

**JOHANNESBURG WATER (SOC) Ltd.**

**BULK WASTEWATER**

**PARTICULAR SPECIFICATION**

**E13 : ELECTRICAL MEDIUM VOLTAGE**

**SWITCHGEAR**



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Revision 4

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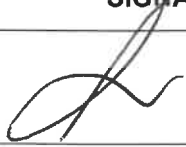

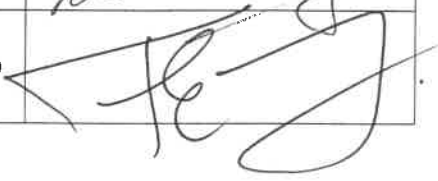
## DOCUMENT CONTROL SHEET

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**PARTICULAR SPECIFICATION: VOLUME E13: ELECTRICAL MEDIUM VOLTAGE SWITCHGEAR**  
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## **E13.1 SCOPE**

This specification covers the supply, delivery, installation, testing and commissioning of indoor metal-clad switchgear and associated equipment.

## **E13.2 STATUTORY DOCUMENTS AND STANDARDS**

### **E13.2.1 Standards**

All materials and apparatus shall be new and of the best quality and shall comply with the relevant current specifications of the SANS, BSI or IEC and as stated in this document.

The following standards may be used as a guide but must not be regarded as a complete list.

SANS 62271-1	: High-voltage switchgear and controlgear Part 1: Common specifications for alternating current switchgear and controlgear
SANS 62271-200	: High-voltage switchgear and controlgear Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
SANS 62271-103	: High-voltage switchgear and controlgear Part 103: Switches for rated voltages above 1 kV up to and including 52 kV
SANS 62271-100	: High-voltage switchgear and controlgear Part 100: Alternating-current circuit-breakers
SANS 62271-102	: High-voltage switchgear and controlgear Part 102: Alternating current disconnectors and earthing switches
SANS 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
SANS 62271-107	: High-voltage switchgear and controlgear Part 107: Alternating current fused circuit-switchers for rated voltages above 1 kV up to and including 52 kV
SANS 62271-206	: High-voltage switchgear and controlgear Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV
SANS 60282-1	: High-voltage fuses Part 1: Current-limiting fuses
SANS 60529	: Degrees of protection provided by enclosures (IP Code)
SANS 60044-8	: Instrument transformers Part 8: Electronic current transformers
SANS 61869-2	: Instrument transformers Part 2: Additional requirements for current transformers
SANS 61869-3	: Instrument transformers Part 3: Additional requirements for inductive voltage transformers
IEC 62271-1	High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear
IEC 60255	: Measuring relays and protection equipment

**E13.2.2** Particular Specifications to be read in conjunction with this specifications

The following particular specifications shall be read in conjunction with the Project Specification:

- (a) E06 : ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION
- (b) E05 : LOW VOLTAGE POWER AND CONTROL CABLE
- (c) E20 : BATTERY TRIPPING UNIT
- (d) E08 : WIRING

**E13.3 SERVICE CONDITIONS**

Nominal voltage	11 kV
Rupturing capacity	20 kA
Impulse level	95 kV
Highest system voltage	12 kV
Rated short-time withstand current (Ik)	20 kA (1 S)
Frequency	50 Hz
Phases	3
Power factor	0,5 - 0,85 lagging

All switchgear and auxiliary equipment shall be designed to withstand the stresses of an unearthed system.

**E13.4 EXTENT OF WORK**

The successful Tenderer will be responsible for the delivery, off-loading and erection on site, testing and putting into operation of the switchgear. The Contractor shall furthermore be responsible for checking all connections made by others and for commissioning the switchgear. All paintwork damaged during transport and/or erection and/or connecting up, etc., shall be made good to the satisfaction of the Engineer.

**E13.5 SWITCHGEAR LAYOUT**

The switchboard shall be designed as a continuous assembly in a straight line, capable of being extended at either end.

The switchboard will be located in a totally enclosed, naturally ventilated chamber and shall be suitable for installation directly on a finished floor.

**E13.6 CUBICLE CONSTRUCTION**

**E13.6.1** General

All cubicles shall be of the totally enclosed, floor mounted type and shall be vermin proof and where possible dustproof. The cubicles shall have a minimum enclosure rating of IP 42 to SANS 60529.

Cubicles shall be designed so that it is possible to add additional panels to existing switchboards without undue difficulty.

**E13.6.2** Segregation of circuits

Each circuit in a switchboard shall be provided with an individual cubicle so arranged that accidental contact with live parts in adjacent circuit cubicles is impossible.

It shall be possible to terminate the cables of any circuit without exposure to any live conductors

of the same circuit while the busbars are energized.

#### E13.6.3 Doors

Where doors are provided on circuit breaker switch cubicles, the doors shall be fitted with handles consisting of a push-button-and-handle combination with a spring-loaded latch or a rotary handle-and-catch combination. The closing mechanism shall be designed to draw the door closed. Flush mounted ring type handles or square key operated latches are not acceptable. Locking latches shall be padlockable.

Doors shall be suitably braced and stiffened to carry the weight of equipment installed in doors and to prevent warping.

Control panel doors shall be fitted with handle closing mechanisms as described above. Alternatively, captive knurled bolts designed to be screwed in by hand may be used.

Doors shall have stops to prevent overswing of the door when opening and to prevent interference with adjacent panels.

Doors shall be fitted with suitable rubber or synthetic rubber seals.

All doors shall be bonded to the framework by a braided copper earth strap.

#### E13.6.3.1 Earthing

All metal parts other than those forming part of electrical circuits shall be connected to the cubicle earth bar.

All non-current carrying conductive parts, including relays, instruments, transformer and contactor cores, etc. shall be effectively connected to the earth bar either by means of their mounting arrangements on the panel or by means of a special earthing conductor fitted with lugs for attaching to the earth bar.

