ANNEXURE-1A TO PY55295

STANDARD SPECIFICATION FOR HT SWITCHBOARDS

PROJECT	**75MW VISAKH REFINERY MODERNIZATION PROJECT (VRMP)**
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CONSULTANT	**ENGINEERS INDIA LIMITED**

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1.0 SCOPE

This specification covers the design, manufacture, testing, packing and supply of indoor, draw out type 11kV High Voltage Switchboards, incorporating Vacuum circuit breakers.

2.0 CODES & STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS: 5	Colours for ready mixed paints and enamels
IS: 1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS: 2071	High Voltage Test Technique
IS: 2544	Porcelain post-insulators for systems with nominal voltage greater than1000V
IS: 2705	Current transformers
IS: 3156	Voltage transformers
IS: 3231	Electrical relays for power system protection
IS: 3427	AC Metal enclosed switchgear and control gear for rated voltages above 1kV up to and including 52 kV
IS: 3618	Phosphate treatment of iron and steel for protection against corrosion
IS: 5082	Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
IS: 5578	Guide for marking of insulated conductors
IS: 6005	Code of practice for phosphating of iron and steel
IS: 9920	High voltage switches for rated voltage above 1 kV
IS: 9921	AC disconnectors (isolators) and earthing switches for voltage above 1000V
IS: 10601	Dimensions of terminals of high voltage switchgear and controlgear
IS: 11353	Guide for uniform system of marking and identification of conductors & apparatus terminals
IS: 12729	Common High voltage Switchgear and Controlgear standards
IS: 13118	High Voltage Alternating Current Circuit Breakers
IS: 13703	Low voltage fuses for voltages not exceeding 1000V AC or 1500V DC.
IEC 60282-1	High voltage fuses — Current Limiting fuses
IS/IEC 60470	High Voltage Switchgear Alternating Current Contactors and Contactor based motor starters
IS/IEC 62271 (Part 1, 102, 105, 200)	High Voltage Switchgear and Controlgear
IEC 62271	High Voltage Switchgear and Controlgear

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications/data sheet and statutory regulation, most stringent requirements shall prevail. However, owner's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

3.3 Vendor shall give a notice of at least one year to the end user of equipment and EIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

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4.0 SITE CONDITIONS

4.1 The switchboards shall be suitable for installation and satisfactory operation in a pressurized sub-station or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

4.2 The switchboards shall be designed to operate under site conditions as specified in the main specification PY55295.

4.3 All equipments described in this specification are intended for continuous duty operation, as per nameplate rating under the specified ambient conditions, unless indicated otherwise.

5.0 DESIGN AND FABRICATION REQUIREMENTS

5.1 Enclosure and Protection

5.1.1 The High Voltage Switchboard shall be metal-enclosed and shall comprise of standard pre-fabricated, cold-rolled, sheet steel units, assembled to form a rigid, freestanding, dead-front structure. As a minimum, 2mm (14 SWG) CRCA sheet steel shall be used for all front and rear doors and covers, and 1.6mm (16 SWG) CRCA sheet steel for inter-panel partitions. Wherever required, stiffeners shall be provided to increase stiffness of large size doors and covers.

As an alternative to CRCA, Aluzinc/pre-galvanised sheet steel can also be provided for internal inter-panel partitions only. However, all external surface shall be of CRCA with specified paint shade.

5.1.2 Vertical panels shall be assembled to form a continuous line-up of uniform height both for HV chamber as well as control chamber. Rear extension panels shall also be of full height.

5.1.3 The switchboards shall be totally enclosed and vermin-proof. If necessary, openings for natural ventilation shall be provided. These shall be louvered and provided with wire mesh having opening less than 1 mm. Design of louvers/ opening shall be such that the arc does not come out in case of internal arc. The same shall be type tested for internal arc, as specified. The enclosure shall have complete protection against approach to live parts or contact with internal moving parts (IP-4X) as per IS: 3427.

5.1.4 All openings, covers and doors shall be provided with suitable Neoprene/ XLPE/ EPDM gaskets around the perimeter to make the switchboard dust and vermin proof.

5.1.5 Each unit of the switchgear shall have necessary internal sheet metal barriers to form separate compartments for circuit breaker, busbars, instruments and relays, cable connections etc. Compartments for cable connections shall allow cable termination and connection work with the switchgear energised. Suitable interlock shall be provided such that cable compartment can be opened only when earth switch is ON or Earthing truck is inserted.

