
- V.T. cubicle (VC) (if any)	mmxmmxmm	-	-		

Invitation to Bid No.:
Specification No.:M-8/2017
Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
<u>Circuit-breaker</u> – common features					
Manufacturer	-	-	-		
Country of origin	-	-	-		
Type/Model	-	-	-		
Type designation of circuit-breaker	-	Vacuum	Vacuum		
Vacuum interrupter					
- manufacturer	-	-	-		
- country of origin	-	-	-		
- type/model	-	-	-		
Rated short-circuit breaking current	kA	25	25		
Rated short-circuit making current	kA	63	63		
Current consumption at nominal voltage for shunt trip coil	A	-	-		
Current consumption at nominal voltage for closing coil	A	-	-		
Total closing time of circuit-breaker	ms	-	-		
Total opening time of circuit-breaker	ms	-	-		
Total breaking time of circuit-breaker	ms	not more than 70			
Method of opening					
- mechanical	YES/NO	YES	YES		
- electrical	YES/NO	YES	YES		
Method of closing					
- mechanical	YES/NO	YES	YES		
- electrical	YES/NO	YES	YES		

Invitation to Bid No.:
Specification No.:M-8/2017

Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
No. of operating life cycle					
- at no-load	times	-	-		
- at full load	times	-	-		
- at short circuit	times	-	-		
Rated operating sequence	-	O-0.3S-CO-15S-CO			
Rated auto-reclosing duty	-	O-0.3S-CO-15s-CO			
Emergency mechanical manual trip	YES/NO	YES	YES		
Driving mechanism of circuit-breaker					
Type/Model	-				
Rating of driving motor	VDC				
Total charging time of closing spring	s				
Load break switch/circuit-breaker for station service transformer unit cubicle (SS)					
Manufacturer	-	-	-		
Country of origin	-	-	-		
Type/Model	-	-	-		
Type designation of load-breaker switch/circuit-breaker					
- Air insulated switchgear	-	Switch with fuse	-		
- SF_6 gas insulated switchgear	-	-	-		
Rated current	A	200	200		
Rated breaking current for no-load transformer	A	16	-		

Invitation to Bid No.:
Specification No.:M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Rated short-time current, 1 s	kA	10	10		
Rated peak withstand current	kA	25	25		
Type of closing mechanism					
- Load break switch	-	Quick acting	-		
- VCB	-	motor drive	motor drive		
Pole center distance	mm	-	-		
Number of operations at rated current	-	-	-		
Number of mechanical operations	-	-	-		
Number of spare auxiliary contacts					
- according to manufacturer's design	-	-	-		
- for Authority use	-	4 NO/4 NC	4 NO/4 NC		
Earthing switch					
Manufacturer	-	-	-		
Country of origin	-	-	-		
Type/Model	-	-	-		
Rated short-time current, 1 s	kA	25	25		
Rated peak withstand current	kA	63	63		
Type of operation					
- Air insulated switchgear	-	manual	-		
- SF6 gas insulated switchgear	-	motor drive	motor drive		

Invitation to Bid No.:
Specification No.:M-8/2017 Manufacturer:
Bidder:
2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Number of spare auxiliary contacts					
- according to manufacturer's design	-	-	-		
- for Authority use	-	2 NO/2 NC	2 NO/2 NC		
<u>Current transformer</u> common features					
Manufacturer	-	-	-		
Country of origin	-	-	-		
Type designation	-	-	-		
Type/Model	-	Cast resin/post or ring type			
<u>For Incoming Cubicle (IN)</u>					
Rated primary current	A	1,800/1,500/900			
Rated secondary current:					
- Measuring 1 core	A	1	1		
- Protection 3 cores	A	1	1		
Accuracy class and accuracy limit factor					
- Measuring 1 core	-	0.5 FS 5	0.5 FS 5		
- Protection 3 cores	-	5 P 20	5 P 20		
Power rating (burden)					
- Measuring 1 core	VA	20			
- Protection 3 cores	VA	20			
<u>For Outgoing Cubicle</u> (F)					
Rated primary current	A	600/300			

Invitation to Bid No.:
Specification No.:M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Rated secondary current:					
- Measuring 1 core	A	1	1		
- Protection 1 core	A	1	1		
Accuracy class and accuracy limit factor					
- Measuring 1 core	-	0.5 FS 5	0.5 FS 5		
- Protection 1 core	-	5 P 20	5 P 20		
Power rating (burden)					
- Measuring 1 core	VA	20			
- Protection 1 core	VA	20			
For Bus Section Cubicle (BC)					
Rated primary current	A	1,800/1,500/900			
Rated secondary current:					
- Measuring 1 core	A	1	1		
- Protection 1 core	A	1	1		
Accuracy class and accuracy limit factor					
- Measuring 1 core	-	0.5 FS 5	0.5 FS 5		
- Protection 1 core	-	5 P 20	5 P 20		
Power rating (burden)					
- Measuring 1 core	VA	20			
- Protection 1 core	VA	20			
For Capacitor Bank Cubicle (CC)					
Rated primary current	A	600/300			