### **E13.7 CIRCUIT BREAKERS**

#### E13.7.1.1 General Construction

Circuit breakers may be of the trip-free, double break, SF6 or vacuum type.

Circuit breakers shall be of the horizontal draw-out truck mounted type with either vertical or horizontal isolation action.

Each circuit breaker shall be installed in a freestanding metal clad cubicle and the front of each panel shall be totally enclosed.

It shall be possible to remove the circuit breakers from the cubicles without moving the cubicle, without removing parts thereof or without disconnecting any wiring thereto.

Any circuit breaker shall be interchangeable with any other panel of the board of the same rating. It shall not be possible to insert a circuit breaker into a higher rated circuit.

Contact spouts, bushings, covers, busbar insulators, etc. shall be designed to minimise dust collection.

Mechanical stops shall be provided to ensure accurate location of the circuit breaker truck prior to racking into the service position. The breaker carriage shall be locked in position on both sides of the cubicle with a robust mechanical lock that will not distort or jam under fault conditions.

All openings, joints, etc., in the entire switchboard shall be adequately vermin proofed.

All components including screws, nuts, bolts, washers, etc. used in the construction of or fixing of components shall be rendered corrosion proof.

#### E13.7.1.2 Circuit breaking features

The circuit breaker contacts shall ensure rapid and consistent extinction of the arc with a minimum release of arc energy under all loading and fault conditions and a low power factor.

The arcing contacts shall be tipped or coated with an erosion resistant material, preferably a tungsten alloy.

The main contacts shall be self-aligning with a high contact pressure and a self-cleaning action.

#### E13.7.1.3 Busbar and circuit shutters

Protective shutters, which automatically cover the contacts of the fixed portion of the switchgear when the circuit breaker is withdrawn to the isolation position, shall be provided.

The busbar orifices shall be provided with automatic separate shutters.

Facilities shall be provided for padlocking the shutters in the closed position.

All shutters shall close automatically after being opened by hand and it shall not be possible for the shutters or shutter operating links to be jammed by the circuit breaker.

Shutters shall be painted and designated as follows:

##### (a) Busbar shutters

The word "BUSBAR" in black lettering on a red background.

- Circuit shutters

The word CABLE in black lettering on a yellow background.

- Earthing shutters

The word "EARTH" in black lettering on a green background.

- Lettering shall be a minimum of 40 mm high.

#### E13.7.1.4 Interlocks

The switchgear shall be mechanically interlocked in accordance with SANS 62271 and all interlocks shall be robust and shall not distort or jam in the event of an incorrect operation. The minimum safety features provided shall prevent the following actions:

- (a) A closed circuit breaker from being withdrawn from or inserted into the isolating contacts. The circuit breaker shall trip if an attempt is made to do so.
- (b) The closing of the circuit breaker except when it is correctly located and fully racked in the "service" or "earthing" positions or in the fully lowered position. It must, however, be possible to close the circuit breaker when it is fully withdrawn from the cubicle.
- (c) The lowering of the tank of circuit breakers unless the circuit breaker is fully withdrawn and the racking-in of the circuit breaker unless the tank is securely bolted in position.
- (d) The circuit breaker from being closed when the secondary circuits are not fully engaged. It shall also not be possible to remove the secondary circuit plugs unless the circuit breaker contacts are fully open.
- (e) Electrical tripping of the circuit breaker when the circuit breaker is in the earthed position. Padlocking facilities shall also be provided to lock off the mechanical trip lever on the breaker mechanism.
- (f) The integral earthing switch (where applicable) from closing unless the circuit breaker is in the correct earth position. It must not be possible to close the earth switch onto live busbars.

#### E13.7.1.5 Secondary isolating contacts

The connections in the secondary circuit between the fixed and moving portions of the equipment shall be by means of self-aligning contacts. Robust guide pins or other approved guides shall engage before the contacts.

Circuit breaker auxiliary contacts for functions common to the various panel type specified, shall be wired to secondary isolating contacts in the same relative position on all panel types specified.

The secondary isolating contacts must be so arranged that when the circuit breaker is in the lowered or racked down position the secondary isolating contacts can still be made without the addition of separate jumper equipment.

#### E13.7.1.6 Position stops

Immediately prior to racking in, positive stops shall be engaged to locate the circuit breaker in the



correct position relative to the busbar selection guides or other approved means shall be provided to ensure accurate entry into the guides.

A positive stop shall be provided to ensure correct location without danger of "over-run" in the "racked in" position.

#### E13.7.1.7 Earthing

Integral earthing facilities shall be provided.

Integral earthing facilities through the circuit breaker are preferred, but separate earthing devices or earthing switches mounted on separate trucks are acceptable.

Where separate earthing devices or earthing trucks are supplied, the gear shall be suitable for use on all the circuit breakers in a switchboard and shall also be suitable for earthing either the busbar or the cables. A full set of earthing devices or earthing trucks shall be supplied for each switchboard.

Earthing equipment shall have a making capacity and a rated short-time withstand current (Ik) equal to the rest of the switchboard.

#### E13.7.1.8 Capacities and Fault Levels

The complete primary circuit (CB's, busbars, etc.) shall be capable of withstanding the rated short time withstand current.

The circuit breakers shall have continuous current ratings as specified in the Detail Technical Specification.

There shall be no audible corona discharge under working conditions. These requirements shall be taken to be complied with only if the audible corona extinction voltage is less than 9 kV to earth or 14 kV between phases.

Compliance may be conceded if it can be shown that any discharge below the specified levels takes place at points remote from all dielectric materials, and cannot cause their deterioration.

The switchgear shall have an assigned impulse rating of not less than 95 kV at sea level, supported by recent test certificates proving successful testing, using a standard 1/50 micro-second voltage wave, on identical units manufactured in the factory from which an order would be executed.