5.1.6 The panel shall be internal arc tested as per IS/IEC 62271-200 requirements for full short circuit current and for a duration of 0.1 second and shall be qualified to comply with all the 5 criteria as per IS/IEC 62271-200. Independent pressure relief devices shall be provided for all HV compartments, i.e. bus bar, cable and breaker compartments and each compartment shall have type test certificate for internal arc classification (IAC) as per IS/IEC 62271-200 for the short circuit current and duration as specified. IAC test shall be conducted on the offered panel variants such as smallest width panel, panel with louvers, panel with thermography window and any other variants (as applicable) as per job requirements. The panel shall also be AFLR tested as per IS/IEC 62271-200 requirements.

5.1.7 All identical equipment and corresponding parts shall be fully interchangeable.

5.1.8 Safety barriers / shutters shall be provided to permit personnel to work safely within an empty compartment with the bus bars energised. Loss of Service Continuity (LSC) category of the switchgear shall be LSC2B as per IS/IEC-62271-200.

5.1.9 It shall be possible to extend the switchgear in either direction at a later date. Ends of bus bars shall be suitably drilled for this purpose. Panels at extreme ends shall have openings, which shall be covered with plates screwed to the panel. Details of drilled holes in bus bar and openings in the panels, provided for future extension shall be clearly shown in the vendor drawings.

5.1.10 The drawout carriage on the switchboard shall have three positions: "Service", "Test" and "Drawout" viz:

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- "Full in" or "Service" position - In this position both power and control circuits shall be connected. This shall be the normal operating position of the circuit breaker.
- "Test" position - The power contacts shall be disconnected in this position but the control connections shall not be disturbed, it shall be possible to close and trip the breakers in this position.
- "Draw out" Position - both power and control circuits shall be disconnected in this position. Alternatively, "Test Position" with the secondary control circuit disconnected may be provided in lieu of "Draw out Position".

Circuit breaker operation shall be possible only in "Service" and "Test" positions. The circuit breaker shall be lockable in "Test" / "Draw-out" positions. Automatic safety shutters shall be provided to ensure the inaccessibility of all live parts after the carriage is drawn out.

There shall be a distinct overall door for the breaker compartment, which can be closed with the carriage in drawout position and it shall be lockable type.

5.1.11 All circuit breaker modules of the same rating shall be inter-changeable. Suitable interlocks shall be provided to prevent the following operations:
- "Plugging in" or "drawing out" of a closed breaker.
- "Plugging in" a breaker with the earthing isolator closed.
- "Closing" of the earthing isolator with the breaker "plugged in".
- Pulling out the auxiliary circuit plug with the breaker in the service position. Pushing in the breaker to the service position, with the auxiliary circuit plug not in position.

Additionally, the following shall also be provided:
- All operations such as breaker rack-in, breaker rack-out, breaker On/Off, spring charging, earth switch On/Off etc. shall be possible only with panel door closed.
- Pad locking arrangement shall be provided for rack in operation of breaker as well as for the panel door meeting LOTO requirements.

LOTO arrangement shall include provision for the following:
a) Provision for hooking lockout devices by multiple lock arrangement to prevent opening of panel door and racking-in of circuit breaker.
b) Provision for attaching tag-out device for warning against energisation and to provide information regarding date of isolation, agency working on the equipment, etc.
c) Provision for Hasp such that the same shall be put-in and closed in the locking arrangement of the breaker/switch and panel door.

5.1.12 All hardware shall be corrosion-resistant. All joints and connections of the panel members shall be made by zinc-passivated high-quality Grade 8.8 or superior steel bolts, nuts and washers, secured against loosening.

5.1.13 Suitable eyebolts/ lifting clamps shall be provided for the lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panels.

5.1.14 If specified in datasheet, light/ arc/ pressure based sensors with controller shall be provided to quickly detect internal arc and immediately initiate tripping action.

5.1.15 Thermo-graphy window for infrared electrical inspection shall be provided as specified in datasheet Annexure-1C. The switchgear with thermo-graphy window shall be type tested and certified for internal arc faults as per IS/IEC 62271-200 requirements.