Invitation to Bid No.:
Specification No.:M-8/2017 Manufacturer:
Bidder:
2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Rated secondary current:					
- Measuring 1 core	A	1	1		
- Protection 1 core	A	1	1		
Accuracy class and accuracy limit factor					
- Measuring 1 core	-	0.5 FS 5	0.5 FS 5		
- Protection 1 core	-	5 P 20	5 P 20		
Power rating (burden)					
- Measuring 1 core	VA	20			
- Protection 1 core	VA	20			
<u>Voltage transformer</u>					
Manufacturer	-	-	-		
Country of origin	-	-	-		
Type/Model	-	-	-		
Type designation	-	Cast resin			
Rated primary voltage	V	22,000/√3			
Rated secondary voltage:					
- Measuring core	V	110/√3			
- Protection core	V	110/√3			
Accuracy class					
- Measuring core	-	Class 0.5 (1.9 VF)			
- Protection core	-	Class 0.5 (1.9 VF)			

Invitation to Bid No.:
Specification No.:M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of 22 kV and 33 kV Indoor Switchgear

Description	Unit	Required Data		Proposed Data	
		22 kV	33 kV	22 kV	33 kV
Power rating (burden)					
- Measuring core	VA	50			
- Protection core	VA	50			
Type Test					
1. Dielectric tests	-	Report No./Institute (Lab.)			
2. Temperature rise tests	-	Report No./Institute (Lab.)			
3. Measurement of the resistance of the main circuit	-	Report No./Institute (Lab.)			
4. short-time and peak withstand current tests	-	Report No./Institute (Lab.)			
5. Verification of making and breaking capacities	-	Report No./Institute (Lab.)			
6. Mechanical operation tests	-	Report No./Institute (Lab.)			
7. Verification of the degree of protection	-	Report No./Institute (Lab.)			
8. Arcing due to internal fault					
8.1 Bus bar compartment	-	Report No./Institute (Lab.)			
8.2 Circuit-breaker compartment	-	Report No./Institute (Lab.)			
8.3 Cable connection compartment	-	Report No./Institute (Lab.)			
List of routine tests	YES/NO	Submission of list(s)			
List of commissioning tests	YES/NO	Submission of list(s)			
Field experience					
Under tropical condition for at least three (3) years	YES/NO	Submission of reference list(s)			
Certificate For Quality Assurance (ISO 9000)	YES/NO	-	-		

Invitation to Bid No.:

Specification No.: M-8/2017

Manufacturer:

Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
General Construction			
Type designation	-	Numerical	
Key pad included	YES/NO	YES	
Digital displayed included	YES/NO	YES	
Internal real time clock	YES/NO	YES	
Programmable scheme logic included	YES/NO	YES	
Self-monitoring included	YES/NO	YES	
Back-up Battery	YES/NO	YES	
Degree of protection	YES/NO	YES	

Invitation to Bid No.:
Specification No.: M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
Functions	-	IP5X	
Protection functions			
- overcurrent timed and instantaneous phases and ground fault	YES/NO	YES	
- Auto reclosing	YES/NO	YES	
- Under frequency load shedding	YES/NO	YES	
- Breaker failure protection	YES/NO	YES	
- Under/over voltage	YES/NO	YES	
- Trip circuit supervision	YES/NO	YES	
Metering functions			
- Type designation	-	Separately mounted digital power meter	
If use separately mounted digital power meter:			
a) Manufacturer	-	-	
b) Type/model	-	-	
- Phase voltage (V)	YES/NO	YES	
- Phase current (A)	YES/NO	YES	
- Active power (kW)	YES/NO	YES	
- Reactive power (kVar)	YES/NO	YES	
- Energy (kW-h), (if any)	YES/NO	-	
- Power factor (cos Ø), (if any)	YES/NO	-	
Others	YES/NO	-	
Recording and monitoring functions			
- Event recorder	YES/NO	YES	
- Fault recorder	YES/NO	YES	

Invitation to Bid No.:
Specification No.: M-8/2017

Manufacturer:
Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
- Self monitoring	YES/NO	YES	
- Oscillography	YES/NO	YES	
Communication			
- Front panel	-	RS 232	
- Rear panel	-	Fiber optic/RS 485	
- Type of protocal	-	-	
- Data transfer rates	bps.	-	
Protective device – common features			
Rated secondary current (In)	A	1	
Rated secondary voltage (Vn)	V	110	
Rated frequency	Hz	50	
DC supply			
- Rated DC voltage	VDC	125	
- Tolerances	%	$\pm$ 20%	
Environment withstand			
- Impulse voltage test	-	IEC 60255-5	
- Interference test	-	IEC 60255-22-1	
- Electrostatic discharge test	-	IEC 60255-22-2	
- Radio frequency interference test	-	IEC 60255-22-3	
- Temperature range	^{o}C	up to 55	