Circuit breaker tanks and top plates shall be capable of withstanding, without permanent distortion, a hydraulic pressure of 700kPa for 1 minute, unless a lower pressure is approved after reference to actual pressures measured during short circuit tests.

Each circuit breaker shall be clearly and indelibly marked to show the current and voltage ratings and breaking capacities.

#### E13.7.1.9 Closing Mechanisms

The closing mechanism shall be either of the hand charged, spring or hand operated, spring assisted or motor wound spring charging or solenoid operated types as specified in the Detail Technical Specification.

The closing action of the hand operated, spring assisted mechanisms shall ensure that once closing is initiated the action becomes independent of the operator.

All mechanisms shall be of the trip-free type and it shall not be possible for the mechanism to maintain the circuit breaker in a "closed" position during fault conditions or when the "open" signal has been initiated.

The electrical closing circuitry shall be open circuited as soon as the closing sequence has been completed to prevent continued electrical loading of the closing circuitry and to deactivate the closing signal until a new sequence is initiated.

Where auto-reclosing duties are specified, the mechanisms shall be capable of performing a "BREAK-MAKE-BREAK" operation.

All electrically operated closing devices shall be at least suitable for operation at any voltage between 80% - 120% of the nominal control voltage at the device terminal. The nominal control

voltages are specified in the Detail Technical Specification.

Anti-pumping devices shall be provided on all mechanisms to prevent pumping while the closing circuit remains energised and the circuit breaker either fails to latch or trip during closing due to the operation of the protection system. The arrangement shall be to the approval of the Engineer.

**E13.7.1.10 Tripping Mechanisms**

A manual tripping mechanism shall be provided on each circuit breaker. It shall be clearly marked "MANUAL".

Where shunt tripping is specified DC shunt trip coils shall be provided. The rated control voltage shall be as specified in the Detail Technical Specification.

Shunt trip coils shall be suitable for operation at any voltage between 80% - 120% of the nominal voltage at the device terminals.

Secondary contacts operated by the circuit breaker mechanism shall be provided and rated to interrupt the maximum trip coil current after the circuit breaker has opened. These contacts shall close the tripping circuitry before the circuit breaker closes.

**E13.7.1.11 Racking Mechanisms**

The racking mechanisms for inserting or withdrawing the circuit breaker shall be designed and constructed to provide a positive action throughout the operations.

**E13.7.1.12 Indicating devices**

Each circuit breaker shall be equipped with mechanical indicators to indicate the switching positions and the state of the spring mechanisms (if applicable).

A mechanical indicator shall also be provided to indicate whether the circuit breaker is racked in or out.

All mechanical indicators shall be clearly visible from the front of the panel.

In all cases positive indication must be provided.

**E13.7.1.13 Auxiliary Contacts**

Circuit breakers shall be provided with sufficient auxiliary contacts to suit the circuits served.

Auxiliary contacts shall be positively driven in both directions and shall be readily accessible for maintenance and shall be properly adjusted where necessary.

At least two spare normally open and two spare normally closed contacts shall be provided and shall be completely wired to an accessible terminal block.

**E13.8 NON-AUTOMATIC SWITCHES AND FUSED SWITCHES**

**E13.8.1 General**

The switches shall be of the fault-making, load-breaking type with earthing and testing facilities.

The switches shall be manufactured and tested in accordance with SANS 62271.

**E13.8.2 Construction**

The switches shall be totally enclosed, metal-clad, air or SF6-insulated type.

The switch units shall be designed for extension with circuit breaker panels described in this specification and/or similar switch units.

Each unit shall be installed in a free standing metal clad cubicle and the front of the cubicle shall be totally enclosed.

The switch may be either of the horizontal draw-out with vertical or horizontal isolation, or non-withdrawable fixed tank types.

**E13.8.3 Busbar and circuit shutters**

Busbar and circuit shutters shall be provided on all withdrawable type switches as specified for circuit breakers.

#### E13.8.4 Interlocks

The mechanism shall be incapable of moving directly to the "EARTH" position from the "ON" position.

A time delay shall be built into the mechanism to prevent immediate opening of the switch after closure. This shall be achieved by means of non-reversible operating handles, mechanical sliding interlocking gates or a non-reversible movement.

Padlocking facilities shall be provided.

Access to the testing facilities shall only be possible with the switch in the "EARTH" position. With the testing devices fitted operation to either the "ON" or "OFF" positions shall be prevented.

Interlocks shall be provided on withdrawable type switches to prevent:

- The switch from being withdrawn from or inserted into the isolating contacts.
- The closing of the switch except when it is correctly located or fully withdrawn.
- The opening of the tank unless the switch is fully withdrawn and the racking-in of the switch unless the tank is securely fitted.

##### E13.8.4.1 Operating Mechanism

The switch shall have three positions, namely "ON", "OFF" and "EARTH".

Except for removing the earth, the switch actuating mechanism shall have a positive action and shall be spring assisted to ensure that once the operation is initiated, it becomes completely independent of the operator.

The fused switch shall close fully when making onto a fault to ensure full clearance of the fault by the fuses before tripping and opening the switches.

A blown fuse on any of the three phases shall open all three phases of the switch and shall inhibit the closure of the switch pending fuse replacement.

##### E13.8.4.2 Earthing

Integral cable earthing facilities shall be provided for non-withdrawable switch units. For withdrawable switches earthing facilities similar to that of circuit breakers shall be provided.

##### E13.8.4.3 Cable Test Facilities

Cable test facilities are required and must be easily accessible.

Refer to paragraph 8.4 regarding interlocking of test facilities.

In the event of a separate test unit being provided, it shall be easily fitted.

##### E13.8.4.4 Ratings

The fault making capacities, impulse levels and busbar ratings shall be identical to the ratings of the circuit-breakers installed in the same switchboards.

