Eskom	Standard	Technology

Title: **LV Switchgear and Control Gear Assemblies and Associated Equipment for Voltage up to and Including 1000V AC nd 1500V Standard**

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1. INTRODUCTION

This Standard describes the safety, design, type-testing, performance, constructional and routine testing 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 specification also covers the Eskom requirements for fit-for-purpose free standing metal-enclosed type tested Low-voltage Switchgear and Controlgear ASSEMBLIES in accordance with the requirements of SANS 10142-1, SANS 1973-1 and SANS 60439-1 and with the reference design.

Switchgear 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

This Specification describes the safety, design, type-testing, performance, constructional and routine testing 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 specification also covers the Eskom requirements for fit-for-purpose free standing metal-enclosed type tested Low-voltage Switchgear and Controlgear ASSEMBLIES in accordance with the requirements of SANS 10142-1, SANS 1973-1 and SANS 60439-1 and with the reference design.

Switchgear 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.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.1.3 Legal Requirements

a. Eskom and its vendors are subject to the Occupational Health and Safety Act with regulations (Act no. 85 1993 of the Republic of South Africa), Project and Construction Management Professions Act, (Act No. 48 of 2000 of the Republic of South Africa) as well as, the Engineering Profession Act (Act No. 46 of 2000 of the Republic of South Africa).

b. All the equipment shall meet the requirements of the Act or the legislative requirements applicable to the territory in which the equipment shall be located.

c. LV Switchgear and Controlgear ASSEMBLY shall comply with the fundamental safety requirements of Clause 5 of SANS 10142-1.

d. LV Switchgear and Controlgear ASSEMBLY shall as a minimum be designed, constructed and tested in accordance with the requirements of Clause 6.6 of SANS 10142-1

e. 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.

f. Any conflict between this Specification and statutory requirements shall be brought to the attention of Eskom for written clarification.

g. Occupational Health and Safety requirements for contractors are given elsewhere

2.1.4 Service Conditions

The equipment shall be suitable for use under the service conditions as per Appendix E of this Specification, details in Schedule A of an enquiry document and SANS 1973-1 Annex B.

2.2 NORMATIVE/INFORMATIVE REFERENCES

The following national, international and Eskom specifications and standards shall be read in conjunction with this Specification. In cases of conflict, the order of preference shall be as follows: the South African Compulsory Specifications, SANS 10142-1, the requirements of this Specification and thereafter the International Standards.

2.2.1 Normative

The following national, international and Eskom specifications and standards shall be read in conjunction with this Specification. In cases of conflict, the order of preference shall be as follows: the South African Compulsory Specifications, SANS 10142-1, the requirements of this Specification and thereafter the International Standards.

South African Mandatory Specifications

[1] VC 8003 Manually Operated Switches for Fixed Installations

[2] VC 8006 Electric cables- flexible cords and flexible cables

[3] VC 8035 Earth-leakage protection units - Part 1 'Fixed earth leakage protection units.

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

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

South African National Standards

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

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

[8] SANS 804 Unwrought tough pitch coppers: Electrolytic tough pitch high conductivity copper

[9] SANS 1091 National colour standards

[10] SANS 1195 Busbars

[11] SANS 1213 Mechanical cable glands

[12] SANS 1411-1 Materials of insulated electric cables and flexible cords. Part 1: Conductors

[13] SANS 1973-1 Low-voltage switchgear and controlgear ASSEMBLIES Part 1: Type-tested ASSEMBLIES with stated deviations and a rated short-circuit withstand strength above 10 kA (Use with SANS 60439-1)

[14] SANS 1973-7 Low-voltage switchgear and controlgear ASSEMBLIES Part 7: Requirements for testing under conditions of arcing due to internal fault

[15] SANS 1507 Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) - Part 1: General, Part 2: Wiring cables, Part 3: PVC distribution cables, Part 4: XLPE distribution cables, Part 5: Halogenfree distribution cables, Part 6: Service cables.

[16] SANS 1574 Electric flexible cores, cords and cables with solid extruded dielectric insulation Part 1: General, Part 3 : PVC insulated cores and cables, Part 4: Rubber insulated cores and cords, Part 5: Rubber insulated cores and cables.