Invitation to Bid No.:
Specification No.: M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
Contact data			
Making current	A	-	
Continuous current	A	-	
Breaking current	A	-	
Overcurrent phases and ground fault function			
3x(51/50) and (51/50) G			
Manufacturer/country of origin	-	-	
Type/Model	-	-	
Burden			
AC burden	VA	-	
DC burden	VA	-	
Setting range			
Current setting, for phase			
- time delay unit	XIn	0.5 to 2	
- instantaneous unit	XIn	1 to 20	
Current setting, for ground			
- time delay unit	XIn	0.2 to 0.8	
- instantaneous unit	XIn	1 to 8	
Inverse time characteristic	-	Normally inverse, very inverse, extremely inverse	
Accuracy			
Within reference conditions:			
- current setting	%	-	
- time setting	%	-	
- repeatability	%	-	

Invitation to Bid No.:
Specification No.: M-8/2017

Manufacturer:
Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
Thermal withstand			
Continuous	XIn	-	
Short-time	XIn(s)	-	
Front plate signals			
Availability/Stand-by	YES/NO	YES	
Delayed tripping	YES/NO	YES	
Instantaneous	YES/NO	YES	
Weight	kg	-	
Auto-Reclosing Function			
Manufacturer/country of origin	-	-	
Type/Model	-	-	
Number of operation to lockout	shots	not less than 2	
Timing setting			
Dead time:			
- 1st shot	s	0.3 – 20	
- 2nd shot	s	15 – 30	
Reclaim time	s	10 – 50	
Pulse time	s	-	
Front plate signals			
Availability	YES/NO	YES	
Dead time running	YES/NO	YES	
Autoreclose	YES/NO	YES	
Lockout	YES/NO	YES	
Weight	kg	-	

Invitation to Bid No.:
Specification No.: M-8/2017

Manufacturer:
Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
Under frequency load shedding function (81)			
Manufacturer/country of origin			
Type/Model			
- Number of steps for load shedding functions	4	YES	
- Complete with selector switch, 5 position, "OFF", "Step#1", "Step#2", "Step#3", and "Step#4"	5 Position	YES	
Burden			
AC burden	VA	-	
DC burden	VA	-	
Setting range			
Number of switching point setting	-	4	
Frequency setting	Hz	47.0 to 50.0	
Setting steps, maximum	Hz	$\pm$ 0.03	
Operation time:			
- tripping time, minimum	msec	150	
- delayed tripping time	msec	100 – 1,200	

Invitation to Bid No.:
Specification No.: M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
Accuracy			
Within reference conditions:			
- current setting	Hz	± 0.03	
- time setting	%	± 10	
Front plate signals			
Frequency indication	-	-	
Tripping	-	-	
Weight	kg		
Under voltage function (27) and Over voltage function (59)			
Manufacturer/country of origin			
Type/Model			
Burden			
AC burden	VA	-	
DC burden	VA	-	
Setting range			
- Under voltage			
Pick up voltage	XVn	0.80 to 1.00	
Time delay	sec	0 to 60	
- Overer voltage			
Pick up voltage	XVn	1.0 to 1.15	
Time delay	sec	0 to 60	

Invitation to Bid No.:
Specification No.: M-8/2017 Manufacturer:
Bidder:

2a Design data and guarantee of Protective Device and Metering, for 22 kV and 33 kV systems

Description	Unit	Required Data	Proposed Data
Front plate signals			
Under voltage	YES/NO	YES	
Over voltage	YES/NO	YES	
Weight	kg	-	
Trip circuit supervision function			
Manufacturer/country of origin			
Time delay			
Fixed setting (approximately)	s	-	
Supervision current			
Maximum trip circuit supervision current	mA	-	
Weight	kg	-	
Breaker failure protection function			
Manufacturer/country of origin	-	-	
Type/Model	-	-	

Invitation to Bid No.:
Specification No.: M-8/2017

Manufacturer:
Bidder:

2a Design data and guarantee of Corrosion Protection, Painting and Finishing

Description	Unit	Required Data	Proposed Data
Switchgear and control board			
Corrosion protection system	-	Epoxy powder paint by cathodic elctro-deposition system	
Colour code	-	RAL-7032	
Coat thickness	micron	At least 50	
AC, DC board and battery-charger			
Corrosion protection system	-	Epoxy powder or ordinary painting	
Colour code	-	RAL-7032	
Coat thickness	micron	At least 50	
Battery rack			
Corrosion protection system	-	Primer coat and two coats of acid resistant paint/hot-dip galvanized	

Invitation to Bid No.:
Specification No.: M-8/2017

Manufacturer:
Bidder:

2a Design data and guarantee of ARC Detection System

Description	Unit	Required Data	Proposed Data
Type designation of Arc detection system	-	Light detection	
Operating time of system from detection to initiated circuit breaker tripping	ms	-	
Operating time of system from detection to arc clearing	ms	Not more than 100	
Light detection system			
(1) Light sensor			
- Manufacturer/Country of origin	-	-	
- Type/Model	-	-	
- Fiber optic design	YES/NO	YES	
- Operating time	ms	-	
- Install in each high voltage compartment	YES/NO	YES	
(2) Current sensing unit			
- Manufacturer/Country of origin	-	-	
- Type/Model	-	-	
- Current setting	XIn	-	
- Operating time	ms	-	
When the internal fault occurs in cable connection compartment of the feeder cubicle the system shall disconnect only outgoing circuit breaker without disturbing the other feeders also.			