The continuous current rating of a switch shall not be less than 400 A and that of a fused switch not less than 90 A.

Each unit shall be clearly marked to show the current and voltage ratings and fault making capacity.

##### E13.8.4.5 Indicating Devices

Each switch shall be equipped with positive mechanical indicators to indicate the switching position and the racked mode (where applicable).

All indicators shall be visible from the front of the panel.

Potential indicator lights shall be provided to indicate the status of all three phases of the cable circuit.

##### E13.8.4.6 Fuses

Fuses shall comply with SANS 60282-1.

Fuse links shall be of the striker pin type, hermetically sealed and shall be suitable for use under oil.

The fuse link carriage shall be suitable to accept either 254 mm or 359 mm long fuses both with a diameter of 63,5 mm. The carriage shall be adjustable for this purpose and shall not necessitate additional parts.

Automatic shutters shall be provided to safeguard against inadvertent contact with live parts when the fuse carriage is removed.

The ratings of the fuses shall be as specified.

## **E13.9**

### **BUSBARS**

#### **E13.9.1**

##### Design and rating

Busbars shall be manufactured of solid drawn high conductivity copper with rectangular cross-section in accordance with BS 159, SANS 1195 and BS 13601, where applicable.

The busbars shall be rated for the continuous current carrying capacity specified in the Detail Technical Specification and the fault levels specified in paragraph 1.3. The busbars shall be designed to withstand mechanical and temperature stresses for normal and fault conditions taking into account correction factors for different configurations, "proximity and skin" effects, the effect of ferrous enclosures, ventilation, etc. The maximum allowable temperature of busbars carrying full load at the specified ambient temperature is 80°C. Tables 1 and 2 may be used as a guide to determine the current rating of the busbars.

**Table 1 :Derating Factors for Laminated Busbars**

Area of cross-section (mm)	Number of parallel busbars per phase		
	2	3	4
500	1,78	2,24	3,13
1 000	1,72	2,36	3,00
1 500	1,65	2,24	2,84
2 000	1,60	2,16	2,70
2 500	1,55	2,10	2,60
3 000	1,52	2,02	2,52
3 500	1,48	1,98	2,48
4 000	1,44	1,96	2,45

**Table 2 : Current Rating of Single Copper Busbars (A)**

Width (mm)	Thickness (mm)						
	2,5	3,15	4,0	6,3	10	12,5	16
12,5	155	180					
16	190	220	250				
20	230	265	300				
25	280	320	365	470			
31,5	340	385	440	560			
40	420	475	540	680	870		
50	510	575	650	820	1030	1160	
63			790	990	1240	1370	
80			970	1200	1480	1640	
100			1160	1430	1760	2180	
125				1710	2100	2310	2570
160				2070	2530	2780	3090
200						3290	3660
250						3900	4300
315						4630	5120
400							6230

In additions to current rating busbars shall comply with the following fault level rating:

$$A = 8,2 \times I \times (t)$$

where:

A = minimum cross section (mm)

I = prospective fault current (kA)

t = maximum time in seconds required for protection equipment to clear the fault.

(Minimum allowable value for t = 3s.)

Where a busbar consists of two or more busbars per phase (laminations), the laminations shall be separated by a minimum distance of the thickness of one lamination. The laminations shall be clamped together with copper spacers at intervals not exceeding 450 mm in order to equalize the current distribution in the laminations.

Busbars shall be able to carry the rated current along their entire length. Tapering is not permitted.

The manufacturer shall, where requested, provide design calculations of the busbar ratings.

Busbars shall be as short and straight as possible.

Busbars shall be adequately ventilated and shall be situated in separate, totally enclosed, dust free, metal enclosures.

At each end of a switchboard a removable cover shall be fitted to the busbar chamber in order to extend the switchboard in both directions in the future.

The busbar ends shall be suitably manufactured and drilled for future extensions without modifications to the existing busbars.

#### E13.9.1.1 Insulation and joints

All busbars and connections shall be air insulated and shall be shrouded with heat-shrinkable sleeving or shall be epoxy resin encapsulated. PVC taping, insulating compound or oil immersion is not acceptable. The colours shall correspond to the colour of the supply phase:

Red, Yellow or White                      Phases

Blue or Black                                Neutral

Busbar joints and tees shall be encased in a non-hardening compound and taped with PVC tape unless suitable shrouds are provided.

The complete primary system shall withstand the full power frequency test voltage specified by SANS 62271 and the insulations level of all busbars and connections shall be in accordance with the values specified in paragraph 8.3.

Where connections between busbars and any other part of the switchgear consist of bare copper conductors, and no other insulation except air exists between phases or phases and earth, the clearance distances and insulator lengths shall be in accordance with SANS 62271 with correction for altitude as required.

#### E13.9.1.2 Earth busbar

An earth busbar shall be installed in a convenient position along the entire length of the switchboard. The cross-sectional area of earth busbars shall be calculated in accordance with the following formula in IEC 439 with a minimum cross-section of 6,3 x 20 mm:

$$S = \frac{I \sqrt{t}}{X \sqrt{dT}} \quad \begin{matrix} \frac{1}{2} \\ \frac{1}{2} \end{matrix}$$

where

S = cross-section (mm)

I = the r.m.s. value of the current (A)

X = 13 for Copper

t = operating time of protective equipment (s)

(Minimum value for t = 3 s)

dT = temperature rise (°C)

= 120°C for insulated conductors

= 180°C for uninsulated conductors

If t is between 2 s and 5 s then dT may be increased in the same formula

to:

dT = 145°C for insulated conductors

= 215°C for uninsulated conductors

In addition the longer side of the earth bar shall be at least twice the diameter of the largest bolt that will be fitted to the busbar.

## **E13.10 SECONDARY CIRCUITRY**

### **E13.10.1 Cabling**

Gland plates, suitably drilled to accept the glands for all the external power, control protection and DC supply cables, shall be provided.