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

[18] SANS 60044 Instrument transformers, Part 1: Current transformers

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

[20] SANS 60439-1 Low-voltage switchgear and controlgear ASSEMBLIES. Part 1: Type-tested and partially type-tested ASSEMBLIES, Part 2: Particular requirements for busbar trunking systems (busways).

[21] SANS 60529 Degrees of protection provided by enclosures (IP Code).

[22] SANS 60614 Conduits for electrical installations - Specifications Part 1: General requirements, Part 2: Particular specifications for conduits Section 5: Flexible conduits.

[23] SANS 60695-2-10 Fire hazard testing - Part 2 Section 10: Glowing/ hot-wire based test methods-Glow wire apparatus and common test procedure.

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

[25] SANS 60890 A method of temperature-rise assessment by extrapolation for partially-tested ASSEMBLIES (PTTA) of low voltage switchgear and controlgear.

[26] SANS 60947-1 Low-voltage switchgear and controlgear. Part 1: General rules.

[27] SANS 60947-2 Low-voltage switchgear and controlgear. Part 2: Circuitbreakers.

[28] SANS 60947-3 Low-voltage switchgear and controlgear. Part 3: Switches, disconnectors, switch-disconnectors and fuse combination units.

[29] SANS 60947-4-1 Low-voltage switchgear and controlgear. Part 4: Contactors and motor starters. Section 1: Electromechanical contactors and motor starters.

[30] SANS 60947-5-1 Low-voltages switchgear and controlgear. Part 5: Control circuit devices and switching elements. Section 1: Electromechanical control circuit devices.

[31] SANS 60947-6-1 Low-voltages switchgear and controlgear. Part 6: Multiple function equipment Section 1: Transfer switching equipment.

[32] SANS 61000 Electromagnetic compatibility (EMC)

[33] SANS 61117 A method for assessing the short-circuit withstand strength of partially type-tested ASSEMBLIES (PTTA)

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

[35] SANS 61643-1 Low-voltage surge protective devices Part 1: Surge protective devices connected to low-voltage power distribution systems - Requirements and tests.

International Standards

[36] BS 1706 Method for specifying electroplated coatings of zinc and cadmium on iron and steel.

[37] 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.

[38] BS EN 61238 Specification for performance of mechanical and compression joints in electrical cable and wire connectors. Part 1: Compression joints in copper conductors, Part 2: Compression joints in nickel, iron and plated copper conductors, Part 3: Mechanical and compression joints in aluminium conductors.

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

[40] IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories Parts 1: Definitions and general requirements, Part 2: Special requirements for ampere meters and voltmeters, Part 3: Special requirements for watt meters and var meters, Part 4: Special requirements for frequency meters, Part 5: Special requirements for phase meters, power factor meters and synchroscopes, Part 6: Special requirements for ohmmeters (impedance meters) and conductance meters.

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

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

[43] IEC 60695-2-10 Fire hazard testing - Part 2-10: Glowing/hot-wire based test methods - Glow-wire apparatus and common test procedure.

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

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

[46] ISO 9001 Quality management systems - Requirements

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

[48] UL 94 Flammability specifications

Eskom Standards, Specifications and Standard Drawings:

[49] ESKPVAEY6 Operating Regulations for High-Voltage Systems, Eskom

[50] ESKASAA04 Standard for electronic protection and fault monitoring equipment for power systems, Eskom

[51] ESKASAAN3 Standard arrangement for metering and measurement at Hydro and coal fired power stations

[52] ESKSCAAD0 Specification for continuous analogue indicating instruments for electrical quantities

[53] GGR 0992 Plant Safety Regulations, Eskom

[54] GGS 0803 Generation MV and LV Protection Philosophy for Power Stations

[55] 240-56357346 List of Approved Relays for Use on Power Stations Standard

[56] NPSZ-45-45 KKS Key Part- Fossil Power Station

[57] NWS 1582 Labels on control ASSEMBLIES, relay ASSEMBLIES and other indoor and outdoor equipment

[58] SCSSCAAP9 Corrosion Protection for New Indoor and Outdoor Distribution Equipment Manufactured from Steel