5.2 **Accessibility:**

5.2.1 All relays, metering, and control components shall be mounted on the panel front only. However, auxiliary contact multiplier relays with auto reset can be mounted inside the panel.

5.2.2 The switchgear shall be considered to be accessible to authorized personnel having access all around and shall be tested for following type of accessibility as per IS/IEC 62271-200:
Type of accessibility AFLR

where
Accessibility type A : Restricted to authorised personnel only
F : for front side
L : for lateral side
R : for rear side

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5.2.3 Checking and removal of components shall be possible without disturbing adjacent equipment. All equipment shall be easily accessible. It shall be possible to set all measuring relays and instruments in-situ without de-energising the switchboard. All mounted equipment shall have identification tags of self-sticking PVC tapes at the rear also. In addition, permanent identification details shall be provided on the panel. Mounting of relays for a particular breaker feeder panel shall be limited to that particular feeder only.

5.2.4 All terminals shall be shrouded with plastic covers to prevent accidental contact.

5.3 **Bus bar:**

5.3.1 The switchboard shall comprise of 3-phase bus bars which shall extend through all units of the switchgear line-up. The main bus bars shall have uniform cross-section throughout their length and shall be sized to carry continuously the rated current specified in the data sheet.

5.3.2 Bus bars shall be of high conductivity electrolytic aluminium for 11kV, 2000A CPP Aux Switchboard & 11kV, 1250A Emergency Switch board. Bus bars shall be of high conductivity electrolytic copper for 11kV, 3500A, Utility switch board.

5.3.3 Bus bars shall be supported on insulators made of non-hygroscopic, non-inflammable material with tracking index equal to or more than that defined in Indian standards. Self supporting busbars can also be accepted provided the same is type tested design.

5.3.4 Bus bars shall be housed in a separate chamber and shall be accessible for inspection. Wire guards /cover shall be provided inside the enclosure to avoid accidental contact when the cover is removed.

5.3.5 Both bus bars and the supports shall be adequately sized and braced to withstand the specified short-circuit current for 1 second. Dynamic stresses shall be calculated on the basis of the specified peak short-circuit current. All bus supports shall be of non-carbonising material, resistant to acids and alkalies.

5.3.6 Bus bars shall be insulated by using heat-shrinkable sleeves suitable for withstanding heat under worst operating condition. The sleeves shall be rated to withstand the system line-to-line voltage for 1 minute. This shall be verified by a type test in which the line voltage will be applied between the sleeved main bus bar and an aluminium foil wrapped closely around the insulation over a length of at least 500mm.

5.3.7 All bus bar joints and all tap-off connections from the main horizontal bus bars shall be provided with removable FRP/PU/PVC shrouds. The material of the shrouds shall be flame retardant (FR).

5.3.8 Bus bars shall be prominently marked with Red, Yellow and Blue colour rings/ stickers for easy phase identification at regular interval and at every power tap off point.

5.3.9 The thermal design of the bus bars shall be based on installation of the switchgear in poorly ventilated conditions. The cooling air volume shall take into account only the bus bar enclosure.

5.3.10 The hot spot temperature of busbars, including joints, at design ambient temperature shall not exceed 90°C under normal operating conditions while for silver plated joints, the allowable maximum temperature shall be 115°C in line with IS/IEC-62271-1.

5.3.11 Only zinc passivated high tensile strength high-quality Grade 8.8 or superior steel bolts, nuts and washers shall be used for all busbar joints and supports.

5.3.12 The current rating as defined for switchboard and components in Single line diagram (Annexure-3) are for design ambient temperature at site conditions and for being inside the cubicle at fully loaded condition. The vendor shall suitably derate the nominal rating to suit the above condition.

5.4 **HV Power Connections:**

5.4.1 The incoming power connection shall be through XLPE cables / busduct and outgoing power connection shall be through XLPE cables, as indicated in the single line diagram (Annexure-3). Ample space for connection of these cables shall be provided at the rear of the switchboards. In order to avoid accidental contact in the cable compartment while carrying out inspection by opening the rear cover, a removable expanded metal barrier/ wire mesh shall be provided in the cable compartment. In order to facilitate infra-red electrical inspection through thermography window, metal barrier/ wire mesh may not be

provided. Unless otherwise specified, the power cable shall enter the switchboard from the bottom. Non-magnetic cable gland plates shall be provided for feeders wherever single core cables are used.