C3 Schedule of detailed requirement

Invitation to Bid No.:

Item	PEA Material No.	Quantity	Description
1	-	………set	22 kV-Indoor metal clad air insulated switchgear, with : 1.1 …..units Incoming cubicle of 22 kV with protection relay 1.2 …..units Outgoing cubicle of 22 kV with protection relay 1.3 …..units PT for synchronize bus bar protection cubicle of 22 kV 1.4 …..units Capacitor bank cubicle of 22 kV with protection relay 1.5 …..units Station service transformer cubicle unit of 22 kV 1.6 …..units Dummy cubicle 1.7 …..units Arc detection system equipment **Note:** Each substation shall be completed with 1 lot of Supervisor(s) for installation the above 22 kV-Indoor metal clad air insulated switchgear until ready for operation at PEA's sub-transmission substation.
	I		

PROVINCIAL ELECTRICITY AUTHORITY

POWER SYSTEM STANDARD DIVISION

Specification No. M-8/2017 : 22 kV INDOOR SWITCHGEARS

C4 Price schedule

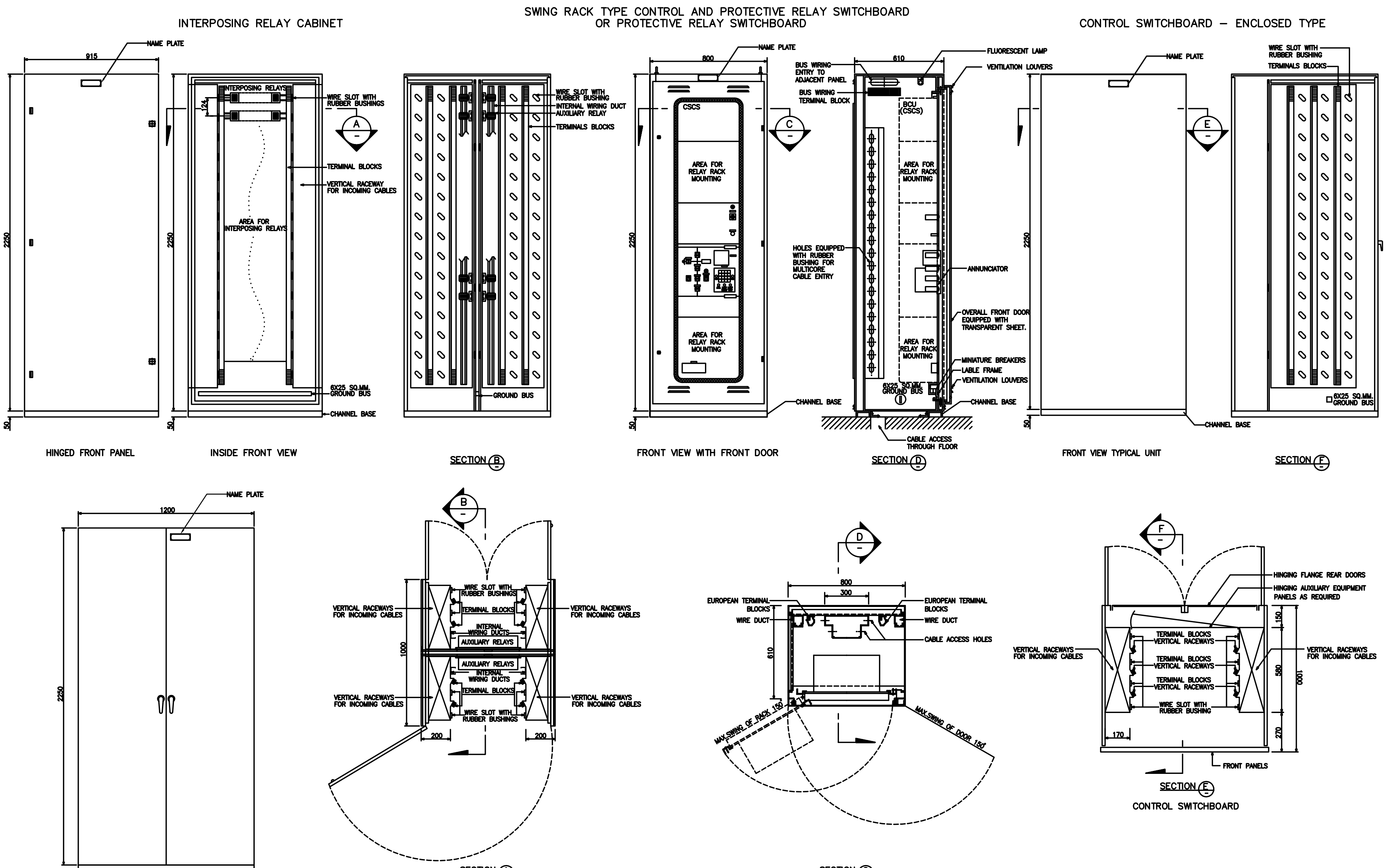
Invitation to Bid No.