[59] Drawing 0.00/1705 Construction power supply

[60] Drawing 0.00/2839 Standard Padlock

[61] Drawing 0.00/10335 Sheets 1-4, Wiring Termination Standard, Power and Control

[62] Drawing 0.54/3695 Sheets 1-2, MV, LV and DC Switchgear Labels and Nameplate Details

2.2.2 Informative

None

2.3 DEFINITIONS

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.
Back-to-Back ASSEMBLY	An ASSEMBLY with two single sided arrangements standing in a back-to-back configuration with all functional units arranged for front entry only and having transport sections to enable front and rear access to distribution busbars.
Barrier	A part providing protection against direct contact from any usual direction of access (minimum IP2X) 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.
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 protective gear.
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.
Incomer Unit	A functional unit through which electrical energy is fed into the ASSEMBLY.
Intelligent ASSEMBLY	A low-voltage ASSEMBLY equipped with intelligent protection and control devices connected to a Distributed Control System (DCS) and/or Supervisory Control and Data Acquisition (SCADA) system either by hard-wiring or via a dedicated process control network, even both. The direct interface enables automatic control and switching of the process and the capturing of processing information and data.
Intelligent Electronic Device (IED)	Microprocessor-based device with the protection, control, monitoring and communication functionalities.
Modular Design	An ASSEMBLY System which accommodates a variety of section sizes, sub-section sizes, and busbar and cable compartment sizes in such a way that the different combinations has been subjected to all type-tests as prescribed by SANS 1973-1.
Padlocking facility (Padloackable)	Part of the ASSEMBLY or component that allows one to insert a padlock for locking purposes during maintenance. Standard 00.2839 applies.
Partition	A part of the enclosure of a compartment separating it from other compartments.

Definition	Description
Protective Gear	Individual or combinations of circuit-breakers and or switch-disconnectors and or fused switch-disconnectors.
Stated Deviations	Derivations from a type-tested ASSEMBLY which is documented in the Engineering Design System and supported by type-test reports
Transport Unit	A part of an ASSEMBLY or a complete ASSEMBLY suitable for shipping without being dismantled.
Type-Tested ASSEMBLY with stated deviations	An ASSEMBLY System which has been verified by a comprehensive range of tests of worst case scenarios and documented in accordance with an approved Engineering Design System with all type-tests performed in accordance with the requirements of SANS 10142-1, SANS 1973-1 and SANS 60439-1.
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 Proofing Inverter
EDS	Engineering Design System
EMC	Electromagnetic compatibility
FAT	Factory Acceptance Test
f_n	Rated frequency
HEM	High Efficiency Motor
HRC	High Rupturing Capacity
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronic Engineers
IP	Ingress Protection
ISO	International Organisation for Standardisation

Abbreviation	Description
KKS	Plant code number
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
PTTA	Partially Type-tested ASSEMBLY
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
SPD	Surge Protection Device
TTA	Type-tested ASSEMBLY
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

None

2.6 PROCESS FOR MONITORING

None

2.7 RELATED/SUPPORTING DOCUMENTS

None

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

3.1 DESIGN AND CONFORMANCE REQUIREMENTS

a. ASSEMBLIES shall be fit-for-purpose type-tested low-voltage free-standing metal-enclosed switchgear and controlgear ASSEMBLIES with stated deviations in accordance with the requirements of this Specification, SANS 10142-1, SANS 1973-1, SANS 60439-1 and SANS 1973-7. The ASSEMBLIES shall also meet the Eskom requirements in terms of safety, operation and maintenance requirements.

b. A type-tested ASSEMBLY with stated deviations will comply in all respects with the requirements of SANS 1973-1 when derivations in accordance with the Engineering Design System (EDS) are subjected to type-testing for the claimed performance.

c. The EDS shall fully describe maximum allowable power losses per section or sub-section and grouping thereof and it shall be demonstrated by test reports on temperature-rise limits achieved and calculations in accordance with SANS 60890.

d. ASSEMBLIES shall be constructed only of materials capable of withstanding the mechanical and electrical stresses as well as the effects of humidity which are likely to be encountered in normal service.