5.4.2 The switchboard shall be supplied complete with supports for clamping outgoing and incoming cables. The head-room available between cable gland plate and terminal lugs shall not be less than 600 mm for 11kV switchgear.

5.4.3 In case the standard panel depth cannot accommodate the specified number of cables, a rear extension panel of full height shall be provided. An earth strip shall also be brought to this extension panel.

5.4.4 All power cables shall enter the switchgear from the bottom.

5.5 **Auxiliary Wiring and Terminals:**

5.5.1 Inside the cubicles, the wiring for control, signalling, protection and instrument circuits shall be done with BIS approved, PVC insulated, flame retardant low smoke (FRLS) type, copper conductor wire. The insulation grade shall be 660 V. The wiring shall preferably be enclosed in plastic channels or neatly bunched together. Wiring between I-W breakers or cable compartments to relay and metering compartments shall be routed through flexible conduits.

5.5.2 A minimum of 10% spare terminals shall be provided on each terminal block. Conductors shall be terminated with adequately sized compression-type lugs for connection to equipment terminals and strips. Stranded conductors shall be soldered at the ends/ crimped with suitable lugs before connections are made to the terminals. Sufficient terminals shall be provided on each terminal block to ensure that not more than one outgoing wire is connected per terminal. Terminal strips shall preferably be separated from power circuits by metal barriers or enclosures. All spare contacts of auxiliary relays, timers, etc shall be wired up to the terminals.

5.5.3 Each wire shall be identified at both ends by correctly sized PVC ferrules. Shorting links shall be provided for all CT terminals.

5.5.4 PVC insulated copper conductor of cross section 1.5 mm2 may normally be used provided the control fuse rating is 10A or less. For 16A control fuse circuit 2.5 mm2 copper conductors shall be used. Each wire shall be terminated at a separate terminal. CT Circuit wiring shall be done with 2.5 mm2 copper conductors. Shorting links / suitable shorting arrangement for shorting CT secondary shall be provided.

5.5.5 All control cables shall enter the switchgear from the bottom.

5.5.6 Supporting facilities shall be provided for clamping the control cables.

5.5.7 All inter-panel control wiring within each shipping section shall be by switchgear vendor. The inter-panel wiring shall be taken through PVC sleeves or suitable grommets. For inter-panel wiring between the shipping sections, wires in rolls of the required length, connected at one point, shall be supplied with the panel for connection at site.

5.6 **Control and Indication:**

5.6.1 Breaker tripping, closing and spring charging devices shall be fed with DC control power supply. The rated DC voltage shall be as specified in the data sheet (Annexure-1C). The power supply for breaker opening, closing and indication devices shall be arranged as follows:

a. One DC feeder shall be provided for each bus section. The bus coupler panel may be fed from any of the two supplies.
b. One separate, single-phase power supply shall be provided for each bus section for feeding space heaters, etc. Supply voltage shall be 240 V AC.
Provision to receive DC and AC control supply shall preferably be provided in bus-coupler panel / bus PT panel.

5.6.2 Breaker positions (CLOSE, OPEN, spring-charged, test position, service position) shall be indicated mechanically. Electrical indications, with colours as given below, shall also be provided:

Breaker 'CLOSED'	:	Red lamp
Breaker 'OPEN'	:	Green lamp
Breaker 'Auto-trip'	:	Amber lamp
Trip circuit healthy	:	White lamp

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Spring charging : Blue lamp

5.6.3 A common DC control supply fail indication shall be provided for each bus section with a blue coloured lamp.

5.7 **Earthing Connections**

All cubicles shall be connected to an earth bus bar running throughout the length of the switchboard. The minimum earth bus bar size shall be 50 x 6 mm^2 copper. All doors and movable parts shall be connected to the earth bus with flexible copper connections. Provision shall be made to connect the earthing bus bar to the plant earthing grid at two ends. All non current-carrying metallic parts of the equipment and components shall be earthed. The earth bus shall be brought back to the cable compartment, and earthing bolts shall be provided to ground cable armour. The mating surfaces of all bolted parts shall be zinc passivated to ensure continuity between them.