Manufacturer :

Country of origin :

Trade-mark :

Item	**PEA Material No.**	**Catalogue No.**	**Description**	**Quantity**	**Unit Cost (See details & conditions attached)**	**Total Cost (See details & conditions attached)**
1	-		22 kV-Indoor metal clad air insulated switchgear, with :	…….set		
			1.1 Incoming cubicle of 22 kV with protection relay	……unit		
			1.2 Outgoing cubicle of 22 kV with protection relay	……units		
			1.3 PT for synchronize bus bar protection cubicle of 22 kV	……units		
			1.4 Capacitor bank cubicle of 22 kV with protection relay	……units		
			1.5 Station service transformer cubicle unit of 22 kV	……units		
			1.6 Dummy cubicle	……units		
			1.7 Arc detection system equipment	……units		
					Total of Item 1	
						=============
	I					



NOTES :

1. ALL DIMENSION ARE MILLIMETERS
2. PANEL OR CABINET WIDTH,AND DEPTH FOR EACH CONTROL SWITCHBOARD AND INTERPOSING RELAY CABINET SHALL BE AS INDICATED ON THE DRAWINGS ENTITLED "CONTROL AND PROTECTIVE RELAY SWITCHBOARD EQUIPENT LAYOUT" AND "CONTROL SWITCHBOARD AND PROTECTIVE RELAY SWITCHBOARD EQUIPENT LAYOUT"
3. THE SWITCHBOARD AND CABINET SHALL BE FINISH–PAINTED INSIDE AND OUTSIDE WITH RAL 7032 FULL GLOSS.
4. THE INTERPOSING RELAY CABINET FOR 1200 MM CABINET WIDTH SHALL HAVE TWO HINGED FRONT DOORS SIMILAR TO THE TWO HINGED REAR DOORS. THE OTHER DETAILS SHALL BE SIMILAR TO THE INTERPOSING RELAY CABINET WITH ONE HINGED FRONT DOOR.

NO.	DATE	REVISION	REF.
B	25/06/03	ISSUE FOR REVIEW (TASK 5)	
A	21/01/03	ISSUE FOR REVIEW (TASK 3)	

ATT Consultants Co.,Ltd. Electricite de France
CONSULTING SERVICES FOR SUBSTATION DESIGN AND STANDARD DRAWING AND SPECIFICATION PREPARATION

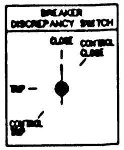
POSITION	SIGNATURE	DATE
DESIGNED	PRABHAS P.	2/12/45
TRACED	SAMRAN S.	13/12/45
CHECKED	JP. PARISOT	23/12/45
APPROVED	BANYAT P.	27/12/45

PROVINCIAL ELECTRICITY AUTHORITY
200 Ngam Wong Wan Road, Chatuchak
Bangkok Thailand

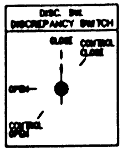
TYPICAL SUBSTATION INSTALLATOIN

TYPICAL CONTROL AND PROTECTION SWITCHBOARDS AND INTERPOSING RELAY CABINET DETAILED CONSTRUCTION

SCALE	1 : 25	0 0 T 1 0 N	01 REV.
FILE NAME	OOTION		01 B

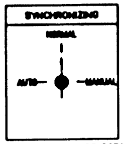


CONTACT	POSITION				REF.DWG. NO.	REMARK
	CONTROL TRIP	RETURN AFTER CONTROL TRIP	RETURN AFTER CONTROL CLOSE	CONTROL CLOSE		
1 - 2	X					
3 - 4				X		
5 - 6	X					
7 - 8				X		
9 - 10	X					
11 - 12				X		
13 - 14	X	X				
15 - 16			X	X		
17 - 18	X	X				
19 - 20			X	X		



CONTACT	POSITION				REF.DWG. NO.	REMARK
	CONTROL OPEN	RETURN AFTER CONTROL OPEN	RETURN AFTER CONTROL CLOSE	CONTROL CLOSE		
1 - 2	X					
3 - 4				X		
5 - 6	X					
7 - 8				X		
9 - 10	X					
11 - 12				X		
13 - 14	X	X				
15 - 16			X	X		
17 - 18	X	X				
19 - 20			X	X		