e. The manufacturer shall have conducted full type tests and specified special tests as required at a Third Party Test House accredited by an internationally recognized Accreditation Authority in terms of ISO 17025 in accordance with SANS 60439-Table 7 for a reference design and shall be in possession of valid type test report/s not older than 5 years that reflects a reasonable and true outcome of the results. In addition, the type tests shall comply with the latest revisions of the applicable standards. In case a certificate is older than 5 years, proof shall be provided that the design and materials used match that of the type tested ASSEMBLY.

f. A valid “scope of testing” certificate issued by the Accreditation Authority shall be submitted.

g. The manufacturer shall be in possession of an Engineering Design System (EDS) as specified in SANS 1973-1, specifically Annex B, in which deviations to meet requirements of this Specification and plant specific requirements (items subject to agreement) as may be detailed in enquiries issued by Eskom can be verified and validated.

h. A type-tested ASSEMBLY with stated deviations would typically be of modular design, extensively type-tested under worst-case conditions of IP Rating, Forms of Separation, a complete range of sizes of sections, sub-sections and busbar compartments. Worst case power losses, highest ratings of protective gear installed, highest possible diversity factors, current ratings, short-time ratings, conditional short-circuit ratings at maximum voltages with type II co-ordinated arrangements, maximum support and busbar configurations, busbar cross-sectional area, conductors installed in the ‘fault-free-zone’ etc.

3.2 CONSTRUCTION AND PERFORMANCE REQUIREMENTS

3.2.1 General

a. Metal-enclosed Low Voltage (LV) Switchgear and Controlgear ASSEMBLIES shall be designed, manufactured, type-tested, and routine tested in accordance with this Specification, the switchgear schedule accompanying the enquiry document to detail Eskom's requirements for the ASSEMBLY and the reference documents referred to in Section 2.2 of this Specification.

b. LV Switchgear and Controlgear ASSEMBLIES shall be constructed as free standing, factory built ASSEMBLIES comprising of several sections and subsections with withdrawable and / or fixed functional units.

c. Unless otherwise specified in the switchgear schedules, ASSEMBLIES shall consist of an enclosure, doors, partitions, main busbars, control busbars, phase and protective earth conductors, functional units and other equipment.

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

e. Sheet steel metal shall be used in the construction and manufacturing of the ASSEMBLY and shall be folded and braced to provide rigid support for the structure and components. The thickness shall not be less than that of the type tested ASSEMBLY.

f. Construction of the ASSEMBLY shall be arranged by welding and/or by bolting the separate parts together as per Schedule A requirements.

g. 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:

- Front operation with rear cable-access; or
- Front operation with front cable-access with minimum cable section width of 400mm and a minimum width/depth ratio of 2; or
- Back to back ASSEMBLIES with front and rear operation and cable-access; and
- Cable-entry from above or below.

h. ASSEMBLIES shall be floor mounted with exterior enclosure including doors and covers presenting a flush and uniform appearance.

i. A base frame shall be provided to Eskom's approval. Segregations in the base frame shall be provided to correspond with the ASSEMBLY transport sections. The base frame shall be painted BLACK.

j. ASSEMBLIES shall be designed and type-tested to permit addition of further sections on both ends of the ASSEMBLY.

k. 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.

l. 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.

m. 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 c) cable slots shall after installation of cables be sealed with a fire resistant material having a two hour fire rating.

n. 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 Doors and covers

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

b. All removable covers shall require the use of a tool for their removal. Opening of doors for all mcb groups shall be padlockable.

c. Doors shall have not less than the following points of hinging:

up to 450mm - 2 hinges,

up to 800mm - 3 hinges

more than 800mm - 4 hinges.

d. All doors shall be secured by square key latches as follows:

up to 450 mm - 2 latches,

up to 800 mm - 3 latches and

more than 800 mm - 4 latches

Any other proven design shall be submitted to Eskom for approval.

e. Door latches shall be of robust construction and be manufactured from steel. At least the center square key latch shall be padlockable.

f. Provision shall be made on the cable compartment door hinges to allow the doors to be lifted off. Metal hinges shall be of robust construction and shall ensure effective electrical bonding to the enclosure is maintained. Plastic and die cast material is not acceptable.

g. 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.