5.8 **Space Heaters**

The panels shall be provided with space heaters to prevent moisture condensation, and maintain cubicle temperature 5°C above the ambient. The space heaters shall be located at the bottom of the panel, and shall be controlled through a double pole MCB and a thermostat with an adjustable setting range of 30 to 70°C. The thermostat shall preferably be located in the metering or relay chamber. Space heaters shall be supplied from 240V AC auxiliary bus for space heater.

5.9 **Panel Supporting Frame**

The panels shall be suitable for installation on panel supporting frame, to be supplied by others. The panels shall be suitable for tack welding, directly to this frame.

5.10 **Nameplates**

5.10.1 The switchgear shall be provided with durable and clearly legible nameplate in accordance with Table-1 of IS/IEC 62271-200 requirements.

5.10.2 A nameplate with the switchboard designation shall be fixed at the top of the central panel. A separate nameplate giving details for each feeder compartment of all panels shall be provided. Danger plate (Red) shall be provided at the front and rear for each panel.

5.10.3 The nameplates for feeder compartments shall be in two parts. One part shall have necessary details pertaining to the compartment's number of vertical panel of the switchboards. The other parts shall be removable and shall contain all details regarding the feeder number for drives/equipment controlled by the particular module as per approved single line diagram.

5.10.4 Blank nameplates shall be provided for all spare and vacant modules.

5.10.5 Nameplate or polyester adhesive stickers shall be provided for each equipment mounted inside the switchboard. Special warning plates shall be provided on removable covers or doors giving access to cable terminals and bus bars.

5.10.6 Engraved nameplates shall preferably be of 3- ply (Black-White-Black) lamicoid sheets or anodised aluminium. However back engraved perspex sheet nameplates may also be acceptable. Nameplates shall be fastened by screws and not by adhesives.

5.11 **Painting**

5.11.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. Alternately, supplier's standard paint procedure as per their ISO standard is also acceptable. The under surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.2 After preparation of the under surface, the switchboard shall be spray painted with two coats of epoxy based final paint or shall be powder coated.

5.11.3 Colour shade of final paint shall be as RAL 7032.

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5.11.4 The finished panels shall be dried in stoving ovens in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint etc. Vendor shall supply final paint (1 litre per switchboard) in non-returnable container for final touch up at site.

5.11.5 All unpainted steel parts shall be Zinc passivated or suitably treated to prevent rust formation. If these parts are moving elements then they shall be greased. Aluzinc/ pre-galvanised sheet, wherever provided, need not be painted.

6.0 SWITCHBOARD COMPONENTS

6.1 Circuit Breakers

6.1.1 Vacuum circuit breakers shall be used in the switchboard. The exact type and rating of breakers shall be as indicated in the Feeder list (Annexure-06) & Single line diagram (Annexure-03). Breaker transport trolleys required for cassette-mounted breakers shall be provided for each switchboard. Number of trolleys to be provided shall be as per annexure-11 of specifications.

6.1.2 Vacuum circuit breakers shall be designed to have low switching-over voltage levels and with a long switching life. The interrupter shall be leak-free.

6.1.3 The breakers shall have at least 6 normally open (NO) and 6 normally closed (NC) spare auxiliary contacts for purchaser's use. If these are not available, auxiliary relays shall be used to multiply the auxiliary contacts of the breakers.

6.1.4 The breakers shall have a motor-operated, spring-charging mechanism. It shall also be possible to charge the springs manually. The closing spring shall get re-charged (for subsequent closing) soon after a closing shot and prior to breaker tripping. In case the limit switch fails to cut out the spring-charging motor with the springs fully charged, the motor shall be automatically de-coupled or else positive isolation (at both ends) of power supply to spring charging motor shall be ensured. The control circuit shall be suitable for local as well as remote control. Breakers shall be trip-free and shall have an anti-pumping device. The breaker operating duty shall be O-3min.-CO-3min.-CO, unless otherwise agreed.

