Eskom	Standard	Technology

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CONTENTS

1. INTRODUCTION

This Standard describes the safety, design verification and routine verification requirements for indoor LV Switchgear and Controlgear ASSEMBLIES which do not exceed 1 000 V AC or 1 500 V DC (hereinafter referred to as 'ASSEMBLIES').

The standard also covers the Eskom requirements for fit-for-purpose factor-built design verified LV Switchgear and Controlgear ASSEMBLIES in accordance with the requirements of relevant parts of SANS 61439 for indoor or outdoor installations.

ASSEMBLIES for installation and use in special environment conditions (i.e. exposure to high temperature, exposure to high pressure, nuclear application, earthquakes, etc.) are subject to additional requirements.

2. SUPPORTING CLAUSES

2.1 SCOPE

2.1.1 Purpose

The standard covers the Eskom requirements for fit-for-purpose factory-built design verified Low-voltage Switchgear and Controlgear ASSEMBLIES in accordance with the requirements of SANS 61439.

Requirements for ASSEMBLIIES with fault level rating below 10kA, e.g. control panels, distribution boards are specified in Appendix B.

2.1.2 Applicability

This document shall apply to the Eskom Generation Group.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

The following documents (all parts including any amendments) contain provision for this specification. For referenced standards, the latest revision of the documents shall apply.

[1] ISO 9001 Quality management systems.

[2] ISO 17025 General Requirements for the Competence of Calibration and Testing Laboratories.

[3] 36-681 Generation Plant Safety Regulations.

[4] 240-115583001 LV Switchgear and Controlgear Assembly Technical Schedule A and B.

[5] 240-71432150 Plant Labelling Standard.

[6] 240-54690969 Engineering Drawing Symbol Standard

[7] 0.00-10341 sheet 01: MV and LV Switchgear Lugs and Terminals.

[8] 0.00-10341 sheet 02: MV and LV Switchgear Pre-Insulated Lugs and Sleeves.

[9] 0.00-10341 sheet 03: MV and LV Switchgear Wiring and Termination.

[10] 0.00-10341 sheet 04: MV and LV Switchgear Circuit Function Letters.

[11] 0.00-10341 sheet 05: MV and LV Switchgear Isolator Padlock

[12] 0.00-10343 sheet 01: MV, LV and DC Switchgear Labels and Nameplate Details English Designation Only Arrangement Diagram.

[13] 0.00-10343 sheet 02: General Labels and Nameplate Details Arrangement Diagram.

[14] SANS 61439-1 Low-voltage switchgear and controlgear ASSEMBLIES, Part 1: General rules.

[15] SANS 61439-2 Low-voltage switchgear and controlgear ASSEMBLIES, Part 2: Power switchgear and controlgear assemblies.

[16] SANS 61439-3 Low-voltage switchgear and controlgear ASSEMBLIES, Part 3: Distribution Boards intended to be operated by ordinary persons.

[17] SANS 61439-6 Low-voltage switchgear and controlgear ASSEMBLIES, Part 6: Busbar trunking systems (busways).

[18] SANS 61641 Enclosed low-voltage switchgear and controlgear assemblies – Guide for testing under conditions of arcing due to internal fault.

[19] SANS 60947 Low-voltage switchgear and controlgear. All parts.

[20] 240-86973501 Engineering drawing standard – common requirements.

[21] 240-56356421 Low voltage switchgear schedule template.

[22] SANS 61869 Instrument transformers, Part 1: General requirements.

[23] SANS 61869 Instrument transformers Part 2: Addition requirements for current transformers.

[24] SANS 61869 Instrument transformers Part 3: Additional requirements for inductive voltage requirements.

[25] SANS 10142-1 The wiring of premises Part 1: Low-voltage installations.

[26] SANS 556-1 Low-voltage switchgear Part 1: Circuit-breakers (Use with: SANS 60947-2).

[27] SANS 767-1 Earth-leakage protection units - Part 1: 'Fixed earth leakage protection circuit-breakers'.

[28] SANS 1091 National colour standards

[29] SANS 1507 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) - Part 1: General.

[30] SANS 1507 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 2: Wiring cables.

[31] SANS 1507 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 3: PVC distribution cables.

[32] SANS 1507 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 4: XLPE distribution cables.

[33] SANS 1507 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 5: Halogenfree distribution cables.

[34] SANS 1507 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 6: Service cables.

[35] SANS 1574 Electric flexible cores, cords and cables with solid extruded dielectric insulation Part 1: General.

[36] SANS 1574 Electric flexible cores, cords and cables with solid extruded dielectric insulation Part 3: PVC insulated cores and cables.

[37] SANS 1574 Electric flexible cores, cords and cables with solid extruded dielectric insulation Part 4: Rubber insulated cores and cords.

[38] SANS 1574 Electric flexible cores, cords and cables with solid extruded dielectric insulation Part 5: Rubber insulated cores and cables.

[39] SANS 60269-1 Low-voltage fuses - Part 1: General requirements.

[40] SANS 60529 Degrees of protection provided by enclosures.

[41] SANS 60865-1 Short-circuit currents - calculation of effects Part 1: Definitions and calculation methods.

[42] SANS 61000 Electromagnetic compatibility (EMC). All parts.

[43] SANS 61238-1 Compression and mechanical connectors for power cables for rated voltages up to 30 kV (Um = 36 kV) Part 1: Test methods and requirements.

[44] IEC 60614 Conduits for electrical installations - Specifications Part 1: General requirements.

[45] IEC 60614 Conduits for electrical installations Part 2: Particular specifications for conduits Section 5: Flexible conduits.

[46] IEC 60755 General requirements for residual current operated protective devices.

[47] ISO 898-1 Mechanical properties of fasteners: bolts, screws and studs, Part 1: Bolts, screws and studs.

[48] 240-56357424 MV and LV Switchgear Protection Standard.

[49] 240-56359083 Metering and Measurement Systems for Power Stations in Generation Standard.

[50] 240-64685228 Generic Specification for Protective Intelligent Electronic Devices (IEDs) Standard

[51] 240-56358929 Electronic Protection and Fault Monitoring Equipment for Power Stations Standard.

[52] 240-56227589 List of Approved Electronic Devices to be used on Eskom power stations Standard.

[53] 240-51999977 Specification for Digital Transducer-based Measurement System for Electrical Quantities.

[54] 240-57649048 Fault Monitoring Equipment for Power Systems Standard.

[55] SANS 1195 Busbars.

[56] SANS 1213 Mechanical Cable Glands.

[57] VC 8003 Manually Operated Switches for fixed Installations.

[58] VC 8006 Electric cables- flexible cords and flexible cables.

[59] VC 8036 Moulded-case circuit-breakers up to 125 A and up to 10 kA.

[60] VC 8075 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) - Parts 1 - 6.

[61] BS 1706 Specification for electroplated coatings of zinc and cadmium on iron and steel.

[62] BS 3382 Specification for electroplated coatings on threaded components. Part 1: Cadmium on steel components, Part 2: Cadmium on steel components. Part 5: Tin on copper and copper alloy (including brass). Silver on copper and copper alloy (including brass) components.

[63] CDA T22 Copper Development Association (CDA), Publication T22, Copper for busbars.

[64] IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories Parts 1: Definitions and general requirements.

[65] IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories Part 2: Special requirements for ampere meters and voltmeters.

[66] IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories Part 3: Special requirements for watt meters and var meters.

[67] IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories Part 4: Special requirements for frequency meters.

[68] IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories Part 5: Special requirements for phase meters, power factor meters and synchro-scopes.

[69] IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories Part 6: Special requirements for ohmmeters (impedance meters) and conductance meters.

[70] IEC 60664-1 Insulation coordination for equipment within low-voltage systems Part 1: Principles, requirements and tests.

[71] IEC 60688 Electrical measuring transducers for converting AC electrical quantities to analogue or digital signals.

2.2.2 Informative

The following documents (all parts including any amendments) contain provisions useful information that cover considerations related to the provisions for this specification.

[72] NRS 002 Graphical symbols for electrical diagrams.

2.3 DEFINITIONS

Definitions contained in SANS 61439 and IEC 60050-441 shall apply. The following are the definitions of specific uncommon terms used in the documents.

Definition	Description
Approval	Written agreement or authorization by Eskom. All requests for approval shall be submitted in writing and any proposed deviation from specified requirements shall be fully justified and agreed by Eskom.

Definition	Description
Arc verified ASSEMBLY	ASSEMBLY consisting only of arc ignition protected zones and/or arc tested zones **NOTE:** Arc verified ASSEMBLY was previously referred to as “Internal arc proof ASSEMBLY”
Barrier	A part providing protection against direct contact from any usual direction of access (minimum IP2X and IP XXB) and against arcs from internal arc faults, if any.
Cable way	A section of the ASSEMBLY that provides a platform for the routing and termination of cables.
Collection Busbars	A type-tested intermediate busbar arrangement between the main busbars to distribute power to especially MCB’s which are connected in cascaded circuit arrangements.
Data Sheets	All drawings, tabulations, sketches, and relevant documentation which Eskom shall submit with an enquiry, to clearly indicate to a bidder or supplier the technical, electrical and physical requirements of the completed equipment.
Design Verification	Verification made on a sample of an ASSEMBLY or parts of ASSEMBLIES to show that the design meets the requirements of the relevant ASSEMBLY standard.
Disruptive discharge	Phenomena associated with the failure of insulation under electrical stress, in which the discharge completely bridges the insulation under test, reducing the voltage between the electrodes to zero or nearly zero.
Distribution Feeder	A functional unit supplying power to another low voltage ASSEMBLY either through a cable or step-down transformer.
Equalizing Busbars	Busbars to which the incoming or outgoing power electric cables are connected to enable an even distribution of current to the terminals of the SCPD.
Factory-built ASSEMBLY	An assembly built and assembled under the responsibility of the manufacturer and conforming to an established type or system, without deviations likely to influence the performance significantly from that of the typical assembly verified to be in accordance with the relevant standard.
Fault-Free Zone	Zone in ASSEMBLY or section of an ASSEMBLY that comprises the conductors (including distribution busbars) between the main bursars and the supply side of functional units, in which, under normal operating conditions, the occurrence of a short-circuit fault is only a remote possibility. **NOTE**: this is also known as non-protected live conductors.
Incomer Unit	A functional unit through which electrical energy is fed into the ASSEMBLY.
Intelligent Electronic Device (IED)	Microprocessor-based device with the protection, control, monitoring and communication functionalities.
Padlocking facility (Pad lockable)	Part of the ASSEMBLY or component that allows one to insert a padlock for locking purposes for safe isolation during maintenance. Standard 0.00-10341 sheet 05 [11] applies.
Partition	A part of the enclosure of a compartment separating it from other compartments.