The internal wiring to be connected to the cabling mentioned above shall be terminated on numbered terminal strips in close proximity to the gland plate in order that the cable cores can be connected directly to the opposite sides of the terminal strips.

#### **E13.10.1.1 Wiring**

All wiring shall present a neat appearance and shall be suitably braced, placed in wiring channels or clipped and/or laced.

Connections to equipment mounted on doors shall be arranged to give a twisting motion and not a bending motion to the conductors.

All panel and equipment terminals, labels, etc. shall be completely accessible after the wiring and cabling has been completed.

Conductors shall be identified at both ends by means of durable closed ring interlocking cable marking ferrules. PVC or other tape is not acceptable. The numbers on the markers shall also be shown on the wiring diagrams.

Where conductors are terminated on equipment terminals that do not require the use of lugs, the identification ferrules shall be fixed so that they do not fall off when disconnecting a conductor.

Identification ferrules shall read from the terminal along the wire.

All wiring terminating on meters, fuse holders and other equipment with screwed terminals, shall be fitted with lugs. The lugs shall be soldered or crimped to the end of the conductor.

Secondary wiring shall generally consist of insulated stranded copper conductors with a minimum cross-sectional area of 2,5 mm<sup>2</sup>. Solid core conductors are not acceptable. Flexible cords not smaller than 1,0 mm<sup>2</sup> shall be installed between equipment mounted on doors and the rest of the switchboard. For voltage ratings in excess of 50 V the wiring insulation shall withstand a test voltage of 2 kV to earth for one minute. For voltages of 50 V or less the insulation shall withstand 500 V to earth for one minute.

All wiring between different panels within the same switchboard shall be installed in wiring channels. Grommets shall be installed in each hole in the metalwork through which conductors pass. Wiring shall also be kept away from exposed metal edges or shall be protected where they cross metal edges. All wiring shall be installed away from terminals, clamps or other current carrying parts.

Conductors may be jointed at equipment terminals or numbered terminal strips only.

To minimize the effect of electrolysis, DC circuits shall be so arranged that the isolating or N/O operation contacts are connected to the positive pole of the battery.

#### **E13.10.1.2 Secondary terminals**

All external wiring and connections to auxiliary contacts, all alarm, protection, intertripping, DC supply circuits, etc. shall terminate on numbered terminal strips. All numbers shall appear on the switchboard drawings.

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

Where stud type terminals are provided they shall have a minimum size of 0 B.A.

Approximately 10% with a minimum of 2 spare terminals shall be provided on each terminal strip.

Terminal and test blocks of a reputable manufacturer, complying with the requirements of SANS 60947-7-1 shall be provided in each panel for the secondary wiring of the current transformers.

## **E13.11 CURRENT TRANSFORMERS**

### **E13.11.1 General**

Current transformers shall comply with the requirements of SANS 60044-8 with the exception of the required impulse test level, refer to paragraph E13.11.6 below.

### **E13.11.2 Ratings**

Current transformers shall be suitable for the primary currents and secondary ratings as specified in the detail specification.

Current transformers shall have secondary outputs of 2.5, 5, 10, 15 or 30 VA as applicable in terms of the burden of the instruments and interconnecting wiring. The current transformer output shall match the actual instrument burden as closely as possible in order not to introduce unnecessary errors.

#### **E13.11.2.1 Accuracy Class**

For metering applications, accuracy classes of 0.1, 0.2, 0.5, 1, 3 or 5 are applicable. Where no accuracy class has been specified, the following table may be used as a guide:

Application	Primary current	Suggested class
Indicating instruments	All	5
Metering applications	Up to 200 A	2
Metering applications	250 to 600 A	0,5
Metering applications	800 A and above	0,2

Where ring type current transformers are specified, the aperture shall not be unnecessarily large as accuracy is thereby reduced.

The classes for protection are 5P, 10P, 15P, 20P or 30P with 5P and 10P being standard. Turns compensation shall be employed on protection current transformers for ratios greater than 30/1.

Class X current transformers shall be used in differential protection systems.

Manufacturers shall supply the magnetization curve details and saturation factors for each different transformer ratio.

#### **E13.11.2.2 Markings**

All current transformers shall come complete with a label on which the following information is indelibly stamped:

- Manufacturer
- Serial No. or Type
- Rated primary and secondary current
- Rated frequency
- Rated output and accuracy class
- Highest system voltage
- Rated insulation level

A duplicate of this label must be attached in a position which is clearly visible on the inside of the protection panel. The specific connections for both the high and low ratio's of a dual-ratio CT, must be clearly labelled at a visible position in the protection panel.

#### **E13.11.2.3 Fault Current**

Current transformers shall be capable of withstanding the dynamic forces resulting from the maximum through-fault current which may be encountered at the point where they are installed. The short time current rating of current transformers shall be at least equal to that of the associated circuit-breaker.



E13.11.2.4 Impulse Level

Current transformers used in system voltages in excess of 660 V shall withstand an impulse test level of 95 kV.

E13.11.2.5 Tests

One protection current transformer of each type used in a contract shall be tested to confirm the estimated characteristics. The following results shall be submitted:

- (a) Magnetization curve
- (b) Secondary resistance
- (c) Secondary leakage reactance, if not negligible or if required by the Engineer.

The power frequency, secondary to earth and overvoltage interturn tests in accordance with BS 3938 shall be conducted on all current transformers. Impulse tests shall be conducted on all current transformers intended for use in system voltages in excess of 660 V.

**E13.12 VOLTAGE TRANSFORMERS**

E13.12.1 General

Voltage transformers shall comply with SANS 61869-1 and 3 where applicable.