6.1.5 Operating Mechanism

a) Electric power operating mechanism shall be motor wound spring charged stored energy type. However, manual-operating mechanism may be of the spring charging stored energy type or spring assisted type. For circuit breakers with electrical power operating mechanism, provision shall also be made for manual spring charging. Closing time of circuit breakers with manual operating mechanism shall be independent of the speed of the operating handle.

b) All stored energy operating mechanisms shall be equipped with the following features:

   i. Failure of springs, vibrations or shocks shall not cause unintended operation of breaker or prevent intended tripping operation.
   ii. Closing of circuit breakers shall be prevented unless the spring is fully charged.

c) All electrical power operating mechanisms shall be suitable for remote operation and shall be equipped with following features:

   i. Provided with motors operable on AC or DC control supplies as specified.
   ii. Provided with emergency manual charging facility. The motor shall be automatically, decoupled (mechanically) once the manual-charging handle is inserted.
   iii. Closing operation of circuit breaker shall automatically initiate charging of the spring for the next closing operation without waiting for tripping of circuit breaker.
   iv. Closing operation shall be completed once the closing impulse is given and the first device in the control scheme has responded even though the control switch / Push Button is released, provided no counter trip impulse is present.

6.1.6 Circuit breaker trip and closing coils, in case of electrically operated breakers, and trip coil in case of mechanically operated breakers and circuit breaker indication shall be suitable for satisfactory operation on a control supply system indicated in data sheet (Annexure-1C). Additional second shunt trip coil (operating on different control voltage supply) shall also be provided as specified in the datasheet (Annexure-1C).

6.1.7 All circuit breakers shall be provided with mechanically operated emergency trip device. This device shall be available on the front of the panel. Mechanically operated 'closing' device shall be provided for all breakers. However mechanical closing shall be inhibited for all circuit breakers in service position.

6.1.8 The breakers shall be provided with anti-pumping & trip free feature. Each breaker shall be also provided with an operation counter.

6.1.9 For all HV VFD feeders, breaker shall be provided with one no. shunt trip coil and with under voltage release. However, in case it is not possible to provide under voltage release in the standard design, as an alternative, two shunt trip coils shall be provided. One shunt trip coil shall be suitable for switchgear DC control supply while second shunt trip coil shall be suitable for external AC control supply. The control supply voltage level shall be as specified in data sheet (Annexure-1C).

6.1.10 Metal Oxide surge suppressors shall be provided on outgoing vacuum circuit breakers as indicated in single line diagram (Annexure-3) to limit the over voltage to a maximum of 2.2 p.u. rated peak line to earth voltage. Sizing calculations for surge suppressor shall be provided post order.

6.1.11 Line PT shall be mounted in a separate drawout carriage. In case of truck mounted breaker, line PT shall be provided in a separate panel.

6.1.12 The complete breaker assembly should have inter-changeability with breakers of identical ratings.

6.1.13 The maximum height of the operating handle/switches/reset knobs/pushbuttons shall not exceed 1900 mm and minimum height shall not be below 300 mm.

6.1.14 A separate earthing carriage/truck, shall be provided. The necessary trolleys for bus-side and cable-side earthing shall be supplied. After withdrawing the circuit breaker, this can be inserted to facilitate earthing of cables and bus bars. Earthing truck shall be complete with the PT and voltmeter, giving audio-visual indication and solenoid interlock to prevent closing of bus side earthing truck on live busbars. Earthing truck operation shall be only with door closed. Integral earthing truck shall be suitable for short time withstand current and peak withstand current rating equal to the corresponding breaker withstand rating.

6.1.15 Number and type of earthing trucks shall be as specified in the feeder list (Annexure-06).

6.2 **Instrument Transformers**

Current and voltage transformers shall be cast-resin insulated. The primary and secondary terminals shall be marked indelibly and easily approachable for termination and testing etc.

6.2.1 Current transformer

i. Current transformers shall conform to IS: 2705. The short-time rating shall be equal to that of the switchboard. They shall be mounted on the stationary part of the switchboard. The CT ratings shall be as shown in the single line diagram (Annexure-03). Protective CTs shall have an accuracy class of 5P and an accuracy limit factor greater than 10. CTs for instruments shall have an accuracy class of 1.0 and an accuracy limit factor less than 5.0. For numerical relays having protection and metering functions, dual rated CT shall be provided suitable for protection class and metering class. One leg of the CTs shall be earthed. Separate CTs shall be provided for Differential and Restricted Earth fault protection.

ii. All CTs shall be star connected. Interposing CT (ICT) shall be provided (if required) for differential protection of transformers having star-delta connection.

iii. Proper access to each set of CTs shall be provided for repair / maintenance.