Definition	Description
Permit to work	A written declaration on the **permit to work** form, signed by the **appointed person** and issued to the **responsible person** in charge of the **work**, informing the latter that the **plant** to be worked on has been **isolated** as detailed. **NOTE**: definition highlighted above are contained in Generation Plant Safety Regulations (36-681)
Reference design	Design of an ASSEMBLY or parts of an ASSEMBLY that has been verified by test
Routine Verification	Verification of each ASSEMBLY performed during and /or after manufacture to confirm whether it complies with the requirements of the relevant ASSEMBLY standard. Also known as Factory Acceptance Tests (FAT)
Transport Unit	A part of an ASSEMBLY or a complete ASSEMBLY suitable for shipping without being dismantled.
Verification test	test conducted on a sample of an ASSEMBLY or on parts of ASSEMBLIES to verify that the design meets the requirements of the relevant ASSEMBLY standard **NOTE**: Verification tests are equivalent to type tests
Withdrawable Unit	A functional unit which can be moved from the connected position to the isolated position and to a test position, if any, whilst remaining mechanically attached to the ASSEMBLY.

2.3.1 Disclosure Classification

Controlled Disclosure: Controlled Disclosure to External Parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation	Description
AC	Alternating Current
ACB	Air Circuit Breaker
ANSI	American National Standards Institute
BS	British Standard
BSI	British Standard Institution
CT	Current Transformer
DC	Direct Current
DCS	Distributed Control System
DPI	Dip Proof Inverter
EMC	Electromagnetic compatibility
FAT	Factory Acceptance Test
f_n	Rated Frequency

Abbreviation	Description
HRC	High Rupturing Capacity
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronic Engineers
IP	Ingress Protection
ISO	International Organisation for Standardisation
LV	Low Voltage
MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MCCB	Moulded Case Circuit Breaker
OEM	Original Equipment Manufacturer
OHS Act	Occupational Health and Safety ACT
PE	Protective Conductor
PEN	Combined Protective Earth & Neutral
RCC	Regulatory Certificate of Compliance
RDF	Rated Diversity Factor
SABS	South African Bureau of Standards
SANS	South African National Standards
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SCPD	Short Circuit Protective Device
SIL	Safety Integrity Level
SPD	Surge Protection Device
U_e	Rated Operational Voltage
U_{imp}	Rated Impulse Withstand Voltage
U_n	Rated Voltage
UPS	Uninterruptible Power Supply
VT	Voltage Transformer

2.5 ROLES AND RESPONSIBILITIES

Generation Plant Engineering is a custodian of the standard and should ensure that acquisition of all new LV Switchgear and Controlgear Assemblies are done in accordance to the provisions of this document.

2.6 PROCESS FOR MONITORING

None

2.7 RELATED/SUPPORTING DOCUMENTS

This standard is related to Technical Schedule A&B (240-115583001).

3. SPECIFICATION FOR LV SWITCHGEAR AND CONTROL GEAR ASSEMBLIES AND ASSOCIATED EQUIPMENT FOR VOLTAGE UP TO AND INCLUDING 1000V AC AND 1500V

3.1 DESIGN VERIFICATION OF LV SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

3.1.1 General

3.1.1.1 ASSEMBLIES shall be fit-for-purpose factory-built design verified LV switchgear and controlgear ASSEMBLIES with the requirements of this Standards; SANS 1973-1, SANS 61439 and SANS 61641. The ASSEMBLIES shall also meet the Eskom requirements in terms of safety, operation and maintenance requirements.

3.1.1.2 An ASSEMBLY which is verified in accordance with SANS 61439 by an original manufacturer and manufactured or assembled by another does not require the original design verifications to be repeated if all the requirements and instructions specified and provided by the original manufacturer are met in full. Where the assembly manufacturer incorporates their own arrangements not included in the original manufacturer's verification, the assembly manufacturer is deemed to be the original manufacturer in respect of these arrangements and is responsible for verification of the these alternate arrangements.

3.1.2 Design verification (Type Test)

3.1.2.1 All design verifications described in SANS 61439-1 shall be performed and are intended to verify compliance of the design of an ASSEMBLY or ASSEMBLY systems. Where tests on the ASSEMBLY have been conducted in accordance with the SANS 60439 series (withdrawn) or previous editions of the SANS 61439 series, and the test results fulfil the requirements of the current edition of the relevant part of SANS 61439 series, the verification of the these requirements need not be repeated.

3.1.2.2 If modifications are made to a verified ASSEMBLY, Clause 10 of SANS 61439-1 shall be used to check if these modifications affect the performance of the ASSEMBLY. New verifications shall be carried out if an adverse effect is likely. The various methods include:

- verification testing;
- verification comparison with the tested reference design(s);
- verification assessment, i.e. confirmation of the correct application of calculations and design rules, including use of appropriate safety margins.

See Annex D of SANS 61439-1.

3.1.2.3 The data used, calculations made and comparisons undertaken for the verification of ASSEMBLIES shall be recorded in verification report. This verification report shall be submitted to the Employer for acceptance before manufacturing of the ASSMBLY commences.

3.1.2.4 When the offered ASSEMBLY's short circuit withstand rating is designed by comparing with reference design, the offered ASSEMBLY shall comply with the check list in Table 13 of SANS 61439-1 and shall be demonstrated to the end user. The allowed deviations from Table 13 of SANS 61439-1 for South African environment are captured in SANS 1973-1.

3.1.2.5 The performance of the ASSEMBLY may be affected by the verification tests (e.g. short-circuit test). These tests should not be performed on an ASSEMBLY that is intended to be placed in service.

3.1.2.6 Type test authorities for switchgear and controlgear ASSEMBLIES shall be accredited in accordance with ISO 17025. The ASSEMBLY supplier shall be in possession of valid verification test (type test) report/s not older than 5 years that reflects a true outcome of the results.

3.1.2.7 In case a verification test (type test) report is older than 5 years, proof shall be provided that the design and materials used match that of the design verified ASSEMBLY.

3.1.2.8 Switchgear and controlgear shall comply with the relevant parts of SANS 60947. All components and electric conductors fitted to the ASSEMBLY shall be certified as safe by means of a valid Regulatory Certificate of Compliance (RCC) in accordance with SANS 10142-1 Table 4.2 or an SABS Mark of approved performance.

3.1.2.9 Voltage Transformers shall be type tested in accordance with SANS 61869-3.

3.1.2.10 Current Transformers shall be type tested in accordance with SANS 61869-2.

3.1.3 Testing under conditions of arching due to internal faults

ASSEMBLIES shall be tested in accordance with SANS 61641 guide and shall comply with the following:

- Classification with regards to the protection characteristics
- Classification with regard to persons who have access

The above mentioned classifications shall be specified in schedule A.

3.1.4 Routine verification of ASSEMBLIES

3.1.4.1 Schedule B together with agreed deviations items shall be verified to ensure that the ASSEMBLY complies with Eskom standard.

3.1.4.2 Routine verification shall be performed on all ASSEMBLIES at the factory in accordance SANS 61439-1 as follows:

3.1.4.3 Construction:

- degree of protection of enclosures;
- clearances and creepage distances;

- protection against electric shock and integrity of protective circuits;
- incorporation of built-in components;
- internal electrical circuits and connections;
- terminals for external conductors;
- mechanical operation.

3.1.4.4 Performance:

- Dielectric properties;
- Wiring, operational performance and function

3.1.4.5 CTs and VTs shall be tested in accordance with SANS 61869-2 and SANS 61869-3 respectively.

3.1.4.6 Routine verification shall be repeated when the ASSEMBLY has been erected and bolted into position prior to connecting of external cables.

3.2 CONSTRUCTION AND PERFORMANCE REQUIREMENTS

3.2.1 General

3.2.1.1 Low Voltage (LV) Switchgear and Controlgear ASSEMBLY shall be designed, manufactured, design verified and routine tested in accordance to SANS 61439.

3.2.1.2 LV Switchgear and Controlgear ASSEMBLY shall be arc verified ASSEMBLY in accordance with SANS 61641. The required classification with regards to the protection characteristics shall be specified is Technical Schedule A&B (240-115583001).

3.2.1.3 LV Switchgear and Controlgear ASSEMBLY shall be constructed as free-standing (for ASSEMBLIES above 10kA), factory-built ASSEMBLIES comprising of several sections and subsections with withdrawable and/or fixed functional units.

3.2.1.4 Measures shall be taken to prevent electrolytic corrosion where dissimilar metals are in contact with each other.

3.2.1.5 The ASSEMBLY's mechanical design shall, without forcing a complete shutdown of the ASSEMBLY, allow for the following typical combinations of operation methods and cable access arrangements:

3.2.1.5.1 Front operation with rear cable-access or front cable-access

3.2.1.5.2 Back to back ASSEMBLIES with front and rear operation and cable-access; and

3.2.1.5.3 Cable-entry from above or below.

3.2.1.6 ASSEMBLIES (above 10kA) shall be floor mounted with exterior enclosure including doors and covers presenting a flush and uniform appearance.

3.2.1.7 Segregations in the base frame shall be provided to correspond with the ASSEMBLY transport sections. The base frame shall be painted BLACK.

3.2.1.8 ASSEMBLIES shall be designed to permit addition of further sections on both ends of the ASSEMBLY.

3.2.1.9 Each ASSEMBLY shall be constructed to allow for transport units, each section comprising of no more than four sections and length as per Schedule A.

3.2.1.10 The physical layout of sub-sections shall be arranged in a logical manner to enable easy operation and maintenance. A layout drawing of each ASSEMBLY shall be submitted for approval.

3.2.1.11 Access for sealing the cable slot shall be provided from the front or rear of the ASSEMBLY to;

- Reduce the danger of fire spreading,
- Prevent vermin to enter and;
- Cable slots shall after installation of cables be sealed with a fire resistant material having a two hour fire rating.

3.2.1.12 Whenever back-to-back ASSEMBLIES are specified, distribution busbar compartments shall be shared for functional units on each side of the ASSEMBLY. All components, cabling and busbars shall be accessible from each side of the ASSEMBLY. Where distribution busbars are required, the arrangement shall be such that we have the same sequence (phase rotation) on both sides to ensure compatibility of the feeders.

3.2.2 Creepage and clearance distances

3.2.2.1 ASSEMBLIES's main circuit shall have a minimum rated insulation voltage of 1 000 V except for MCB's, MCCB's and Fuses.

3.2.2.2 Power-frequency withstand voltage for main circuits as well as auxiliary and control circuits that are connected to the main circuit shall be subjected to the test voltage of 2.2kV (a.c) or 3.11kV (d.c) in accordance with Table 8 of SANS 61439-1. Application of the test voltage shall be in accordance with SANS 61439-1. The acceptance criteria for the test shall be that; overcurrent relay shall not operate and there shall be no disruptive discharge during the tests.

3.2.2.3 Power-frequency withstand voltage for auxiliary and control circuits (a.c. or d.c.) that are not connected to the main circuit shall be subjected to the test voltage in accordance with Table 9 of SANS 61439-1. The test voltage shall relate with the claimed insulation voltage of auxiliary and control circuits. Application of the test voltage shall be in accordance with SANS 61439-1. The acceptance criteria for the test shall be that; overcurrent relay shall not operate and there shall be no disruptive discharge during the tests.