The voltage transformers are of the epoxy resin insulated type and are used to supply measurement and protection devices. VT's can be installed as a fixed assembly or installed on removable and withdrawable trucks. Fixed voltage transformers can be installed directly on the main busbar system in a dedicated VT compartment. Withdrawable trucks must allow replacement of the fuses with the switchgear in service. The withdrawable truck arrangement must be fitted with automatic shutters between the live parts of the switchgear and the instrument compartment. The VT can have one pole (L-N) with a secondary voltage of  $110/\sqrt{3}$  (63.5V) or two poles (L-L) in which case the secondary voltage shall be 110 V unless specified to the contrary.

E13.12.1.1 Voltage Transformer Protection

The primary side of all voltage transformers shall be connected to the circuit through high voltage HRC fuses. Fixed VT installations will have external MV fuses and withdrawable VT installations will have internal MV fuses.

Secondary HRC fuses or protective circuit breakers shall be provided on the output terminals, located in the LV compartment.

E13.12.1.2 Voltage Transformer Ratings and Tests

The voltage transformers shall have an output suitable for the connected load but at least 200 VA per phase at class B accuracy.

The voltage ratios shall be suitable for the primary busbar and the required output voltages.

Voltage transformers shall be tested in accordance with BS 3941 and shall withstand an impulse level of 95 kV.

**E13.13 CURRENT AND VOLTAGE SENSORS**

Current and voltage sensors shall comply with SANS 61869.

- (a) IEC 61869-10: Instrument transformers - Part 10: Additional requirements for low-power passive current transformers
- (b) IEC 61869-11: Additional requirements for low power passive voltage transformers

Current and voltage sensors are designed without the use of a ferromagnetic core. The current sensor is based on the principle of Rogowski coil. Voltage sensor uses the principle of resistive voltage divider. The main benefit is that the behaviour of the sensor is not influenced by magnetizing curve that results in a highly accurate and linear response across a wide dynamic range of measured quantities. The linear and highly accurate characteristic curve of the sensor

across its full operating range enables several metering and protection classes to be combined in one particular winding.

## **E13.14 PROTECTION RELAYS**

Protection relays shall comply with IEC 60255: Measuring relays and protection equipment.

Digital protection relays which use a microprocessor to analyse power system voltages, currents or other electrical quantities for the purpose of detection of faults in an electric power system will be supplied. The characteristics and behaviour of the protection relay must be programmed to requirements. The protection relay must offer multifunctional protection (overcurrent and earth-fault as a minimum).

The protection relay should offer the following features:

- (a) Self-checking facility;
- (b) Local HMI display with basic system parameters shown;
- (c) Low burden on current and voltage sensors;
- (d) Communication port for the connection to a LAN;
- (e) Adaptive relaying schemes which can vary its setting parameters in response to changes in the power system;
- (f) Storage of historical data with time stamping;
- (g) Simple and easily maintainable.

## **E13.15 INSTRUMENTS**

### **E13.15.1**

#### **General Requirements**

Instruments shall be suitably rated for the supply voltage and frequency to be applied, which shall be 400/230 V, 50 Hz unless specified to the contrary.

All the instruments used for a particular application or a specific project shall be from the range of a single reputable supplier and shall have the same face dimensions. The face dimensions shall be square and not less than 96 x 96 mm.

All instruments shall comply with IEC 60051-1.

Instruments shall be screened against magnetic interference and shall have anti-static against magnetic interference and shall have anti-static, impact-resistant faces.

Preference will be given to locally manufactured instruments.

Instruments shall be insulated to achieve a 2 kV insulation resistance to earth.

All instruments shall be splash proof and dustproof unless more stringent requirements are specified for hazardous locations.

Instruments shall be sufficiently resistant to vibration that may be encountered in the specific application.

For normal environmental and supply conditions, instruments shall be suitable for use inside the limits specified in IEC 60051-1.

All instruments shall be capable of withstanding overloads of continuous or short duration in accordance with IEC 60051-1.

Instruments shall be provided with studs for rear connection. Shrouds shall be provided to prevent accidental contact where instruments are to be installed in hinged panels of switchboards.

### **E13.15.1.1 Voltmeters and Voltmeter Selector Switches**

Voltmeters shall be of the moving iron type with class 1,5 accuracy as specified in IEC 60051-1.

A zero adjustment screw shall be provided.

Unless specified to the contrary, a single voltmeter and selector switch shall be provided. The voltmeter switch shall have an "OFF" and three metering positions to indicate readings between neutral and each of the three phases.

The markings shall be indicated clearly on the face plate of the selector switch and the handle position shall be accurate in relation to the markings on the face plate.

The selector switch shall be of the cam-actuated or wiping air break type with two breaks per pole.

#### E13.15.1.2 Ammeters

Ammeters shall have a moving iron element to indicate instantaneous values.

Current transformer operated ammeters shall be 5 A full scale, calibrated to read actual primary circuit currents. The current transformer ratio shall be indicated on the faceplate.

A zero adjustment screw shall be provided.

Where combined maximum demand and indicating ammeters are specified, a bimetallic spiral element shall be provided in the same housing to indicate mean value over a 15 minute period.

The bimetal element shall drive a residual pointer to indicate maximum mean current between resetting. This pointer shall operate on the main scale and shall be of a distinctive colour. The pointer shall be resettable from the face of the meter.

The bimetal element shall be designed to compensate for limits of ambient temperature between -20°C and 70°C.

Full load or rated current shall be clearly indicated, preferably with a red line. Unless specified to the contrary, a 100% condensed over scale shall be provided for instantaneous reading instruments and no over scale for combined maximum-demand ammeters.

The intrinsic error, expressed in terms of the fiducial value in accordance with IEC 60051-1, shall be class 1,5 for the instantaneous readings and class 2,5 for the mean maximal.

Where saturation current transformers are required, these shall form an integral part of the meter. Separate saturation current transformers are unacceptable.