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

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

j. Doors of 800mm or longer shall be provided with webs or other methods to prevent wobbling when the door is operated.

3.2.3 Fixed pattern functional units

a. 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.

b. The MCCB's used on the fixed pattern functional unit shall be of the withdrawable type. 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.

c. A visible air gap shall be achieved by means of plug-in MCCB's installed on the line-side of Type II coordinated combinations

d. Accessible live parts inside the ASSEMBLY shall have a degree of protection of at least IP2X.

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

f. 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.

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

3.2.4 Withdrawable functional units

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

b. 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.

c. 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 the 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 the 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 can not be moved to another position. It would be preferredd 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 (IP2X) with live conductors on removal of the unit and shall be padlockable in the closed position. Further, the inadvertent contact (IP2X) with busbars shall be prevented when the shutters are open. Busbar spout shutters shall be labeled with the word "BUSBARS". Cable spout shutters shall be labeled with the word "CABLE".

d. 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.

e. 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.

f. 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 a isolated position.

g. 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.

h. 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.

i. 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.

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

3.2.5 Main, Distribution, Equalizing and Collection Busbars

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

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

c. Main and distribution busbar dimensions shall take into account the maximum allowed surface temperature-rise, the expected power losses per running metre, the ASSEMBLY form of separation, the external degree of protection IP and the ability of the ASSEMBLY to dissipate the power losses at the assigned rated current. For main busbars, the maximum permissible surface temperature-rise at rated current shall not exceed 65 K and for distribution busbars 55 K.

d. Unless stated otherwise, the neutral busbar shall not be rated at less than 50 % of the main or associated distribution busbars and shall be easily accessible.

e. 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.

f. Joints and tees in busbar connections shall comply with the recommendations of the Copper Development Association laid down in TN 22 - "Copper for Busbars". High tensile bolts of 8,8 strength grade to ISO 898-1 shall be used. Bolts, nuts, washers etc. shall be zinc plated and chromate passivated.

g. Joints shall be made with at least two bolts and the overlap shall be sufficient to ensure ample mechanical strength and joint conductivity. The busbar overlap shall be not less than six times the thickness or shall equal the width of the busbar material whichever is the greater. For busbar connections, conical washers will be preferred above spring washers.

h. The distribution busbar compartment shall be rigid and supported all the way from the main busbar section down to the gland plate below the bottom end of the distribution busbars. Standard approved busbar supports with a minimum fault current rating in line with that of the main busbar support shall be used as supports for distribution busbars.

i. The span of the distribution busbar shall not interfere with the ASSEMBLY cable entry zone, allowing for easy cabling of even the lowest functional unit. Provision shall be made for easy inspection of all functional unit connections to the distribution busbars.

j. 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.

k. Busbars shall be colour coded as follows:

- AC busbars are colour coded RED, WHITE & BLUE for the phases and BLACK for neutral busbar.
- DC busbars rated at 220 V shall be colour coded RED, for the positive conductor and BLACK for the negative.
- 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)

l. 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.

m. 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.

3.2.6 Protective earth conductor and the screened earth busbar

a. 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.

b. 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.

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

d. 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 ASSEMBLY 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.

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

f. Where specified, a screened earth busbar made of copper material shall be installed in the inside rear of the ASSEMBLY along its entire length. The screened earth busbar shall be completely insulated from all metal parts and shall be located in an accessible position to allow for the connection of cable screens.

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

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

3.2.7 Gland Plates

a. Cable gland plates of a uniform design shall be provided at a minimum height of 300 mm above the point of entry. 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 cable gland plate shall be mounted at the point of entry.

b. 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.

c. 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.

d. 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.

e. Metal gland plates shall be bonded to the PE conductor by means of a bonding conductor whose cross-section is selected in accordance with SANS 60439-1 Table 3A.

3.2.8 Cable securing arrangements

a. Cables of 10 mm^2 and larger cross sectional area shall be provided with cable glands.

b. Supports shall be provided within the cabling compartment to permit the cabling contractor to securely position each incomer cable and outgoing cable with a cable clamp.