3.2.2.4 Rated impulse withstand voltage shall be 8 kV for main circuits and the verification shall be made by test or by assessment. The test voltage shall be in accordance with Table 10 of SANS 61439-1.

3.2.2.5 Minimum creepage distances shall be for Pollution Degree 3, material group IIIa with the specified insulation voltage in accordance with Table 2 of SANS 61439-1 (edition 2).

3.2.2.6 Minimum clearance shall be 8mm which correspond to 8kV impulse withstand voltage.

3.2.3 Access and clearance between components

3.2.3.1 A minimum clearance shall be maintained between items of equipment and the side of compartment (withdrawable unit). Adequate space between terminals and cable trunking shall be allowed for identification ferrules to be visible.

3.2.3.2 No components or equipment shall be mounted in any position where it is not visible and accessible to a viewer looking into the compartment through the door opening (fixed circuits), or into a withdrawable unit from the top (withdrawable circuits).

3.2.4 Degree of Protection

3.2.4.1 The indoor ASSEMBLY's metal enclosure shall have a minimum external degree of protection of IP3X in accordance with SANS 60529.

3.2.4.2 The outdoor ASSEMBLY's metal enclosure shall have a minimum external degree of protection of IP53 in accordance with SANS 60529.

3.2.4.3 The ASSEMBLY’s internal barriers or distances shall have degree of protection of at least IP XXB and shall be provided to prevent accidental contact with live conducting parts of the circuit.

3.2.4.4 The design of the gland plates shall ensure a degree of protection of IP2X before and after installation of the incoming / outgoing cables.

3.2.4.5 The front enclosure of withdrawable units shall form part of the ASSEMBLY of that sub-section and providing a minimum IP3X degree of protection.

3.2.4.6 Functional unit shutters shall have a degree of protection of at least IPXXD in the closed position.

3.2.5 Forms of internal separation

3.2.5.1 Forms of separation for ASSEMBLY shall be in accordance with SANS 61439-2, for different sections and sub-sections; Forms of separation shall be as follows:

3.2.5.1.1 Incoming functional units (incomer and bus-sections panels) shall have a Form 4b.

3.2.5.1.2 Outgoing functional units shall have a minimum of Form 3b.

3.2.5.1.3 MCB groups shall have a minimum of Form 2b.

3.2.5.1.4 For control panels below 10kA, form of separation shall have minimum of Form 1 or as agreed with the user.

3.2.5.2 Sheet metal barriers shall be used to separate the functional units.

3.2.5.3 Claimed Forms of Separation shall be proven by design verification of temperature-rise limits for the specific configuration of functional units proposed.

3.2.6 Future extension of ASSEMBLIES

3.2.6.1 Provision shall be made in the verification report to indicate methods for future extension on either side of the ASSEMBLY.

3.2.6.2 Provision shall be made for an increase in the electrical supply capacity of the ASSEMBLY as per above physical space requirement.

3.2.7 ASSEMBLY finish and protective coating

3.2.7.1 The finished external colour of the AC ASSEMBLIES shall be G29: LIGHT GREY to SANS 1091 except for mounting plates and other support structures, which can be galvanized, or alloy cold rolled zinc steel. The base-frames shall be painted BLACK.

3.2.7.2 The finished external colour of the DC ASSEMBLIES shall be A11: SIGNAL RED to SANS 1091 except for mounting plates and other support structures, which can be galvanized, or alloy cold rolled zinc steel.

3.2.7.3 After installation, all nuts and bolts used for securing cabinets, section or sub sections, etc. to support beams shall be patch primed with Epoxy Resin Oxide or Zinc Chromate and then over-coated with the wet paint supplied by the coating manufacturer for repairs, if mild steel bolts are used.

3.2.7.4 The finishing coat shall be free from craters, pinholes, embedded foreign matter, and other visual defects. The topcoat shall also provide complete hiding, consistent coverage and thickness, and uniform colour

3.2.7.5 Resistance to corrosion test for Indoor and Outdoor ASSEMBLIES shall be Severity test A and Severity test B respectively in accordance with SANS 61439-1. Internal ferrous metallic parts of outdoor ASSEMBLIES may be tested by Severity test A.

3.2.8 Doors and covers

3.2.8.1 For easy access, each cable compartment and each fixed pattern functional unit sub-section shall be provided with individual hinged doors.

3.2.8.2 All removable covers shall require the use of a tool for their removal. Opening of doors for all MCB groups shall be padlockable. Each MCB shall be provided with a robust padlocking mechanism in order for Eskom **Permit to Work** system to take effect.

3.2.8.3 Door latches shall be of robust construction. At least the centre square key latch shall be padlockable.

3.2.8.4 Provision shall be made on the cable compartment door hinges to allow the doors to be lifted off. Hinges shall be of robust construction.

3.2.8.5 The method of fastening the latches and hinges shall be such that it will not wear loose due to vibration or rough handling of the door.

3.2.8.6 The door latches and hinges shall be able to withstand an internal arc of magnitude and time as specified in Schedule A.

3.2.8.7 Doors shall have stops to prevent over swing when opening and to avoid interference with adjacent compartments.

3.2.8.8 Doors shall be provided with webs or other methods to prevent wobbling when the door is operated.

3.2.9 Fixed pattern functional units

3.2.9.1 All functional units of DC ASSEMBLIES shall be of the fixed pattern design. Where required, AC ASSEMBLIES shall also be of a fixed pattern design.

3.2.9.2 When a withdrawable type MCCB's used on the fixed pattern functional unit (incoming or outgoing unit), a mechanical interlock, shall be provided to ensure that the withdrawable MCCB cannot be engaged or disengaged unless the main contacts are fully open. Padlocking facilities shall be provided to ensure that no device can be inserted in the space of the withdrawable MCCB when removed.

3.2.9.3 Accessible live parts inside the ASSEMBLY shall have a degree of protection of at least IP XXB in accordance with SANS 60529.

3.2.9.4 Barriers between power terminals shall be robust with high impact strength and made of material that is self-extinguishing or resistant to flame propagation.

3.2.9.5 For maintenance purposes, padlocking facilities shall be installed for all switch disconnection devices and provided both on the outside and the inside of the section or sub-section to lock the switch-disconnecting device in the isolated position.

3.2.9.6 Provision shall be made for testing of control circuits while the padlock is on.

3.2.10 Withdrawable functional units

3.2.10.1 Withdrawable functional units shall have a plug-in connection on the line supply, load and control circuits.

3.2.10.2 A mechanical interlock shall be provided to ensure that the functional unit cannot be engaged or disengaged unless the main contacts of the switch-disconnection device are fully open.

3.2.10.3 The facilities shall be provided to padlock withdrawable functional units in all of the following positions:

- **Test position with mechanical movement of the withdrawable part**

  Padlock the main switch-disconnecting device in the test position and padlock the withdrawable tray in the test position thus preventing it from being inserted into a connected position or being removed from the ASSEMBLY or moved to the isolated position. It would be preferred if only one padlock is required to ensure test position is selected and prevent insertion or removal of switchgear.

  Note: In test position, the control of the functional unit shall be able to be tested from the DCS.

- **Test position without mechanical movement of the withdrawable part**

  Padlock the main switch-disconnecting device in the test position and padlock the withdrawable tray to ensure that it cannot be moved to another position. It would be preferred if only one padlock is required to ensure test position is selected and prevent withdrawal of the functional unit from the ASSEMBLY.

  Note: In test position, the control of the functional unit shall be able to be tested from the DCS.

- **Isolated position with mechanical movement of the withdrawable part**

  Padlock the main switch-disconnecting device in the isolated position and padlock the withdrawable tray in the isolated position thus preventing it from being inserted into a test/connected position or being removed from the ASSEMBLY. It would be preferred if only one padlock is required to ensure isolated position is selected and prevent insertion or removal of the functional unit in the ASSEMBLY.

- **Isolated position without mechanical movement of the withdrawable part**

  Padlock the main switch-disconnecting device in the isolated position and padlock the withdrawable tray to ensure that it cannot be moved to another position. It would be preferred if only one padlock is required to ensure isolated position is selected and prevent movement to another position of the functional unit in the ASSEMBLY.

- **Removed position**

  Busbar shutters shall be provided to prevent inadvertent contact (IPXXB) with live conductors on removal of the unit and shall be padlockable in the closed position. Further, the inadvertent contact (IPXXB) with busbars shall be prevented when the shutters are open. Busbar shutters shall be labelled with the word "BUSBARS". Cable shutters shall be labelled with the word "CABLE".

3.2.10.4 Where busbar shutters are not provided, lockable dummy withdrawable units shall be provided to ensure that the busbars are inaccessible. There shall be a sufficient number of these lockable dummy withdrawable units for all different functional unit sizes for each ASSEMBLY.

3.2.10.5 The functional units shall have a plug-in connection on the line, load and control circuits. A provision shall be made to test the circuit with the line and load plug-in connection disconnected and the control circuit connected.

3.2.10.6 The withdrawable unit shall have an earth contact (or pin) to ensure the earth connection between the unit and the ASSEMBLY's earth in the connected position as well as the test position. The earth contact shall make before any other contacts when moving the unit to a connected position, and break after all other contacts when moving the unit to an isolated position.

3.2.10.7 A guiding pin or other aligning device shall be provided to guide the withdrawable unit into the connected position and to ensure that the plug-in connections are lined up properly.

3.2.10.8 Functional units of the same type and rating shall be provided with insertion interlock facilities. It shall not be possible to insert a functional unit of one type and rating into a circuit designed for a functional unit of a different type and rating. Where a mixture of with and fixed pattern units is provided the operating features shall be uniform.

3.2.10.9 In a case where functional units heavier than 25 kg are mounted, a trolley and associated lifting equipment shall be provided. The number of trolleys and associated equipment shall be as specified in Schedule A of the tender enquiry.

3.2.10.10 A damping device shall cause the withdrawable unit to slow down before the point of engaging.

3.2.11 Motor starter functional unit design

3.2.11.1 All components associated with a withdrawable motor starter shall be mounted within a single housing.

3.2.11.2 In the case of fixed pattern unit, the functional unit shall be provided with a padlockable, hinged door.

3.2.11.3 In the case of fixed pattern, padlockable mechanism on the isolating device inside the functional unit shall be provided to allow for isolation of a power circuit while troubleshooting is performed on the control circuit.

3.2.11.4 All switching device of the fixed pattern units shall be door interlocked. This door interlocking arrangement shall be such that the switch must be in the open (OFF) position before the door can be opened for inspection and cannot be closed (ON) before the door is closed. Provision shall be made to enable the door interlock to be bypassed thus permitting authorised persons to obtain access to live parts while the equipment is live. The interlock shall automatically be restored on re-closing the door.