### E13.16 AUXILIARY EQUIPMENT

#### E13.16.1 Control Switches

Circuit-breaker closing and tripping control switches shall close the associated circuit breaker when rotated clockwise.

Control switches may be fitted with one pair of lazy contacts, i.e. contacts which make when the control switch is turned to the closed position, remain closed when the handle returns to the neutral position and only open when the control switch is moved to the trip position.

The switches shall be provided with a suitable faceplate indicating the angle of throw and the switching positions.

The switches shall be suitable for the supply voltage and the contacts shall be silver-plated or gold laminated and shall be suitably rated for the switching functions intended.

Control switches shall be lockable in the "NEUTRAL" or "OFF" position.

#### E13.16.2 Fuses

All fuses for the protection of auxiliary circuits shall be of the high rupturing capacity cartridge type and shall be mounted on insulated draw-out carriers which shall hold the fuses positively after withdrawal.

The top terminal shall be the live terminal in all cases.

HRC fuses shall be provided in the positive leads of all DC circuits.

Fuses shall be so positioned that they are readily accessible to a person standing on the floor in front of the panel.

Labels shall be fitted adjacent to fuses stating their use, rating and duty.

**E13.16.3**      Indicator Lamps

The following indications shall be provided:

Function .....	Colour
Circuit-breaker closed .....	Red
Circuit-breaker open .....	Green
Incoming supply available (on incoming panel only) .....	White
Auto-trip.....	Amber
Trip circuit healthy .....	White

A lamp test pushbutton for all the indicating lights shall be provided on each switchboard.

The "trip circuit healthy" indication shall normally be off and a pushbutton shall be provided to indicate the status. The purpose of the indication is to ensure that the tripping voltage supply is available on the panel before the circuit-breaker is closed. An indicator light with pushbutton is required on each panel and one indication per switchboard is not sufficient. The circuitry shall be arranged to provide indication with the circuit breaker in both the "OPEN" and "CLOSED" positions.

The conditions indicated shall be designated below each light.

**E13.16.4**      Voltage Indicator System

All switchgear will be fitted with a capacitive divider voltage indicator system (VDS) connected to the cable side of the switchgear. All systems supplied will permit phase comparison (with specialised measuring Units) All VDS's will comply with IEC 61243-5.

**E13.16.5**      Instrument Test Blocks

For the purpose of connecting external test equipment or instruments in the secondary circuits of the current transformer or potential circuits, these circuits shall be wired via an approved test block mounted on each panel.

The test blocks shall be fitted with terminal strips and links for performing the various short circuiting and bridging functions.

**E13.16.6**      Labels

Labels shall be made of durable material to approval. Metal labels where used shall be engraved or etched. Labels made of trifoliate or other similar materials shall have engraved lettering. Self-adhesive printed tape labels shall not be used. All labels shall be fixed mechanically.

**E13.17**      **CABLE END BOXES**

Cable end boxes to accept the cables specified for each panel shall be provided.

The boxes shall be of the metal clad type suitable for indoor use. These shall be equipped with armour clamps and brass or gunmetal conical wiping glands for lead covered steel tape or galvanized steel wire armoured, paper-insulated cables or XLPE galvanized steel wire armoured cables (as specified in the Detail Technical Specifications).

The cable boxes shall be fitted with insulating pieces to allow for the possible future installation of frame leakage busbar zone protection when specified in the Detail Technical Specifications.

Cable boxes shall be so designed that cable terminal connections can be made below compound level.

**E13.18**      **FINISH**

The switchboards shall be finished with a high quality paint applied according to the best available method. Baked enamel, electrostatically applied powder coating or similar proven methods shall be used.

## **E13.19 LABELS**

Care shall be taken to ensure that all equipment is fully labelled.

Panel designation labels shall appear on the front and back of each panel and on the circuit breaker truck.

Engraved sandwiched interchangeable plastic or ivory strips shall be used throughout. The strips shall bear white lettering on a black background.

Labels shall be secured by means of brass bolts, nuts and washers. Where this is not practicable cadmium-plated self-tapping screws may be used. The gluing of labels will not be acceptable. Sufficient fixing screws shall be provided to prevent labels from warping.

## **E13.20 BATTERY TRIPPING UNIT**

Please refer to specification E24: Electrical battery Tripping Unit

A battery tripping unit, suitable for connection to a 230 V, 50 Hz, single-phase ac supply shall be provided with each switchboard. The charger shall be metal-clad and shall be suitable for charging a Ni-Cad battery with voltage and capacity as specified in the detail specification. The charger shall be such that the change-over from trickle to boost charge is automatic. The tripping unit shall be supplied complete with fuses on the ac supply side and on the outgoing dc. side of the charger, an ammeter to indicate the charging current, a voltmeter with spring-loaded push buttons to indicate battery voltage and a circuit to test the state of battery charge.

## **E13.21 TESTS**

All component parts of the equipment shall be subject to type tests and routine tests in accordance with the relevant SANS, BSI or IEC standard specifications.

Circuit breakers shall be subjected to the following tests in accordance with IEC 62271-1, adjusted for atmospheric correction:

- (a) Type Tests
  - Mechanical endurance
  - Temperature rise
  - Dielectric strength and impulse voltage
  - Making and breaking capacity and short time current
- (b) Routine tests
  - Power, frequency, voltage
  - Resistance of the main circuit
  - Mechanical operation.

### **E13.21.1 On site tests**

The equipment shall be tested on site after erection and prior to commissioning.

The following minimum tests shall be performed:

- (a) Pressure tests on the primary and secondary circuits in accordance with IEC 62271-1.
- (b) Insulation resistance tests.
- (c) Primary injection tests.
- (d) Earth continuity and earth resistance tests.
- (e) Operating tests.
- (f) Any other tests which may be required to ascertain the correct functioning of the equipment.