6.2.2 Potential transformer

i) The potential transformers shall conform to IS: 3156. The potential transformers shall be of drawout-type, and shall be provided with 4 pole miniature circuit breakers with auxiliary contacts on the secondary side.

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ii) The drawout mechanism shall disconnect the PT from the busbars. The primary connection shall be disconnected before the PT becomes accessible. Neutral point of the star connected PTs both on the primary and secondary sides shall be earthed.

iii) The PTs shall have an over-voltage factor of 1.9 for 30 seconds, and an accuracy class of 1.0 from 10% to 120% of normal voltage. PT selected shall be compatible with system grounding.

iv) The primary rated voltage shall be equal to the rated voltage V of the system, or $V/\sqrt{3}$, if the PT is connected between phase and neutral.

v) If not otherwise specified, the secondary voltage shall be 110 V, or $110/\sqrt{3}$ V. The burden and class of accuracy shall be as specified in single line diagram (Annexure-03). For directional relays, either a 3-phase 5-limb PT, or 3 single-phase PTs with secondary windings connected in open delta shall be provided.

6.3 **Measuring Instruments**

All analogue instruments shall be of square pattern, 96 x 96 mm, flush-mounted type. Measuring instruments shall be provided, as specified in the single line diagram (Annexure-03) . All required auxiliary equipment such as shunts, transducers, CTs, PTs, etc, shall be included in the scope of the switchboard supplier. The accuracy class for all instruments shall be 1.0 as per IS: 1248.
Digital instruments shall also be acceptable, provided specific approval of EIL/Owner for make and model is obtained before placement of switchboard order.

6.3.1 Ammeters and voltmeters

Analogue meters shall be of moving-iron type. The range shall be as indicated on the drawings. Ammeters for motor feeders shall have a non-linear compressed scale above rated current to indicate motor starting current.

6.4 **Relays**

6.4.1 Protection relays shall be numerical type as specified on the switchboard SLD. All other relays shall be electromagnetic type.

6.4.2 All electromechanical protective relays shall be back-connected, of drawout type, suitable for flush mounting, and fitted with dust-tight covers. Alternatively, "plug-in" type relays will also be acceptable. Auxiliary relays are acceptable in fixed execution.

6.4.3 The protective relay cases shall have a provision for insertion of a test plug at the front for testing and calibration using an external power supply without disconnecting the permanent wiring. The insertions of the test plug shall automatically short circuit the CTs and permit extension of external power supply to the relay.

6.4.4 All protective relays shall have hand reset facility and clear operating indication, e.g. flags for electro-mechanical type relays or light emitting diodes for numerical type relays. It shall be possible to reset the flag without opening the relay case.

6.4.5 All tripping relays (electrical fault trip) shall be of lockout type with hand-reset contacts, and shall be suitable to operate on the specified voltage. These relays shall have self coil cut off contacts, and shall be provided with hand-reset operation indicators. However, for process trip, the lock out relay shall be self reset type Tripping relays will be acceptable in non-drawout cases.

6.4.6 The tripping relay shall be suitable for satisfactory operation from 50% to 110% of the specified control supply voltage.

6.5 **Auxiliary Equipment**

6.5.1 Auxiliary relays and contactors:

Auxiliary relays and contactors shall generally be used for inter-locking and multiplying contacts. Auxiliary contacts shall be capable of carrying the maximum anticipated current.

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6.5.2 Control Switches:

i) All control switches shall be rotary type, having a cam-operated contact mechanism otherwise stated. Circuit breaker control switches shall be 3-position CNT, spring return to neutral from both Close and Trip positions. They shall have pistol-grip handles and shall be lockable.

ii) Ammeter selector switches shall have a make-before-break feature on its contacts. The selector switch shall generally have four positions, three positions for reading 3-phase currents and the fourth position for OFF. The voltmeter selector switch shall also have four positions, three positions shall be used to measure phase-to-phase voltages and the fourth position shall be for OFF.

6.5.3 Timers:
For re-acceleration duty, timers unless otherwise stated, shall be pneumatic type and shall have adjustable time setting of 0-60 seconds. Alternatively static timer may be considered. The time settings, where specified, shall be accurately set before despatch of the switchboard. Timer provided for control of capacitor feeder shall have minimum setting of 0-5 minutes.