3.2.11.5 The fixed portion of the switch drive shaft shall be padlockable in the open (OFF) position. If the padlocking arrangement is located behind the door, a viewing window shall be provided in the door to enable the padlock to be seen from the front of the unit.

3.2.11.6 Where required, control selector switches shall be accessible only after the door of the motor starter has been opened. For withdrawable units, the selector switches shall only be possible after it has been withdrawn.

3.2.11.7 If required, push buttons and signal lamps shall be mounted on the door (or on the front of the ASSEMBLY, in the case of a withdrawable unit).

3.2.12 Main, Distribution, Equalizing and Collection Busbars

3.2.12.1 Main busbars and distribution busbars shall be manufactured from electrolytic tough pitch high conductivity copper complying with SANS 804.

3.2.12.2 Conditions of temper for busbar copper shall comply with the designation H2 for half-hard cold working in accordance with SANS 1195.

3.2.12.3 Unless otherwise agreed between the ASSEMBLY manufacturer and user, the neutral busbar/conductor shall be rated at least 60 % of the line current during the three-phase test.

3.2.12.4 The ASSEMBLY shall consist of main and distribution busbars.

3.2.12.5 In the case where the ASSEMBLY is fed directly from a transformer, the neutral busbar shall be connected to the protective conductor by means of a removable bolted link on the cable side of each incoming functional unit. The link shall be readily accessible for removal and testing. The link shall be long enough to allow the fitting of a dedicated ring-core current transformer.

3.2.12.6 All busbars shall be marked in such a way that it is easy to identify to which supply phase or pole they are connected to when any covers are removed.

3.2.12.7 Busbars shall be colour coded as follows:

3.2.12.7.1 AC busbars are colour coded RED, WHITE & BLUE for the phases and BLACK for neutral busbar.

3.2.12.7.2 DC busbars rated at 220 V shall be colour coded RED, for the positive conductor and BLACK for the negative.

3.2.12.7.3 DC busbars rated at 24 V shall be colour coded RED, for the positive conductor and BLUE for the negative, and the zero bar shall be colour coded BLACK (where required).

3.2.12.8 Collection busbars need to be constructed where SCPD's and MCB's need to be connected in cascaded circuits. Collection busbars shall be rated for the full prospective short-circuit rating and equal to the derated current rating of the supply SCPD.

3.2.12.9 In cases where it is found necessary to connect single phase cables to incoming or outgoing circuit-breakers, it may be necessary to install equalizing busbars. Additional fixed supports to the OEM's prescriptions shall be installed to prevent the equalizing busbars to show any signs of deformation when subjected to a short-circuit condition.

3.2.13 Protective earth conductor and the screened earth busbar

3.2.13.1 A separate protective earth (PE) conductor, to which all metal parts are galvanically connected, shall be installed on the inside rear of each ASSEMBLY along the entire length. The bar shall be in an accessible position to allow for the earthing of conductors within a closest distance from the cable entry points and have a provision for connection to the system earth on both ends.

3.2.13.2 Non-current carrying conductive parts, including relays, meters etc, shall be electrically connected to the protective earth conductor by means of their mounting arrangement on the ASSEMBLY or by a separate earthing conductor connected to the protective conductor. This shall include gland plates and earth terminals provided on equipment.

3.2.13.3 Earthing or bonding to the PE conductor shall be applied to all doors by means of at least 6 mm^2 cross-sectional area multi-strand conductors.

3.2.13.4 The size of the PE conductor shall be calculated in accordance with Annex B of SANS 61439-1 edition 2 for thermal stresses due to currents of short duration. The conductor shall also be pre-drilled.

3.2.13.5 All parts of the protective circuit within the ASSEMBLY shall be designed to withstand the highest dynamic stresses that may occur during fault conditions.

3.2.13.6 The position of the PE conductor and the earth bar shall be such that it does not interfere nor obstruct the cabling, particularly in the incomer sections.

3.2.13.7 The PE conductor shall be colour coded GREEN with a YELLOW stripe and the screened earth bar shall be left uncoloured.

3.2.14 Gland Plates

3.2.14.1 Cable gland plates of a uniform design shall be provided at a minimum height of 300 mm above the point of entry to allow for cable bending radius. Where split gland plates are used, a space of 50 mm between the gland plate and the point of entry is required. In case of cables entering from above the ASSEMBLY, the cable gland plate shall be mounted at the point of entry.

3.2.14.2 Adequate access shall be provided beneath the gland plate to ensure that, once the cables have been installed, the floor slot can be sealed from above using fire retardant material. The arrangement shall be such that once this slot is sealed level with the floor, each base frame sub-section shall be sealed from the adjacent base frame sub-section.

3.2.14.3 A minimum of four un-drilled, removable, robust, corrosion resistant, metal, unpainted gland plates per section covering the complete area shall be provided. The gland plates shall be supported to prevent movement of the cables. These gland plates shall be non-magnetic in case of single core cables.

3.2.14.4 Where cables of 95 mm^2 and larger are required, they shall be provided with robust, individual, un-drilled, removable gland plates. These gland plates shall be non-magnetic in case of single core cables.

3.2.14.5 Metal gland plates shall be bonded to the PE conductor by means of a bonding conductor whose cross-section is selected in accordance with Annex B of SANS 61439-1 edition 2.

3.2.15 Cable securing arrangements

3.2.15.1 Cables of 2.5 mm^2 and larger cross sectional area shall be provided with cable glands.

3.2.15.2 Supports shall be provided within the cabling compartment to allow cables to be secured in position.

3.2.16 Conductors installed in the "fault-free" zone (non-protected live conductors) to reduce the possibility of shorts circuits

3.2.16.1 Conductors for measuring instruments installed in the “fault free” zone shall be brazed in such a manner that a short circuit fault is only remote possibility. Where possible busbar mounted fuses shall be installed.

3.2.16.2 Conductors installed in the 'fault-free-zone' shall be braced at intervals not exceeding 300 mm

3.2.16.3 The conductors used in the “fault–free” zones for outgoing functional units shall be double insulated.

3.2.16.4 The conductor size selection and installation shall be in accordance with Table 4 of SANS 61439-1 edition 2.

3.2.16.5 Conductors installed within a “fault-free” zone where they could come in contact with conducting parts shall be protected by supplementary insulation.

3.2.17 Power and control wiring

3.2.17.1 Power conductor wiring and connections in the ASSEMBLY shall be in accordance with SANS 61439-1.

3.2.17.2 All control wiring connected to a source of fault energy shall be capable of carrying continuously a current equal to 1,5 times the rating of the SCPD protecting it and withstanding the total I^2t let-through current of the SCPD under any fault condition from overload to short circuit without suffering perceptible damage.

3.2.17.3 Each individual functional unit control circuit shall be connected directly to the control busbars as far as it is practically possible. Looping of control wires is not preferred. However, if looping is necessary, the wiring shall present neat appearance and the conductors shall be adequately braced, clipped and or laced to avoid loose connections during vibrations.

3.2.17.4 Connections to equipment on swing doors shall be arranged so as to give a twisting motion and not a bending motion to the conductor.

3.2.17.5 Only stranded conductor cable shall be used. Single or solid conductor shall not be used. Aluminium conductors shall also not be used.

3.2.17.6 Multi-strand cable with conductors of 1.5 mm^2 cross sectional area shall be used for control circuits. Wiring of circuits of up to 50 V shall be 0.5 mm^2 multi-strand conductor cables.

3.2.17.7 Wiring used on 24 V DC control circuits shall consist of at least 1.5 mm^2 multi-strand conductors.

3.2.17.8 Joints or splices in any circuit as well as the termination of more than one conductor in one lug will not be acceptable. Only exception will be hook spade lugs for IED wiring terminations.

3.2.17.9 Terminals, which are on the line side of fuses and isolating switches, shall be completely shrouded.

3.2.17.10 In order as to minimize the effect of electrolytic corrosion, coils shall be placed in the circuit so that they are not connected to the positive pole of a battery except through normally open contacts.

3.2.17.11 Compressed lugs shall match the conductor size and all compression joints shall be made with the correct crimping tool for the type of lug used. Compression joints shall be made to successfully pass the test as specified in SANS 61238-1.

3.2.17.12 Conductors passing through holes in compartments shall be protected by means of robust neoprene grommets. Bevelling of steel sheet as a substitute is not acceptable.

3.2.17.13 Conductors carrying currents in excess of 100 A and passing through metal shall either be all three phases, both poles of DC conductors or the metal barrier shall be split.

3.2.17.14 AC and DC conductors shall not be routed in the same wire way.

3.2.17.15 Power circuit cable sizing shall be based on SANS 61439-1.

3.2.17.16 Crimping tools shall be of the type which will not release the termination during normal operation until the conductor crimp has been correctly formed.

3.2.17.17 Correct torque shall be applied when any bolt or screw is tightened.

3.2.18 Accessibility

3.2.18.1 Components shall be arranged and mounted in the ASSEMBLY in such a way that maintenance and troubleshooting work can be performed in a safe and orderly manner.

3.2.18.2 Switchgear and controlgear when mounted shall not cause injury during switching.

3.2.19 Conductor identification

3.2.19.1 Conductors for power conductors shall bear the face colour along the entire length of the phase to which they are connected or may be used in a common colour provided they are phase colour coded at each end of the conductor and at every connection point.

3.2.19.2 Circuit function letters in accordance with 0.00/10341 Sheet 4 shall be used in circuit wiring designation.

3.2.19.3 Control conductor sheath shall be coloured as follows:

3.2.19.3.1 BLACK for AC circuits

3.2.19.3.2 GREY for DC circuits

3.2.19.4 Control bus wiring shall be coloured as follows:

3.2.19.4.1 DC - RED for positive and BLACK for negative

3.2.19.4.2 AC - BROWN and BLUE

3.2.19.5 Conductors of CT and VT circuits shall bear the phase colours. The neutral conductor shall be coloured BLACK.

3.2.19.6 Control conductors shall be marked at both ends with an interlocking type of ferrule with permanent black letters impressed on a white or yellow background. The numbered ferrule shall not fall off when disconnecting the cable. Ferrules shall read in a consistent manner in both vertical and horizontal planes.

3.2.20 Control wiring terminations

3.2.20.1 Conductors for control wiring shall be terminated with pre-insulated compression type lugs.

3.2.20.2 Each terminal strip mounting rail shall be provided with not less than 10% spare length with a minimum of 50 mm.

3.2.20.3 Not more than two control conductors shall be connected to any one side of a terminal.

3.2.20.4 Wiring for voltmeters shall be arranged in such a way that the ASSEMBLY's fault-free-zone's integrity will not be impaired.

3.2.20.5 Screwed terminations for control wiring are preferred. Wiring termination shall be done in accordance to standard 0.00-10341 Sheet 03.