The contractor is to provide a schedule of tests to be done on site prior to commencement of manufacture for approval by the engineer. This schedule must be ticked off prior to commissioning.

After putting the panel to service for a minimum 1 week, a thermal image must be scanned and analysed for any hot spots. The image should be presented as part of the Operations and Maintenance manual.

E13.21.2 Test Certificates

Copies of type test certificates shall be submitted together with the tender.

Copies of test certificates of all other tests i.e. routine tests and on site tests shall be forwarded to the Engineer on completion of the tests.

E13.21.3 Test Performance and Inspection

The Engineer shall be notified in writing at least two weeks in advance of any tests to be conducted to allow its representative to be present at such tests.

The Engineer shall also be notified timeously of the completion of the equipment in order that an inspection may be carried out prior to delivery.

**E13.22 TOOLS AND AUXILIARY EQUIPMENT**

The following equipment shall be provided with each switchboard and the cost shall be included in the tender price:

- (a) One raising and lowering handle for every three circuit breakers.
- (b) One complete set of special maintenance tools for all sizes of circuit breakers.
- (c) A full set of earthing devices or earthing trucks.
- (d) One wall mounted steel box for the storage of the above loose equipment. The door shall be padlockable.
- (e) At least six spare HRC fuses of each rating for secondary circuits and three high voltage HRC fuses for the voltage transformer.
- (f) One cable test unit for each size circuit breaker or oil switch housed in a wall-mountable metal box.

**E13.23 TECHNICAL INFORMATION**

Tenderers shall submit descriptive literature of the equipment with their tenders.

Three copies of erection, operating and maintenance instruction manuals covering each type of equipment shall be provided with each switchboard.

**E13.24 DRAWINGS AND DIAGRAMS**

E13.24.1 Drawings for Approval

A set of three prints of the following drawings shall be submitted to the Engineer for approval.

- General arrangement drawings
- Detailed dimensional drawings
- Schematic diagrams
- Wiring diagrams
- Foundation drawings.

The approval of drawings shall not relieve the Contractor of his responsibility to the Engineer to supply the switchboards according to the requirements of this Specification.

E13.24.2 Final drawings

On completion, a complete set of final transparent drawings shall be delivered to the Engineer. These drawings shall include the following:

- (a) An accurate "as built" wiring diagram of the complete installation showing circuit numbers, terminal strip numbers, conductor colours and numbers, etc.

- (b) A schematic diagram clearly showing the functions of all equipment.
- (c) An equipment schedule showing the make, model and characteristics of all components used, including a recommended spare list.
- (d) Fully dimensioned "as built" physical layout of the panel.

#### **E13.25 COMPLETION**

The contract shall be regarded as incomplete until all tests have been conducted successfully and all drawings and manuals have been handed to the Engineer.

#### **E13.26 MEASUREMENT AND PAYMENT**

<u><b>Item</b></u>	<u><b>Unit</b></u>
Supply medium voltage switch or fused switch panels .....	No

The unit of measurement shall be the number of panels supplied.

The rate shall include full compensation for the supply and delivery of switch panel complete with busbars, cable boxes and potential indicators as specified. Separate items will be scheduled for switch and fused switch panels.

<u><b>Item</b></u>	<u><b>Unit</b></u>
Install medium voltage switch or fused switch panels .....	No

The unit of measurement shall be the number of panels installed.

The rate shall include full compensation for the installing, testing and commissioning of switch panels by the manufacturers of the equipment complete with the connecting of the busbars, secondary wiring and all the material required to complete the installation. Separate items will be scheduled for switch and fused switch panels.

<u><b>Item</b></u>	<u><b>Unit</b></u>
Supply medium-voltage circuit breaker panel .....	No

The unit of measurement shall be the number of panels supplied.

The tendered rate shall include full compensation for the manufacture, supply and delivery of the circuit breaker panel complete with busbars, relays, switches and other equipment as specified in the Detail Specification, to site.

<u><b>Item</b></u>	<u><b>Unit</b></u>
Install medium-voltage circuit breaker panel .....	No

The unit of measurement shall be the number of panels installed.

The tendered rate shall include full compensation for the installing, testing and commissioning of the circuit breaker panel complete with the connecting busbars, secondary wiring and other material required.

<u><b>Item</b></u>	<u><b>Unit</b></u>
Supply battery tripping unit .....	No

The unit of measurement shall be the number of units supplied.

The tendered rate shall include full compensation for the supply and delivery of the battery tripping unit complete as specified in the detailed specification.

<u><b>Item</b></u>	<u><b>Unit</b></u>
Install battery tripping unit .....	No

The unit of measurement shall be the number of units installed.

The tendered rate shall include full compensation for the installing of the battery tripping unit and shall include the cable for the DC connection between the battery tripping unit and the switchboard as well as the cable from the mains outlet to the battery tripping unit.

<u>Item</u>	<u>Unit</u>
Supply and install voltage transformer.....	No

The unit of measurement shall be the number of transformers supplied and installed.

The tendered rate shall include full compensation for the supply and installing of the voltage transformer where the voltage transformer is specified separately.

<u>Item</u>	<u>Unit</u>
Remove existing MV circuit breakers.....	No

The unit of measurement shall be the number of MV circuit breakers removed.

The tendered rate shall include full compensation for the removal of the busbars to which the switchgear are connected, as well as the delivery of the equipment to a location not further than 5km from the original location. The rate shall furthermore provide for the disconnecting of all the MV and LV cable terminations from the switchgear.

<u>Item</u>	<u>Unit</u>
Remove existing MV switches .....	No

The unit of measurement shall be the number of MV switches removed.

The tendered rate shall include full compensation for the removal of the busbars to which the switchgear are connected, as well as the delivery of the equipment to a location not further than 5km from the original location. The rate shall furthermore provide for the disconnecting of all the MV and LV cable terminations from the switchgear.