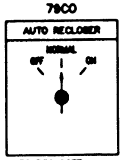
SS



SYNCHRONIZING SELECTOR SWITCH WITH HANDLE LOCKABLE & REMOVABLE AT "NORMAL" POSITION ONLY

CONTACT	POSITION			REF.DWG. NO.	REMARK
	AUTO	NORMAL	MANUAL		
1 - 2			X		
3 - 4			X		
5 - 6			X		
7 - 8			X		
9 - 10			X		
11 - 12			X		
13 - 14			X		
15 - 16			X		
17 - 18	X				
19 - 20	X				
21 - 22	X				
23 - 24	X				
25 - 26	X				
27 - 28	X				
29 - 30	X				
31 - 32	X				
33 - 34		X			
35 - 36		X			
37 - 38		X			
39 - 40		X			

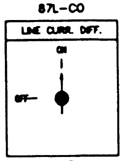
79CO



AUTO RECLOSER CUT-OFF SWITCH SPRING RETURN TO NORMAL "79CO"

CONTACT	POSITION			REF.DWG. NO.	REMARK
	OFF	NORMAL	ON		
1 - 2	X	—			
3 - 4	X	—			
5 - 6	X	—			
7 - 8	X	—			
9 - 10		—	X		
11 - 12		—	X		
13 - 14		—	X		
15 - 16		—	X		

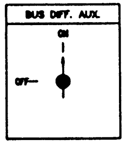
87L-CO



LINE CURRENT DIFFERENTIAL CUTOFF SW.

CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2	X			
3 - 4	X			
5 - 6		X		
7 - 8		X		

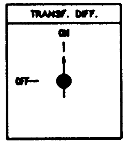
86B-CO



BUS DIFF.AUX. TRIP & LOCKOUT RELAY CUT-OFF SWITCH

CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2		X		
3 - 4		X		
5 - 6	X			
7 - 8	X			
9 - 10		X		
11 - 12		X		
13 - 14	X			
15 - 16	X			
17 - 18		X		
19 - 20	X			

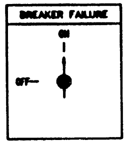
87T-CO



TRANSFORMER DIFFERENTIAL CUT-OFF SWITCH

CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2		X		
3 - 4		X		
5 - 6	X			
7 - 8	X			
9 - 10		X		
11 - 12		X		
13 - 14	X			
15 - 16	X			
17 - 18		X		
19 - 20	X			

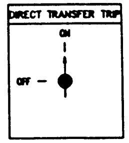
50BF-CO



CIRCUIT BREAKER FAILURE CUT-OFF SWITCH

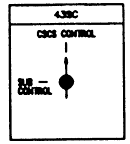
CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2		X		
3 - 4		X		
5 - 6	X			
7 - 8	X			
9 - 10		X		
11 - 12		X		
13 - 14	X			
15 - 16	X			
17 - 18		X		
19 - 20	X			

86DTT-CO



DIRECT TRANSFER TRIP CUTOFF SWITCH

CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2	X			
3 - 4	X			
5 - 6	X			
7 - 8	X			
9 - 10	X			
11 - 12	X			
13 - 14		X		
15 - 16		X		
17 - 18		X		
19 - 20		X		



SUBSTATION CONTROL/CSCS CONTROL SELECTOR SWITCH 43SC

CONTACT	POSITION		REF.DWG. NO.	REMARK
	SUB. CONTROL	CSCS CONTROL		
1 - 2	X			
3 - 4	X			
5 - 6	X			
7 - 8	X			
9 - 10	X			
11 - 12	X			
13 - 14	X			
15 - 16	X			
17 - 18	X			
19 - 20	X			
21 - 22	X			
23 - 24	X			
25 - 26	X			
27 - 28		X		
29 - 30		X		
31 - 32		X		
33 - 34		X		
35 - 36		X		
37 - 38		X		
39 - 40		X		
41 - 42		X		
43 - 44		X		
45 - 46		X		
47 - 48		X		
49 - 50		X		
51 - 52		X		

PUSHBUTTON SWITCH FOR "ON", "OFF", OR "RESET" FOR CONTROL AND PROTECTIVE SWITCHBOARD DEVICES

CONTACT	TYPE		REF.DWG. NO.	REMARK
	NO	NC		
1 - 2	X			
3 - 4		X		

NOTES :

1. ALL CONTROL, SELECTOR, CUTOFF AND PUSHBUTTON SWITCHES SHALL BE USED FOR DIRECT CONTROL SWITCH FUNCTIONS OF THE CONTROL SWITCHBOARDS WITHOUT USING THE INTERPOSING RELAYS. THESE SWITCHES SHALL BE FOR USE WITH THE FOLLOWING SUBSTATIONS :
   - –115 kV BREAKER AND A HALF WITH/WITOUT TRANSFORMER SUBSTATION
   - –115 kV SUBSTATION CONNECTED BY TIE LINE