3.2.9 Conductors installed in the "fault-free" zone

a. Cable installed between the main or distribution busbars and the functional units are deemed to be unprotected "active" conductors and shall be installed and braced in such a manner that a short-circuit is unlikely to occur. The smallest conductor that may be installed in the 'fault-free-zone' is 16 mm^2.

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

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

3.2.10 Power and control wiring

a. Power circuit wiring and connections in the ASSEMBLY shall be rated according to the de-rated operating current of the associated protective gear and not the load current.

b. 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.

c. 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.

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

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

f. 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 0,5 mm^2 multistrand conductor cable.

g. 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.

h. Cable used on 24 V DC control circuits shall consist of at least 1,5 mm^2 multistrand conductors.

i. Joints or splices in any circuit as well as the termination of more than one conductor in one lug will not be acceptable.

j. ASSEMBLY and equipment terminals, labels, etc., shall be accessible after the circuits have been completed. Terminals, which are on the live side of fuses and isolating switches, shall be completely shrouded.

k. 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.

l. 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 BS EN 61238.

m. 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.

n. 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.

o. AC and DC conductors shall not be routed in the same wireway.

p. Power circuit cable sizing shall be based on SANS 1973-1 Annex H.2.

q. Stripping of insulation shall not result in damage to the conductors, shall result in 90 degrees clean cut and insulation is not damaged. The stripping tools used shall be of the type which permits the length of strip to be preset and the "force" applied to be preset.

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

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

3.2.11 Accessibility

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

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

3.2.12 Conductor identification

a. 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.

b. Control conductor sheath shall be coloured as follows:

- BLACK for AC circuits
- GREY for DC circuits

c. Control bus wiring shall be coloured as follows:

- DC - RED for positive and BLACK for negative
- AC - BROWN and BLUE

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

e. 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.

3.2.13 Control wiring terminations

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

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

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

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

e. Screwed terminations for control wiring are preferred. Wiring termination shall be done in accordance to standard 00.10335.

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

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

3.2.14 Internal power cable terminations

a. 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.

b. 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.

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

d. 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.

e. 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 conditions and shall have been type tested as part of the assembly for all operating conditions.

f. Power and control terminals, associated with each circuit, shall be grouped and mounted on terminal rails adjacent to the associated circuit at the rear of the section or sub-section.

g. Power terminals shall be separated from the control terminals by means of a barrier and are fully shrouded to prevent accidental contact.

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

i. 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.

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

3.2.15 Outgoing cable termination

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

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

c. 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.

3.2.16 Control power supply

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

- Single bus fed from the predefined supply point through a miniature circuit breaker (mcb) or fuse and a neutral link.
- Where specified, the above bus system shall be energised through a stabilised power supply.
- The design of the ASSEMBLY shall allow for six control busbars.

b. Contactors and motor starters shall have individual control circuits fed from these

busbars through mcb's or fuses and/or links mounted in the section or sub-section dedicated to that contactor.

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

3.2.17 ASSEMBLY finish and protective coating

a. 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.

b. 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.

c. 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.

d. 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

e. All steelwork shall be corrosion protected in accordance with SCSSCAAP9.

3.2.18 Nameplates and Labels

3.2.18.1 General

a. Labels shall comply with the requirements of Eskom Drawing Standard 0.54/3695 and KKS Coding Standard NMP 45-7.

b. Labels shall be affixed in such a way that they are easily legible and not obstructed by the wiring or by other components. Clamping of the labels shall be in such a way that force is needed to remove any of the labels.

c. 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.

d. Labels shall be inscribed in the English language.

3.2.18.2 Label material

a. Labels shall be of sandwiched layers to enable indelible engraving. The material shall not be affected by radiation and shall have an operational temperature of at least 120 ^{o}C. The label material shall withstand the glow wire test at 850 ^{o}C.

b. Conductive material shall not be used for labels to be installed inside an ASSEMBLY.