6.5.4 Indicating Lamps:
Clustered LED type indicating light with minimum 8mm diameter size shall be provided for indications. The LED shall have a low glow voltage protection and shall not glow on voltage leakage.

6.6 **Operating Philosophy:**

6.6.1 Auto changeover between incomers and bus coupler for 11 kV system shall be provided. Additionally manual change over through synchro-check relay with momentary paralleling shall also be provided. All necessary hardware shall be included to achieve auto, independent and manual operation of incomers and bus coupler.

6.6.2 Auto/Manual change over scheme for switchboard with two incomers and one bus-coupler breakers shall comply with the logic described briefly as follows. Safety interlocks as deemed necessary shall however be considered during detailed engineering.

AUTO CHANGEOVER:

(a) Auto changeover between the two incomers and one bus-coupler shall be in such a way those two-incomer breakers are 'ON' at a time and bus-coupler breaker is normally open.

(b) Bus-coupler breaker is made 'ON' automatically in case the incoming supply at incomer breaker no. 1 or 2 fails and the respective breaker trips on under voltage.

(c) Blocking of auto transfer (i.e., closing of bus-coupler) if any incomer breaker trips due to a fault. Trip due to 64R shall allow the transfer.

(d) Tripping of incomer on under voltage shall be blocked, if both the incomers simultaneously experience an under voltage.

MANUAL CHANGEOVER:

(a) Incomer no. 1 and 2 breakers are 'ON'. Bus-coupler breaker is 'OFF' Manual closing of bus-coupler with momentary paralleling (interlocked with check synchronizing relay) of the incoming supplies to facilitate taking out any of the incomer breakers for maintenance.

(b) Trip incomer 1 or 2 (pre-selected) after closing of coupler to avoid continuous paralleling of incomers.

INITITIATION OF AUTO CHANGEOVER:

(a) When the incoming supply to breaker no. 1 or 2 fails, the respective incomer is tripped through under voltage relays and a timer. The time delay is in the range of 0.5 to 5 sec. Breaker trip on under voltage is blocked in case of power failure on both the incomers.

(b) The voltage on healthy bus section has been above the set value of normal voltage for a specified duration (settable through a timer 0.5-5 sec) and the incomer breaker of healthy bus is closed in service position.

(c) Bus-coupler is open and in-service position.

(d) Auto/ Manual switch is set for 'AUTO' operation.

CLOSING OF BUS COUPLER BREAKER UNDER AUTO OPERATION:

(a) One of the incomer breaker has tripped on under voltage.

(b) The residual voltage on the bus that has lost supply is less than 40% of normal voltage.

(c) Incoming voltage of healthy incomer has been above 80% of normal voltage for a specific duration of 3 sec. (Through timer 0.5 sec - 5.0 sec)

(d) Auto/ Manual switch is set for 'AUTO' operation.

SPECIFIC BLOCKING OF AUTO TRANSFER:

(a) Bus-coupler should not close, if any of the two incomer's trips due to faults. However on operation of REF of transformer, it should not be blocked.

MANUAL TRANSFER AFTER AUTOCHANGEOVER:

(a) When supply is again available at incomer breaker after auto changeover has already taken place, it is possible to restore the system to normal operating condition by operating selector switch (meant for tripping incomer no. 1 or 2 or bus-coupler) and by setting auto/ manual switch in 'Manual' mode.

(b) In manual transfer the closing circuit shall be interlocked through check synchronizing relay.

7.0 INSPECTION, TESTING AND ACCEPTANCE

7.1 During fabrication, the switchboard shall be subject to inspection by EIL / Owner, or by an agency authorised by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used. The manufacturer shall furnish all necessary information concerning the supply to EIL / Owner's inspectors.

7.2 All relevant routine tests shall be conducted as per applicable standards which shall be witnessed by the Purchaser/Engineer. All routine tests shall be performed as per latest amendments of IS / IEC. For all other type tests, test certificates for switchgear of similar rating and design shall be furnished for review. If similar type test certificates are not available, then those type tests shall be carried out without any extra cost to the purchaser.

8.0 PACKING AND DESPATCH

The switchboard shall be divided into several shipping sections for protection and ease of handling during transportation. All outgoing feeders shall be packed as separate shipping sections. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The panels shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', `PO number.' etc., shall be clearly marked on the package together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should also be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed.

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