2. NUMBER OF CONTACTS AND CONTACT ARRANGEMENT FOR EACH TYPE OF CONTROL, SELECTOR, CUTOFF AND PUSHBUTTON SWITCHES AS INDICATED HEREIN ARE MINIMUM REQUIREMENT ONLY. IF THE SCHEMES FOR CONTROL, PROTECTION AND OTHER EQUIPMENT AS PROPOSED BY THE CONTRACTOR AND APPROVED BY THE AUTHORITY, REQUIRE ADDITIONAL CONTACTS THAN THOSE LISTED IN THIS DRAWING, THE CONTRACTOR SHALL FURNISH THESE EXTRA CONTACTS AND CONTACT TABULATION WITHOUT ADDITIONAL COST TO THE AUTHORITY.

NO.	DATE	REVISION	REF.
B	[illegible]	ISSUE FOR REVIEW (TASK 5)	
A	[illegible]	ISSUE FOR REVIEW (TASK 3)	

ATT Consultants Co.,Ltd. Electricite de France
CONSULTING SERVICES FOR SUBSTATION DESIGN AND STANDARD DRAWING AND SPECIFICATION PREPARATION

POSITION	SIGNATURE	DATE
DESIGNED	PRADHAS P.	2/10/40
TRACED	SAMRAN S.	12/12/40
CHECKED	JP. PARISOT	22/12/40
APPROVED	SAWAT P.	27/12/40

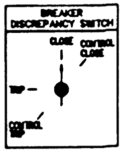
PROVINCIAL ELECTRICITY AUTHORITY
200 Ngam Wong Wan Road, Chatuchak
Bangkok Thailand

TYPICAL SUBSTATION INSTALLATION

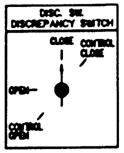
CONTROL, SELECTOR, CUTOFF AND PUSHBUTTON SWITCHES ESCUTCHEON PLATES AND CONTACT TABULATION

SCALE	NOT TO SCALE
FILE NAME	[illegible]

0 0 T 1 5 N

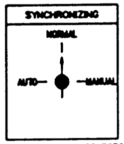


CONTACT	POSITION				REF.DWG. NO.	REMARK
	CONTROL TRIP	RETURN AFTER CONTROL		CONTROL CLOSE		
		TRIP	CLOSE			
1 - 2	X					
3 - 4				X		
5 - 6	X					
7 - 8				X		
9 - 10	X	X				
11 - 12			X	X		
13 - 14	X	X				
15 - 16			X	X		



CONTACT	POSITION				REF.DWG. NO.	REMARK
	CONTROL OPEN	RETURN AFTER CONTROL		CONTROL CLOSE		
		OPEN	CLOSE			
1 - 2	X					
3 - 4				X		
5 - 6	X					
7 - 8				X		
9 - 10	X	X				
11 - 12			X	X		
13 - 14	X	X				
15 - 16			X	X		

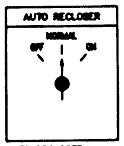
SS



SYNCHRONIZING SELECTOR SWITCH WITH HANDLE LOCKABLE & REMOVABLE AT "NORMAL" POSITION ONLY

CONTACT	POSITION			REF.DWG. NO.	REMARK
	AUTO	NORMAL	MANUAL		
1 - 2			X		
3 - 4			X		
5 - 6	X				
7 - 8	X				
9 - 10		X			
11 - 12		X			
13 - 14		X			
15 - 16		X			

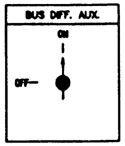
79CO



AUTO RECLOSER CUT-OFF SWITCH SPRING RETURN TO NORMAL "79CO"

CONTACT	POSITION			REF.DWG. NO.	REMARK
	OFF	NORMAL	ON		
1 - 2	X				
3 - 4	X				
5 - 6	X				
7 - 8	X				
9 - 10			X		
11 - 12			X		
13 - 14			X		
15 - 16			X		

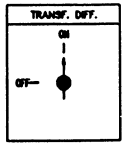
86B-CO



BUS DIFF.AUX. TRIP & LOCKOUT RELAY CUT-OFF SWITCH

CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2		X		
3 - 4		X		
5 - 6	X			
7 - 8	X			
9 - 10		X		
11 - 12		X		
13 - 14	X			
15 - 16	X			
17 - 18		X		
19 - 20	X			

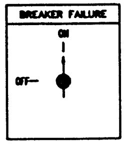
87T-CO



TRANSFORMER DIFFERENTIAL CUT-OFF SWITCH

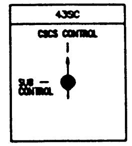
CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2		X		
3 - 4		X		
5 - 6	X			
7 - 8	X			
9 - 10		X		
11 - 12		X		
13 - 14	X			
15 - 16	X			
17 - 18		X		
19 - 20	X			