3.2.18.3 Nameplate

a. Each ASSEMBLY shall have a nameplate in accordance with SANS 1973-1 stating at least the following:

- Name of the ASSEMBLY
- Plant coding
- Manufacturer
- Manufacturer's address and contact telephone number
- Contract Number

- Standard to which it was manufactured and type-tested
- 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

3.2.18.4 Main Label

a. Each ASSEMBLY shall be provided with a main label stating the name of the ASSEMBLY and KKS Code (or any other plant coding system).

b. Writing shall be clear and visible

3.2.18.5 Circuit designation labels

a. Circuit designation labels shall be provided in triplicate for each fixed pattern functional unit and in four fold for each withdrawable functional unit.

b. Labels shall be affixed in accordance with the labelling specification for the following: the front door of each section and sub-section, in the cable compartment adjacent to the terminals or terminating conductors associated with this circuit, and in the case of withdrawable functional units, also on the padlock shutter flap, so that they are visible with the withdrawable unit removed.

c. Circuit designation labels mounted on a flat surface can be fixed by means of clip-in plastic rivets or other approved method providing that the distance between fixing points does not exceed 100mm.

d. The circuits of the spare circuits shall be left blank without engraving. They shall be fitted in such a way that it is easily to remove them for engraving purposes.

3.2.18.6 Operating Labels

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

b. 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.

3.2.18.7 Component labels

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

b. 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.

c. The label height shall not be smaller than 10 mm and the printing height on the label shall not be less than 6 mm.

d. 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 KKS code and the component size.

3.2.18.8 Identification labels

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

b. 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.

c. Protective devices and controlgear shall be provided with nameplates in accordance with SANS 60947 Parts 2 and 3.

d. Series or cascading combinations shall be labelled as per SANS 10142-1.

3.2.19 Heat dissipation characteristics of the ASSEMBLY

a. The ASSEMBLY shall be designed to allow for heat that is generated within the ASSEMBLY to be dissipated through the steel structure.

b. Enclosed equipment shall be correctly rated in accordance with the OEM's installation configuration.

c. 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. The installation of the power electronic devices shall not compromise the temperature-rise requirements and the ASSEMBLY's degree of protection.

   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 is in compliance with the following requirements:

   - No tripping of the switching device is allowed if any of the fans fail
   - Monitoring of fans using fan failure indications and alarms
   - Full redundancy of cooling
   - The cooling fan motor assembly is readily available in South Africa
   - Low speed high volume fans are used

d. Components or devices with the lowest rated working temperature shall determine the highest working temperature of the section or sub-section of the ASSEMBLY.

e. The OEM shall state the highest temperature-rise allowed on the load side of the incomer protective gear and on the line side of the outgoing protective gear.

f. A diversity factor at a minimum of 0.8 shall have been applied on all outgoing circuits during verification of temperature-rise limits of the different configurations of Assemblies submitted for full type-testing.

3.2.20 Dielectric Properties

a. ASSEMBLIES shall have a minimum rated insulation voltage of 1 000 V.

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

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

3.2.21 Clearance and Access

a. A minimum clearance on equipment mounting panels of 25 mm 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.

b. 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).

3.2.22 Degrees of Protection

a. The ASSEMBLY shall be designed and manufactured to the degree of protection as specified in Schedule A of an enquiry document.

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

c. Barriers with an internal degree of protection of at least IP2X shall be provided to prevent accidental contact with live conducting parts of the circuit and to protect the unit from falling objects.

d. Fully separated components shall be provided for main busbars, auxiliary busbars, cabling as well as incoming and outgoing functional units. The internal degree of protection of at least IP2X shall be maintained between the different compartments and adjacent sections or sub-sections.

e. The design of the gland plates shall ensure an internal protection of at least IP2X before and after installation of the incoming / outgoing cables.

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

g. Functional unit shutters shall have a degree of protection of at least IP2X in the closed position.

3.2.23 Insulation

a. Insulating material used on any part of the busbars and distribution busbars including supports and shrouds shall withstand the glow wire test at 960 ^{o}C to SANS 60695-2-10.

b. Where specified, heat shrink material for insulation or indication shall have a rated working temperature of at least 130 ^{o}C.

c. The class of insulation for all supports and shrouds shall be Class E or better.

d. Insulating material used on any part of the busbars and distribution busbars including busbar supports and shrouds shall be flame retardant, non-hydroscopic, non-halogen gassing and resistant to tracking with a minimum continuous operating temperature of not less than 105 ^{o}C. The insulation materials shall also be able to withstand the thermal effects of the rated short-time withstand current.