3.2.20.6 Terminal barriers shall be fitted between terminals with different voltage levels.

3.2.21 Internal power cable terminations

3.2.21.1 Conductors of up to and including 6 mm^2 cross sectional area shall be terminated with pre-insulated compression type lugs. Conductors with a cross sectional area above 6 mm^2 shall be terminated with compression type lugs when used with stud type terminals.

3.2.21.2 Stud terminal shall allow for at least two ring lugs and nut. Two terminal studs are provided for each cable way, and are of sufficient length to accommodate two ring tongue terminations in addition to a full nut and a locking device. Barriers are provided between terminal in the cable way. These barriers project at least 3 mm above the studs.

3.2.21.3 Loose links, where provided, shall be secured by a nut and washers (flat and spring), and are of tin-plated copper or brass.

3.2.21.4 Drilled solid copper bars are provided for terminating all external power cables above 185 mm^2 and also where three or more cables in parallel are specified. The arrangement is suitable for accepting cable lugs on conductors up to 630 mm^2 and is complete with bolts, nuts, washers and locking devices.

3.2.21.5 In an event that more than one core per phase of single or multi-core core cables is terminated in an incomer or feeder compartment, equalising busbars shall be provided to facilitate the connection. The equalising bars shall be adequately rated and braced to withstand the thermal and dynamic stresses under normal, short circuit and internal arc operating by design verification.

3.2.21.6 Power and control terminals, associated with each circuit, shall be grouped and mounted on terminal rails adjacent to the associated outgoing functional unit or at the rear of the section or sub-section (cable compartment).

3.2.21.7 Power terminals shall be separated from the control terminals by means of a barrier and are fully shrouded to prevent accidental contact with in line with degree of protection IP XXC.

3.2.21.8 Terminals or terminating conductors associated with one circuit shall be grouped together.

3.2.21.9 Cables routed within the cable compartment shall be braced and firmly attached to the ASSEMBLY to prevent damage by vibration and forces acting on terminations**.**

3.2.22 Outgoing cable termination

3.2.22.1 Where extensions to outgoing terminals for cable connections are made, such extensions shall without distortion, withstand the full short-circuit rating of the ASSEMBLY.

3.2.22.2 Terminals or terminating conductors associated with one functional unit shall be grouped together.

3.2.22.3 All termination arrangement not in accordance with degree of protection IP XXC shall be provided with separate covers to act as shroud so that accidental contact is impossible when making off adjacent cables.

3.2.23 Control power supply

3.2.23.1 Where specified, the following control busbars or conductors shall be provided:

3.2.23.1.1 Single bus fed from the predefined supply point through a miniature circuit breaker (MCB) or fuse and a neutral link.

3.2.23.1.2 Where specified, the above bus system shall be energised through a stabilised power supply in a form of DPI or UPS control supply.

3.2.23.2 Busbars through MCB's or fuses and/or links mounted in the section or sub-section dedicated to that contactor.

3.2.23.3 Protection gear for control circuits shall be designed for selectivity and cascading (where applicable) in accordance with OEM design and installation prescriptions.

3.2.24 Nameplate and Labels

3.2.24.1 **Nameplate**

Each ASSEMBLY shall have a nameplate stating at least the following:

a. Name of the ASSEMBLY
b. Plant coding
c. Manufacturer
d. Manufacturer's address and contact telephone number
e. Contract Number
f. Standard to which it was manufactured and design verified
g. ASSEMBLY rated busbar current
h. ASSEMBLY rated operational voltage
i. ASSEMBLY rated insulation voltage
j. ASSEMBLY rated frequency
k. ASSEMBLY Arc Classification
l. Control voltage

m. Rated power frequency withstand

n. Rated impulse withstand voltage

o. Degree of protection

p. Short-circuit rating in kA and duration in seconds

q. Form of separation of respective sections

r. Degree of Pollution

3.2.24.2 **Labels**

3.2.24.2.1 **General**

a. All label types' dimensions, fixing methods and materials shall be in accordance Eskom Plant Labelling Standard 240-71432150.

b. The method of mounting the label shall be such that it will be permanent and will not become loose within the design lifespan of the ASSEMBLY.

c. Labels shall be inscribed in English language.

3.2.24.2.2 **Operating Labels**

d. Labels pertaining to operating instructions shall be provided for protective gear and any other items where such instruction is required.

e. Labels shall detail in a descriptive and diagrammatic format how the device is to be removed, inserted, manually operated, isolated, earthed or any other applicable operation.

3.2.24.2.3 **Component Labels**

f. Terminal strips, terminals, neutral and earth links and all components shall be labelled according to the schematic diagram.

g. Protective devices, VT's and CT's shall have a label inscribed with appropriate rating adjacent to the components. The label on VT's and CT's shall be visible from the front with the doors opened.

h. For components, labels shall be fitted on the components and on the chassis next to the component position. Component labels should at least contain the relevant plant code and the component size.

3.2.24.2.4 **Identification Labels**

i. Each section and sub-section of the ASSEMBLY shall be identified by means of labels, front and back.

j. Where it is possible to remove doors or covers which carry circuits' designation or operating labels, or if such doors or covers are not fully interchangeable, they shall be identified by means of labels to ensure replacement in the correct position.

3.2.25 Heat dissipation of the ASSEMBLY with Power Electronic Devices

3.2.25.1 Where required, the ASSEMBLY shall accommodate power electronics devices such as Variable Speed Drives (VSD's), soft starters, cycle controllers, etc. in the form of a fixed pattern functional unit. When sizing the functional unit, design verification shall be submitted to the Employer for acceptance, that the functional unit is correctly sized to house the power electronics devices without compromising temperature rise requirements.

3.2.25.2 Arrangement of functional units and spacing between them shall be such that forced cooling is not necessary. Where forced cooling forms part of the standard design, the design shall be in compliance with the following requirements:

3.2.25.2.1 No tripping of the switching device is allowed if any of the fans fail.

3.2.25.2.2 Monitoring of fans using fan failure indications and alarms.

3.2.25.2.3 Full redundancy of cooling.

3.2.25.2.4 The cooling fan motor is readily available in South Africa.

3.3 SWITCHGEAR AND COMPONENTS

3.3.1 Air circuit breakers

3.3.1.1 **General**

3.3.1.1.1 Air Circuit Breakers (ACB's) shall be fully type-tested in accordance with the requirements of SANS 60947-2.

3.3.1.1.2 ACB's shall be of the triple pole, withdrawable type.

3.3.1.1.3 A separate compartment shall be provided for the control circuitry, protection equipment and instruments for the ACB. This compartment shall be directly above the ACB compartment.

3.3.1.1.4 Where required, ACB's shall be fitted with complete operational status logging devices that is accessible via the communication link to the DCS.

3.3.1.1.5 ACB shall be provided with non-resettable trip counters.

3.3.1.2 **Ratings**

3.3.1.2.1 ACB's shall be capable of carrying continuously without forced ventilation the main busbar current stated in Schedule A.

3.3.1.2.2 ACB's serving as a bus-section shall be suitable for operation with current flow in both directions.

3.3.1.3 **Mechanism**

3.3.1.3.1 Unless otherwise approved, operating mechanisms shall comply with SANS 60947-2 and shall be of trip-free type. The stored energy closing type is required.

3.3.1.3.2 Integral anti-pumping arrangements shall be provided and their operation shall be demonstrated as part of the routine testing procedure. Anti-pumping relays shall be continuously rated.

3.3.1.4 **Closing Device**

3.3.1.4.1 If provided with the ACB's, the independent manual closing device/button shall be blanked off.

3.3.1.4.2 Electrically operated closing devices, including mechanism charging motors, shall be suitable for operating at any voltage under normal system conditions.

3.3.1.4.3 The maximum and steady-state current at rated voltage required by each closing device shall be stated in Schedule B.

3.3.1.5 **Tripping devices**

3.3.1.5.1 ACB's shall be fitted with a manual tripping device. In addition, where required as per Schedule A, they shall be fitted with tripping releases selected from the following type:

a. shunt release
b. under-voltage release
c. instantaneous over-current release
d. definite time-delay over-current release
e. inverse time-delay over-current release
f. reverse current release (DC only).

3.3.1.5.2 Tripping devices of a circuit-breaker, when the circuit-breaker main circuit is not carrying current, it shall be capable of operating satisfactorily down to 60% of the rated control voltage measured at the device terminals.

3.3.1.5.3 On DC control circuit, it is preferred to install surge protection over the coils or breaking contacts to absorb the back electromotive force (emf).

3.3.1.5.4 Where a circuit breaker is used for safety application, such as Boiler/Turbine Protection Systems, it shall meet the specified safety integrity level (SIL) requirements as a minimum. A confirmation that safety requirement is met must be provided with tender submissions in the form of certification, datasheet, specification, etc.

3.3.1.6 **Indicating Devices**

3.3.1.6.1 A positively driven mechanical indicating device to show whether the ACB is open or closed shall be provided.

3.3.1.6.2 The ACB shall be labelled as follows:

a. On or I for closed position

b. Off or O for open position

3.3.1.6.3 A positively driven mechanical indication shall be provided to indicate whether the circuit-breaker is connected or isolated unless a truck position is clearly visible.

3.3.1.6.4 All mechanical indicators shall be clearly visible from the front of the circuit-breaker.

3.3.1.7 **Disconnecting properties of withdrawable units**

3.3.1.7.1 A mechanical device to positively identify the position of the ACB shall be provided to ensure that the ACB is secured in the:

a. connected position

b. test position

c. isolated position

3.3.1.7.2 It shall not be possible to insert an ACB into a circuit of lower or higher rating than it's rating. In the case of ACB's containing integral overload protection, it shall not be possible to insert an ACB with a lower rating into the circuit.

3.3.1.7.3 Automatically-operated shutters shall be provided so that on disconnecting the circuit-breaker, these shutters cover the isolating to prevent inadvertent contact with live bus bars and conductors.

3.3.1.7.4 Shutters shall be capable of being padlocked in the closed position.

3.3.1.7.5 Shutters shall not require lubrication.

3.3.1.7.6 Facilities shall be provided to padlock circuit-breakers in the isolated position.

3.3.1.7.7 Withdrawable units shall comply with the isolating requirements of SANS 60947-2 when in the withdrawable unit is in the 'test' and 'isolated' positions.

3.3.1.8 **Auxiliary contacts**

3.3.1.8.1 Auxiliary contacts shall be capable of making and carrying continuously a current of 6 A at 230 V AC or 0, 5 A at 220 V DC for utilization categories AC 14 and DC 13 respectively.

3.3.1.8.2 Where insufficient contacts are available, a continuously rated slave relay shall be provided for indication circuits only.

3.3.1.8.3 Two spare contacts shall be provided, one "normally open" and one "normally closed".

3.3.2 Moulded case circuit breakers

3.3.2.1 **General**

3.3.2.1.1 Moulded-Case Circuit Breakers (MCCB's) shall comply with VC 8036 where applicable, SANS 556-1 and SANS 60947-2. The requirements stipulated in SANS 556-1 takes priority over SANS 60947-2.