50BF-CO



CIRCUIT BREAKER FAILURE CUT-OFF SWITCH

CONTACT	POSITION		REF.DWG. NO.	REMARK
	ON	OFF		
1 - 2		X		
3 - 4		X		
5 - 6	X			
7 - 8	X			
9 - 10		X		
11 - 12		X		
13 - 14	X			
15 - 16	X			
17 - 18		X		
19 - 20	X			



SUBSTATION CONTROL/CSCS CONTROL SELECTOR SWITCH 43SC

CONTACT	POSITION		REF.DWG. NO.	REMARK
	SUB. CONTROL	CSCS CONTROL		
1 - 2	X			
3 - 4	X			
5 - 6	X			
7 - 8	X			
9 - 10	X			
11 - 12	X			
13 - 14	X			
15 - 16	X			
17 - 18	X			
19 - 20	X			
21 - 22	X			
23 - 24	X			
25 - 26	X			
27 - 28		X		
29 - 30		X		
31 - 32		X		
33 - 34		X		
35 - 36		X		
37 - 38		X		
39 - 40		X		
41 - 42		X		
43 - 44		X		
45 - 46		X		
47 - 48		X		
49 - 50		X		
51 - 52		X		

PUSHBUTTON SWITCH FOR "ON", "OFF", OR "RESET" FOR CONTROL AND PROTECTIVE SWITCHBOARD DEVICES

CONTACT	TYPE		REF.DWG. NO.	REMARK
	NO	NC		
1 - 2	X			
3 - 4		X		

NOTES :

1. EACH OF BREAKER DISCREPANCY CONTROL SWITCHES, DISCREPANCY CONTROL SWITCHES FOR 115 kV MOTOR OPERATED DISCONNECT SWITCHES, SYNCHRONIZING SELECTOR SWITCHES, AND RECLOSER CUTOFF SWITCHES SHALL BE THE INDIRECT CONTROL FUNCTION TYPE AND SHALL BE ACCOMPLISHED THE SWITCH FUNCTIONS BY USING THE INTERPOSING RELAYS. THESE SWITCHES SHALL BE USED WITH THE CONTROL AND PROTECTIVE RELAY SWITCHBOARDS AND ARRANGED ON THE DRAWING ENTITLED : "CONTROL AND PROTECTIVE RELAY SWITCHBOARD EQUIPMENT LAYOUT". THESE SWITCHES SHALL BE USED FOR THE FOLLOWING SUBSTATIONS :
   - 115 kV AIS MAIN AND TRANSFER BUS
   - 115 kV GIS DOUBLE BUS-SINGLE BREAKER
   - 115 kV AIS DOUBLE BUS-SINGLE BREAKER
   - 115 kV GIS H-CONFIGURATION
   - 115 kV AIS COMPACT H-CONFIGURATION

   FOR OTHER SWITCHES AS SHOWN ON THIS DRAWING WHICH DO NOT MENTION ABOVE SUCH AS TRANSFORMER DIFFERENTIAL CUTOFF SWITCH (87T-CO), BREAKER FAILURE CUTOFF SWITCH (50BF-CO) AND ETC SHALL OF THE DIRECT CONTROL TYPE WITHOUT USING THE INTERPOSING RELAY.

2. NUMBER OF CONTACTS AND CONTACT ARRANGEMENT FOR EACH TYPE OF CONTROL, SELECTOR, CUTOFF AND PUSHBUTTON SWITCHES AS INDICATED HEREIN ARE MINIMUM REQUIREMENT ONLY. IF THE SCHEMES FOR CONTROL, PROTECTION AND OTHER EQUIPMENT AS PROPOSED BY THE CONTRACTOR AND APPROVED BY THE AUTHORITY, REQUIRE ADDITIONAL CONTACTS THAN THOSE LISTED IN THIS DRAWING, THE CONTRACTOR SHALL FURNISH THESE EXTRA CONTACTS AND CONTACT TABULATION WITHOUT ADDITIONAL COST TO THE AUTHORITY.

NO.	DATE	REVISION	REF.
B		ISSUE FOR REVIEW (TASK 6)	
A		ISSUE FOR REVIEW (TASK 3)	

ATT Consultants Co.,Ltd. Electricite de France
CONSULTING SERVICES FOR SUBSTATION DESIGN AND STANDARD DRAWING AND SPECIFICATION PREPARATION

POSITION	SIGNATURE	DATE
DESIGNED	PRADHAS P.	2/12/46
TRACED	SAMRAN S.	13/12/46
CHECKED	JP. PARISOT	23/12/46
APPROVED	BANYAT P.	27/12/46

PROVINCIAL ELECTRICITY AUTHORITY
200 Ngam Wong Wan Road, Chatuchak
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TYPICAL SUBSTATION INSTALLATION

CONTROL, SELECTOR, CUTOFF AND PUSHBUTTON SWITCHES ESCUTCHEON PLATES AND CONTACT TABULATION

SCALE: NOT TO SCALE
FILE NAME: 00T15N-02

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