3.3.2.1.2 MCCB's shall be triple pole, with or without neutral air-break devices, assembled as an integral unit, mounted in a supporting and enclosing moulded case of insulation material.

3.3.2.1.3 MCCBs shall be fitted with flash barriers on the line side.

3.3.2.1.4 Where neutral links are specified, these shall be of the bolted or withdrawable type, accessible from the front of the unit.

3.3.2.2 **Ratings**

3.3.2.2.1 MCCB's shall be able to carry continuously the load current stated in Schedule A, when mounted within the sub-section as per OEM requirements for installation.

3.3.2.2.2 The breaking capacity of MCCB's shall be determined in accordance with the fault rating of its associated ASSEMBLY and in conjunction with associated backup protection.

3.3.2.2.3 The breaking capacity of the MCCB shall be at least 10 % greater than the prospective fault current at its point of installation of the supply system.

3.3.2.3 **Mechanism**

Trip-free operating mechanism shall comply with the requirements of SANS 60947-2.

3.3.2.4 **Operating device**

3.3.2.4.1 MCCB's shall be provided with independent manual closing and tripping devices in accordance with SANS 60947-2.

3.3.2.4.2 Where a MCCB is used for safety application, such as Boiler/Turbine Protection Systems, it shall meet the specified safety integrity level (SIL) requirements as a minimum. A confirmation that safety requirement is met must be provided with tender submissions in the form of certification, datasheet, specification, etc.

3.3.2.4.3 Where fixed type MCCB's are used, the operating shaft shall protrude through the ASSEMBLY face.

3.3.2.4.4 A padlocking device, integral to the MCCB, shall be provided to lock the operating lever in the open (OFF) position only.

3.3.2.4.5 Where this is not possible, the padlocking device shall be mounted on the door provided with padlocking facilities. The fixed portion of the switch drive shaft shall be padlockable in the open (OFF) position.

3.3.2.5 **Releases**

3.3.2.5.1 Moulded-case circuit-breakers shall be fitted with an adjustable inverse time delay overcurrent release with instantaneous tripping under short-circuit conditions in accordance with SANS 60947-2.

3.3.2.6 **Isolation**

3.3.2.6.1 Triple pole MCCB's shall either be of the withdrawable type or of the fixed type.

3.3.2.6.2 When fitted to a fixed pattern functional unit, withdrawable MCCB's shall be provided with automatically operated shutters which can be padlocked in the closed position.

3.3.2.6.3 Facilities shall be provided to padlock MCCB's in the isolated position.

3.3.2.7 **Indication devices**

MCCB's shall have the same indication devices as the ACB's as defined in Section 3.3.1.6 of this Specification.

3.3.2.8 **Interlocks**

The requirements of Section 3.5.1.8 apply.

3.3.2.9 **Auxiliary contacts**

Refer to Section 3.3.1.8 of this Specification for the requirements of auxiliary contacts.

3.3.2.10 **Integral protection devices**

3.3.2.10.1 The MCCB's shall be arranged such that an external source of power is not required for tripping the breaker during short circuit or overload conditions.

3.3.2.10.2 The protection device shall be easily accessible and removable and capable of being tested and calibrated without removing from breaker housing.

3.3.3 Miniature circuit breakers

3.3.3.1.1 Miniature circuit breakers (MCB's) shall comply with the requirements of VC8036, SANS 556-1 and SANS 60947-2. The requirements stipulated in SANS 556-1 takes priority over SANS 60947-2.

3.3.3.1.2 Provision shall be made for MCB's applied on multiple or single phase distribution sections or sub-sections to be operated from the front of the ASSEMBLY and this shall only be possible after opening the front door.

3.3.3.1.3 A transparent flameproof window shall be provided on the front door such that the MCB's are visible from the outside without the need for opening the front door

3.3.3.1.4 With regards to lockable isolating devices, a mechanical hinged pad lockable device shall be installed to disable operation of each of the MCB's individually.

3.3.3.1.5 MCB's shall be of the non-adjustable type.

3.3.3.1.6 Where cascading is required, the MCB's shall be certified by the OEM that the MCB's will be protected by the upstream switching device using proven cascading methods.

3.3.4 Switch-disconnectors

3.3.4.1 **General**

3.3.4.1.1 Switch-disconnectors shall comply with SANS 60947-3.

3.3.4.1.2 Switch-disconnectors shall be of the air-break, gang operated type. The number of poles will be specified in Schedule A.

3.3.4.1.3 Where neutral links are specified these shall be of the bolted or withdrawable type and shall accessible from the front of the switch. Operated with the switch disconnector, the neutral link shall open after and close before the main contacts.

3.3.4.2 **Ratings**

3.3.4.2.1 All switch-disconnectors shall be capable of carrying the rated and fault currents specified in Schedule A when mounted within the compartment.

3.3.4.2.2 They shall be capable of breaking the rated load and making the fault current specified in Schedule A.

3.3.4.2.3 Bus-section switch-disconnectors shall be suitable for operation with the current flow in both directions.

3.3.4.3 **Operating Devices**

3.3.4.3.1 Switch-disconnectors shall be of the independent manual operating type.

3.3.4.3.2 Switch-disconnectors shall be operated from the front of the ASSEMBLY by means of a handle.

3.3.4.3.3 Switch-disconnectors and their compartments shall be provided with the interlocks and padlocking facilities as described for ACB's in this Specification. The fixed portion of the switch drive shaft shall be padlockable in the open (OFF) position.

3.3.4.4 **Indication devices**

3.3.4.4.1 Switches shall be fitted with a device which indicates the positions of the contacts. This position indicator shall be connected to the moving contacts in a reliable way.

3.3.4.4.2 The operating handle of the switch may form part of the indicator, provided it cannot indicate the off position unless all moving contacts are in the open position.

3.3.4.4.3 Such an indicator is not required if contact separation is externally visible.

3.3.4.4.4 The device shall be labelled as follows:

3.3.4.4.5 On or I

3.3.4.4.6 Off or O

3.3.4.5 **Circuit disconnection**

3.3.4.5.1 The indication shall be clearly visible from the front of the ASSEMBLY.

3.3.4.5.2 Series air-break switch-disconnectors of combination units shall be capable of making and breaking the full load current of the circuit-breaker connected in its circuit.

3.3.4.5.3 If the air-break switch-disconnector is not capable of making the full let through fault current of the circuit-breaker connected in series, provision shall be made to ensure that the air-break switch-disconnector can only be closed when the circuit-breaker main contacts are fully open.

3.3.5 Fuse-combination units (Fuse switch-disconnector)

3.3.5.1 **General**

3.3.5.1.1 Fuse-combination units shall comply with SANS 60947-3. These units comprise the following basic components:

3.3.5.1.2 Provision shall be made for the fitting of auxiliary contact to the fuse-combination unit for control and indication purposes.

3.3.5.2 **Ratings**

3.3.5.2.1 Fuse-combination units shall carry the rated current specified in Schedule A when mounted within their compartments and shall be capable of:

a. Making and breaking the rated current in accordance with the utilization category

b. Interrupting the rated fused short-circuit current.

c. The fuse combination units shall be capable of making on a fault equal to the busbar fault rating it is connected to.

3.3.5.3 **Operating devices**

3.3.5.3.1 Fuse-combination unit switches shall be of the independent manual operating type.

3.3.5.3.2 They shall be operated from the front of the ASSEMBLY by means of a handle.

3.3.5.3.3 A padlocking device, integral to the Fuse-combination unit, shall be provided to lock the operating lever in the open (OFF) position only.

3.3.5.4 **Indicating device**

3.3.5.4.1 Fuse combination units shall be fitted with a device indicating the position of the moving contacts. This position indicator shall be connected to the moving contacts in a reliable way. The operating handle of the unit may form part of the indicator, provided it cannot indicate the off position unless all moving contacts are in the open position.

3.3.5.4.2 Such an indicator is not required if the contact separation if externally visible.

3.3.5.4.3 The device shall be labelled as follows:

3.3.5.4.4 On or I

3.3.5.4.5 Off or O

3.3.5.4.6 The indication shall be clearly visible from the front of the ASSEMBLY.

3.3.6 Contactors

3.3.6.1 **General**

3.3.6.1.1 Contactors shall comply with the requirements of SANS 60947-4-1.

3.3.6.1.2 Contactors shall be of the electromagnetic, air-break type and be arranged to interrupt all poles of the supply simultaneously.

3.3.6.1.3 Contactors shall be of the held-in or latched type as specified. Latched contactors shall be provided with a trip coil as well as a closing coil.

3.3.6.2 **Contactor Ratings**

3.3.6.2.1 Contactors are required for the operation of motors and as such shall be rated such that they comply with type 2 co-ordination and correct utilisation category.

3.3.6.3 **Auxiliary contacts**

3.3.6.3.1 Each contactor shall be provided with a sufficient number of normally open and normally closed auxiliary contacts to suit the circuit served.

3.3.6.3.2 These auxiliary contacts shall comply with the requirements of this Standard with the exception that contact convertibility is not required.

3.3.6.3.3 Operating coils of solenoid closing contactors shall be continuously rated. The contacts shall be short-time rated.

3.3.7 Motor Starters

3.3.7.1 **General**

3.3.7.1.1 Motor starters shall comply with SANS 60947-4-1.

3.3.7.1.2 Motor starters shall incorporate isolation and switching facilities, overload and short-circuit protection.

3.3.7.1.3 The design shall be such that the combinations of the different components forming a circuit ensure type 2 co-ordination. Evidence of type 2 co-ordination shall be submitted to the Employer for acceptance.

3.3.7.1.4 The main isolating and over-current interrupting device shall be a circuit breaker fuse combination unit. An Employer shall advice on over-current interrupting device (circuit breaker or fuse).

3.3.7.1.5 Where links are specified, they shall be of the withdrawable or bolted type accessible from the front of the ASSEMBLY.

3.3.7.2 **Motor Starter Rating**

3.3.7.2.1 Components and wiring forming part of the power circuit of the motor starters, shall be suitably rated and braced for the I^2t value of the current limiting device.

3.3.8 Auxiliary Devices and Accessories

3.3.8.1 **Instrument transformers**

3.3.8.1.1 Instrument transformers (i.e. current and voltage transformers) shall comply with IEC 61869-2 and SANS 61869-3.

3.3.8.1.2 Turns-compensation shall not be employed on protection current and voltage transformers.

3.3.8.1.3 Secondary windings of current transformers shall be earthed at one point only. Each group of current transformers (i.e. protection, metering, etc.) shall be earthed by means of bolted or insertion clamp, spring loaded terminal to the PE conductor.

3.3.8.1.4 Instrument transformers shall be naturally air-cooled, and shall be able to withstand the maximum fault current for the duration of time taken by the functional unit to clear, with protective devices set at the maximum time delay setting.

3.3.8.1.5 Current and voltage sensing devices that use different methods to the conventional wire-wound, iron-cored CT's and VT's shall only be considered if the devices form an integral part of the protection device. These devices are subjected to Eskom's approval.

3.3.8.1.6 Conductors that connect VT's to the busbars shall be protected by suitable fuses installed close to the busbars. The fuses used shall be accessible without the use of tools to open doors.

3.3.8.1.7 Instrument transformer rating plates shall be duplicated on the main incomers of an ASSEMBLY. These duplicate plates shall be located on the sidewall of the relay compartment or adjacent to the cable termination (when the protection relay is remote from the ASSEMBLY) and shall identify the phase to which the current transformer is connected.

3.3.8.2 **Signal lamps**

3.3.8.2.1 Signal lamps preferred are the multi-LED bayonet coupling type. If the filament lamps are used, their rating shall be such that an average useful active life of at least 20 000 hours obtained and they shall have miniature Edison screw, large Edison screw or midget flange or grooved bases.

3.3.8.2.2 Signal lamp lenses shall be coloured as follows:

a. circuit-breaker closed RED
b. circuit-breaker tripped (open) GREEN
c. drive running RED
d. drive stopped GREEN
e. valve closed BLUE
f. valve open WHITE
g. valve stopped YELLOW
h. fault-trip WHITE
i. position indication WHITE

3.3.8.2.3 Signal lamps shall be suitable for operation at the control voltages specified in Schedule A.

3.3.8.2.4 Each lamp shall be provided with a series resistor capable of operating continuously in still air without exceeding a temperature rise of 10 ºC. The resistor shall be mounted inside the lamp holder in such a way that it does not compromise ventilation requirements.

3.3.8.3 **Push buttons**

3.3.8.3.1 The contacts of the buttons shall be adequately rated for the duty specified in Schedule A.

3.3.8.3.2 The front of the push button shall be coloured as follows:

a. circuit-breaker close GREEN
b. circuit-breaker trip (open) RED
c. drive start GREEN
d. drive stop RED
e. valve close BLACK
f. valve open WHITE

g. valve stop RED

h. fault reset BLUE

i. lamp test YELLOW

3.3.8.4 **Measuring instruments and accessories**

3.3.8.4.1 **Type of instruments**

a. Instruments shall be of the flush-mounting industrial ASSEMBLY type in accordance with 240-57649048.

3.3.8.4.2 **Instrument scales**

a. The scale shall have a full-scale movement deflection of not less than 90°.

b. Instruments shall have linear scales. All minor scale markings below the lowest major scale marking shall be identified by figures.

c. Where two scales are specified for one instrument, the scale indicated in brackets shall be supplied loose while the other scale shall be fitted to the instrument.

3.3.8.4.3 **AC ammeters**

a. Unless otherwise specified, ammeters shall be of the flush, ASSEMBLY mounted 1 A instantaneous indicating type.

b. Relevant current transformer ratios shall be indicated on each ammeter dial.

c. Ammeter scales shall be direct reading and the full-scale deflection shall be the first standard value above the normal primary current rating of the relevant current transformer.

d. Ammeters associated with motor circuits shall have a suitable overload scale to cater for motor starting currents.

e. All ammeters shall have an overload rating as laid down in IEC 60051. Care shall be taken to ensure that all ammeters for motor circuits are capable of withstanding the starting current of the motor for the time given.

3.3.8.5 **Ammeter selector switches**

a. Ammeter selector switches shall be of the four-position rotary type that complies with 240-57649048. The selector switch shall be mounted directly below the ammeter in such a way that the knob and indicator plate are visible on the front of the door.

b. The selector knob shall be of the insulated type with an engraved arrow indication the switch position.

c. The switch shall have a positively-driven switching mechanism, wired to connect the ammeter to any phase on the secondary side of the current transformers, and disconnect the ammeter in the remaining positions. Current transformer secondary circuits shall not be open circuited.

d. The indicator plate shall have the positions R, W, B and "off" engraved on it in 5 mm high lettering.

3.3.8.5.1 **DC Ammeters**

a. DC ammeters shall be for use with shunts mounted in the positive lead which will produce 50mV across its secondary terminals when the rated current flows through the shunt.

b. Ammeter scales shall be direct reading and the full-scale deflection shall be first standard value above the rated current of the circuit.

c. The meter shall be calibrated at 20 °C and shall have a temperature co-efficient not exceeding 0, 15 % / °C of the scale.

3.3.8.5.2 **Voltmeters**

a. Full-scale deflection shall be such that the nominal voltage is at approximately 75 % of the scale length except in the case of suppressed zero instruments where the nominal voltage shall be at 50 % of the scale.

b. The rated voltage shall be marked with a red line and the scale shall be fully expanded around the rated voltage.

c. Moving-iron instruments shall be as open as possible at the upper end of the scale.

d. Voltmeters shall have the overload rating as recommended in IEC 60051 and shall be protected by fuses.

3.3.8.5.3 **Voltmeter selector switches**

a. Voltmeter selector switches shall be of the four-position rotary type that complies with 240-57649048. The selector switch shall be mounted directly below the voltmeter in such a way that the knob and indicator plate are visible on the front of the door.

b. Selector knobs shall be of the insulated type with an engraved arrow indicating the switch position.

c. Switches shall have a positively driven switching mechanism and shall be wired to connect the voltmeter between any two phases and to disconnect the voltmeter in the remaining positions.

d. The indicator plate shall have the positions "R-W", "W-B", "B-R" and "off" engraved on it in 5 mm high lettering.

3.3.8.5.4 **Running hour recorders and operations counters**

a. Running hour recorders and operations counters shall be of the electromechanical or electronic type with at least five hour digits. The operations counter shall have a seven digit display and shall count each operation.

b. Both the running hour recorders and the operation counters shall be activated by switching on a power supply to the recorder.

c. Where the electromechanically type is used, it shall have either a legible rotating wheel or flap display. No resetting facility shall be provided.

d. The running hour recorder shall have at least five hour digits. The operations counter shall have a seven digit display and shall count each operation. This unit shall be activated by the same switching on of the power supply as the recorder.

3.3.8.5.5 **Auxiliary relays**

a. Auxiliary relays shall be type tested in accordance with SANS 60947-5-1.

b. Auxiliary relays shall be of the electromagnetic type with continuously rated coils and auxiliary contacts suitably rated for the application.

c. They shall be suitable for the voltage specified in Schedule A.

3.3.8.5.6 **Current transducers**

Transducers shall comply with 240-56359083. Input and output values shall be in accordance with the requirements specified in Schedule A.

3.3.8.6 **Terminals and lugs**

3.3.8.6.1 The types of terminals and lugs for all auxiliary circuits shall be selected in accordance with 240-57649048 for the different voltage and current rating application.

3.3.8.6.2 Cross connection facilities shall be provided for connecting two or more adjacent terminal ways without interfering with the terminal openings. Where used in current transformer circuits, the terminals shall be capable of accepting hooked blade lugs on 2.5 mm^2 cable.

3.3.8.6.3 All exposed terminals and cable terminations shall be shrouded using a transparent non-flammable material to prevent accidental contact. Perspex is unacceptable as a shrouding material.

3.3.8.6.4 Lugs are of the compression type. All lugs and their application with different types of terminals are as detailed on Eskom standard drawing 0.00-10341-01 sheet 02.

3.3.8.6.5 Terminals shall be provided for all cables entering the cubicle. Such cables shall not be made off directly onto other components in the cubicle.

3.4 REQUIREMENTS FOR ENGINEERING DRAWINGS

3.4.1 General

3.4.1.1 Reproducible drawings shall be provided in an English language. All drawing shall be in at least A3 size.

3.4.1.2 All engineering drawings shall comply with Eskom drawing standard 240-86973501.

3.4.2 General arrangement drawings

3.4.2.1 General arrangement drawings shall be completely dimensioned, showing:

a. Arrangement of equipment;

b. Top, front, and side views and cross-sections of the ASSEMBLY;

c. Position of each functional unit and their compartments;

d. Reference each functional unit type and size (e.g. 37kW DoL, 250A feeder etc);
e. Clearances for opening doors;
f. Locations of main busbars and distribution busbars;
g. Details on the required openings for the power cables;
h. Incoming and outgoing cable termination positions and details;
i. Cable slot positions;
j. The height of all cable glands above floor level;
k. Mass of transportable sections of equipment;
l. Details and position of the holding down bolts;
m. Magnitude and disposition of all loads imposed on foundations.

3.4.3 Schematic Drawings

3.4.3.1 **Schematic wiring diagrams shall show the following:**

a. Schematic diagrams shall be drawn using electrical symbols in accordance with 240-54690969;
b. All protection, control, indication and devices and their contacts, each of which shall be labelled with its correct circuit function letter and number in accordance with 0.00/10341 sheet 4 drawing;
c. Device terminal numbers, terminal block numbers and terminal numbers in accordance with 0.00/10341 sheet 3 drawing;
d. All wiring within each functional unit;
e. All internal interconnections, bus wiring, inter ASSEMBLY wiring and connections to external equipment;
f. All control and protection switches;
g. Power supply connections;
h. Component schedule for each circuit.

3.4.4 Low voltage switchgear schedule

Low voltage switchgear schedule template (Unique identifier 240-56356421) shall be completed by the ASSEMBLY manufacturer.

3.5 INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTION MANUALS

3.8.1 Instruction manuals shall comply with the requirements laid down in the tender enquiry.

3.8.2 The manuals that cover all equipment forming part of the ASSEMBLY shall be complete with:

a. Power station name and order number;
b. Content list;
c. List of reference drawings;
d. Details of all components.

3.8.3 The manuals to be submitted shall be in loose-leaf binders to ISO format (or equivalent) and nominally A4 size. The use of oversize pages shall be kept to minimum and shall not exceed page height unfolded. Fixings shall preferably be D-ring and be of the snap close type. Post binders or other fixings will not be accepted. Binders shall not exceed 80 mm in overall thickness. The document identity shall appear on both the front cover and on the spine.

3.8.4 Manuals shall contain general arrangements drawings, installation drawings and instructions, operating and maintenance instructions for all components, detailed parts lists which shall be accompanied by exploded view type drawings clearly detailing the part and uniquely identifying it, technical descriptions of the equipment and components parts, spare part ordering instructions and instructions and type test certificates.

3.8.5 Any special instructions pertaining to the storage of spare parts or to their shelf life shall be included in the manual. All drawings required for component locations, dismantling and re-assembly for maintenance shall be included in the manual. All special tools required for maintaining and operating the equipment shall be identified in a schedule to be included in the manual.

3.8.6 The manuals shall be submitted in loose-leaf binders to ISO format and normally A4 size. The use of oversize pages shall be kept to a minimum and does not exceed page height unfolded. The "D" ring fixing of the snap close type is preferred. Post binders or other fixings shall not acceptable. Binders do not exceed 80mm in overall thickness. The document identity appears on both the front cover and on the spine.

3.6 TRANSPORTATION REQUIREMENTS

3.10.1 Each transportable unit of stationary structures shall be furnished with removable lifting angles and/or plates suitable for crane hooks or slings. If transported separately, withdrawable circuit-breakers shall be individually crated and tagged with their correct unit number and the equipment number of the ASSEMBLY to which it belongs. Relays and other electronic devices shall be securely blocked to prevent damage during transportation.

3.10.2 Each transportable unit of stationary structures shall be provided with a permanently attached readily visible identification tag bearing the electrical equipment identification code number on the ASSEMBLY of which it is a part.

3.10.3 Each transportable unit shall be furnished with removable steel channel base plates which will permit using pipe rollers or dollies without damaging the steel frame of the equipment.

4. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Henk Nieuwenhuis	Senior Consultant: Production Engineering Integration
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5. REVISIONS

Date	Rev.	Compiler	Remarks
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May 2013	1	Dyke Monyane	Final document for Publication
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July 2019	1.2	Dyke Monyane	Final Draft after Review Process
July 2019	2	Dyke Monyane	Final Document for Authorisation and Publication

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

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7. ACKNOWLEDGEMENTS

- Acknowledgement goes to all Work Group members listed above in the development team.

APPENDIX A: POWER SUPPLY CONDITIONS

A.1 CONDITIONS FOR AC SYSTEMS

The LV Switchgear and Controlgear ASSEMBLIES shall be issued with a routine test certificate by the manufacturer, fully installed and commissioned in accordance with the requirements of this standard prior to being connected to a power system with the characteristics.

A.1.1 System normal power supply conditions

Extremes of these parameters can occur simultaneously:

a. Voltage: 400 V ± 10 %, 525 V + 5%, 690 V + 5%

b. Voltage unbalance: Negative Phase Sequence (NPS) voltage up to 0.02 of nominal Positive Phase Sequence (PPS) voltage

c. The Zero Phase Sequence Voltage (ZPSV) component can be up to 1% of the PPS component.

A.1.2 System abnormal power supply conditions

The amplitude and duration of temporary abnormal voltage operating characteristics which can occur on the power supply are as follows:

d. **Short duration abnormal conditions**; Short duration under-voltage conditions arise either due to a loss of supply or the supply voltage being depressed due to a short-circuit on the network as well as starting large motors.

e. **Loss of power supply**; When the supply is isolated, the supply voltage either drop rapidly to 0% of nominal value or is sustained at low amplitude at a reduced frequency because of back generation of electrical drives. The initial voltage amplitude during these conditions is less than 80% of nominal value and decays with a time constant of up to 1.5 seconds. The time duration from loss of supply until supply restoration is between 1 second and 2.5 seconds.

f. **Short-circuit**; Depression of supply voltage due to short circuits can result in voltages as low as 0% of nominal value. The duration of the drop can be up to 1 second.

g. **Over-voltage**; Over voltages with amplitudes of 110% of nominal value can occur for up to 10 seconds.

h. **Medium duration power supply deviations**; The switching of loads, such as starting induction motors, can cause voltage depressions of medium duration. The supply voltage can fall as low as 75% of nominal value and the duration of this depression can be up to 15 seconds. An alternative source of this abnormal condition is when power swings occur after a severe disturbance on the network. The supply voltage amplitude may oscillate at a frequency between 0.2 and 2 Hz. In this case, the voltage can fall as low as 65% of nominal and can rise up to 110% of nominal during a swing. The voltage shall not fall below 70% for longer than 0.5 seconds. However, these oscillations, or repeated abnormal voltage conditions, can continue for up to 60 seconds.

i. **Long duration power supply deviations**; Long duration abnormal supply voltage conditions usually originate from operating the plant at its limits. The supply voltage can be up to 110% of

nominal value and can drop as low as 90% of nominal value. The duration of such abnormal conditions is up to 6 hours.

A.1.3 Harmonic voltage distortion

The harmonic distortion of the supply voltage under normal operation is as follows:

a. The Total Harmonic Distortion (THD) of the voltage can be up to 5% of the fundamental component.

b. The voltage waveform can contain harmonic components up to the 100th harmonic.

c. The amplitude of any individual component can be up to 1% of the fundamental component.

A.2 CONDITIONS FOR DC SYSTEMS

The normal supply conditions of the DC power supply are described briefly as follows:

A.2.1 Voltage rated at 220 V DC

a. Voltage: +10 %, -15 %

b. Maximum RMS ripple voltage: 2.5 %

c. DC earthing method: High resistance

A.2.2 Voltage rated at 24 V DC

a. Voltage: +25 %, -12.5 %

b. Maximum RMS ripple voltage: 2.5 %

Extremes of these parameters can occur simultaneously.

APPENDIX B: CONTROL PANEL CONSTRUCTION AND FUNCTIONAL REQUIREMENTS

B.1 THE DESIGN AND MANUFACTURING OF CONTROL PANELS SHALL COMPLY WITH THE FOLLOWING REQUIREMENTS:

a. Accessible live parts inside the CONTROL PANEL shall have a degree of protection of at least IPXXB.

b. For maintenance purposes, padlocking facilities shall be installed for all switch disconnection devices and provided both on the outside and the inside of the section or sub-section to lock the switch-disconnecting device in the isolated position.

c. AC busbars are colour coded RED, WHITE & BLUE for the phases and BLACK for neutral busbar.

d. DC busbars rated at 220 V shall be colour coded RED, for the positive conductor and BLACK for the negative.

e. DC busbars rated at 24 V shall be colour coded RED, for the positive conductor and BLUE for the negative, and the zero bar shall be colour coded BLACK (where required).

f. Collection busbars need to be constructed where SCPD's (Short Circuit Protective Device) and MCBs need to be connected in cascaded circuits. Collection busbars shall be rated for the full prospective short-circuit rating and equal to the derated current rating of the supply SCPD.

g. Earthing or bonding to the protective earth (PE) conductor shall be applied to all doors by means of at least 6 mm^2 cross-sectional area multistrand conductors.

h. The PE conductor shall be dimensioned in accordance with SANS 10142-1 with respect to the thermal stresses due to duration of short-circuit at 60 % of the CONTROL PANEL prospective short-circuit rating kA. The size of the PE conductor shall not be less than 150 mm^2. The conductor shall also be pre-drilled.

i. The PE conductor shall be colour coded GREEN with a YELLOW stripe and the screened earth bar shall be left uncoloured.

j. Where cables of 95 mm^2 and larger are required, they shall be provided with robust, individual, un-drilled, removable gland plates. These gland plates shall be non-magnetic in case of single core cables.

k. All control wiring connected to a source of fault energy shall be capable of carrying continuously a current equal to 1,5 times the rating of the fuse protecting it and withstanding the total I^2t let-through current of the fuse under any fault condition from overload to short circuit without suffering perceptible damage.

l. Only stranded conductor cable shall be used. Single or solid conductor shall not be used. Aluminium conductors shall also not be used.

m. Multistrand cable with conductors of 1,5 mm^2 cross sectional area shall be used for control circuits. Wiring of circuits of up to 50 V shall be 1.5 mm^2 multistrand conductor cable.

n. Wiring of the current and voltage transformer circuits shall be done by multistrand conductor at least 2.5 mm^2 cross-sectional area. The circuits and shall be colour coded according to the phases to which it is connected.

o. Cable used on 24 V DC control circuits shall consist of at least 1.5 mm^2 multistrand conductors.

p. Conductors carrying currents in excess of 100 A and passing through metal shall either be all three phases (both poles of DC conductors) or the metal barrier shall be split.

q. Components shall be arranged and mounted in the CONTROL PANEL in such a way that maintenance work can be performed in a safe and orderly manner.

r. Control conductor sheath shall be coloured as follows:

- BLACK for AC circuits
- GREY for DC circuits

s. Conductors of CT and VT circuits shall bear the phase colours. The neutral conductor shall be coloured BLACK.

t. Control conductors shall be marked at both ends with an interlocking type of ferrule with permanent black letters impressed on a white or yellow background. The numbered ferrule shall not fall off when disconnecting the cable. Ferrules shall read in a consistent manner in both vertical and horizontal planes.

u. Conductors for control wiring shall be terminated with pre-insulated compression type lugs.

v. Each terminal strip mounting rail shall be provided with not less than 10% spare length with a minimum of 50 mm.

w. Not more than two control conductors shall be connected to any one side of a terminal.

x. Wiring for voltmeters shall be arranged in such a way that the CONTROL PANEL's fault free-zone's integrity will not be impaired.

y. Terminal barriers shall be fitted between terminals with different voltage levels.

z. All terminals shall have a flammability rating of V0 in accordance to UL 94.

aa. Terminals or terminating conductors associated with one functional unit shall be grouped together.

bb. All termination arrangement not in accordance with IP2X shall be provided with separate covers to act as shroud so that accidental contact is impossible when making off adjacent cables.

cc. The finished external colour of the AC CONTROL PANEL shall be G29: LIGHT GREY to SANS 1091 except for mounting plates and other support structures, which can be galvanized, or alloy cold rolled zinc steel. The base-frames shall be painted BLACK.

dd. The finishing coat shall be free from craters, pinholes, embedded foreign matter, and other visual defects. The topcoat shall also provide complete hiding, consistent coverage and thickness, and uniform colour.

ee. All steelwork shall be corrosion protected in accordance with 240-75655504 - Corrosion Protection Standard for New Indoor and Outdoor Eskom Equipment, Components, Materials and Structures Manufactured from Steel Standard.

ff. Each CONTROL PANEL shall have a nameplate stating the following;

- Name of the ASSEMBLY

- Plant coding
- Manufacturer
- Manufacturer's address and contact telephone number
- Contract Number
- Standard to which it was manufactured
- Main Busbar current rating
- Rated operating voltage
- Control voltage
- Rated impulse withstand voltage
- IP rating doors open and doors closed
- Short-circuit rating in kA and duration in seconds
- Form of separation of respective sections
- Degree of Pollution

gg. Minimum creepage distances shall be for Pollution Degree 3, material group 111a with the specified insulation voltage.

hh. Rated impulse voltage shall be 8 kV for AC power components, busbars and circuits and 6 kV for AC control circuits.

ii. No components or equipment shall be mounted in any position where it is not visible and accessible to a viewer looking into the compartment through the door opening (fixed circuits).

jj. The CONTROL PANEL's metal enclosure shall have a minimum external degree of protection of IP3X in accordance with SANS 60529.

kk. For control panels below 10kA, form of separation shall have minimum of Form 1.

ll. Barriers with degree of protection of at least IPXXB shall be provided to prevent accidental contact with live conducting parts of the circuit and to protect the unit from falling objects.

mm. Routine testing of CONTROL PANELS shall be in accordance with SANS 1973-3 Annex E.

nn. Routine tests shall be carried out on each CONTROL PANEL during the Factory Acceptance Testing (FAT), prior to dispatch and which shall serve to check for manufacturing and material defects.