3.2.24 Forms of Separation

a. Main busbars, auxiliary busbars, distribution busbars, cable access as well as incoming, outgoing and functional units shall be fully segregated to FORM 3b with the exception of the mcb groups which shall have a minimum of FORM 2b internal degree of separation.

b. Sheet metal barriers shall be used to separate the functional units such that they limit the propagation of arcing into adjacent functional units.

c. Claimed Forms of Separation shall be proven by type-test verification of temperature-rise limits for the specific configuration of functional units proposed and power losses, which are claimed, can be dissipated.

d. The highest Form of Separation for each configuration of Sections and Sub sections with highest achieved power losses shall be proven by type-test reports.

3.2.25 Internal Arc Confinement

a. ASSEMBLIES shall be designed to confine internal arcing faults and to direct arcs and gases arising from these away from the possible operator interface points (i.e. back and front).

b. Provision shall be made to limit pressure build up and / or re-direct gases resulting from an internal arc fault in any section or sub-section.

c. Each section of the ASSEMBLY shall be equipped with a pressure activated relief flap that shall direct ionised materials and gases away from the operator interface points.

d. The two main function of internal arc confinement are to protect the operator in front and also prevent the arc from spreading to any other compartment that might also be energized.

3.2.26 Future extension of ASSEMBLIES

a. Provision shall be made in the EDS and type-test results to indicate methods for future extension on either side of the ASSEMBLY.

b. Physical space for future extension of outgoing circuits shall be provided for as called up in Schedule A of the enquiry document.

c. Provision shall be made for an increase in the electrical supply capacity of the ASSEMBLY as per above physical space requirement by means of proven temperature-rise tests performed on additional circuits added.

3.3 TESTING OF LV SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

3.3.1 Type-testing

All eight type tests described in SANS 60439-1 Table 7 shall be carried out on each design of Type Tested Assembly (TTA). Type tests on similar designs must form the basis of design verification for TTA's with stated deviations.

Any deviation from the type-tested design must be substantiated by the rules of the Engineering Design System (EDS) and the type-test reports.

Type-tests shall be performed under the most onerous mechanical design, physical and operating conditions to ensure functional operation at limits described in the technical schedule (i.e. Schedule A) provided with the enquiry document.

Important aspects regarding the eight tests are briefly described as follows:

3.3.1.1 Enclosure degree of protection (SANS 60439-1 Clauses 7.2 and 8.2.7)

a. Type testing for the enclosure degree of protection or Ingress Protection (IP) shall be performed in accordance with SANS 60529.

b. No IP rating in excess of IP3X can be claimed unless the appropriate verification by test has been made.

3.3.1.2 Temperature-rise tests (SANS 60439-1 Clauses 7.3 and 8.2.1)

a. Verification of temperature-rise limits is one of the most critical in determining the reliability and long service capability of a complete LV Switchgear and Controlgear ASSEMBLY System. Current ratings of components are valid only when the temperature around them is within the limits specified by the component manufacturer. Safety aspects are also of significance although they may arise mainly as a secondary effect through the touching of hot covers or operating handles.

b. Components, materials and functional units shall be tested to ensure that, at maximum output, the temperature-rise does not exceed that for the class of insulating material used. Once installed in the ASSEMBLY, it shall not jeopardize the temperature-rise limits of the ASSEMBLY.

c. The temperature rise limits for the different parts of the ASSEMBLY comply with Table 3 of SANS 60439-1 and are summarised in **Table 1** below.

Table 1: Temperature-rise limits

Parts of the ASSEMBLY	Temperature-rise (K)
Built-in components	In accordance with the component manufacturer's instructions taking into account the temperature in the ASSEMBLY
Terminals for external insulated conductors	70
Manual operating accessories (e.g. handles) made of: • metal • insulating material	 15 25
Accessible external enclosures and covers • metal surfaces • insulating surfaces	 30 40
Discrete arrangements of plug and socket-type connection	Determined by the limit for those components of which the form a part

d. Circuit-breakers shall be de-rated in accordance with the OEM's prescriptions fo the size of section or sub-section in which the circuit-breaker will be installed.

e. The maximum power loss profile achieved per section or sub-section will b proven by temperature-rise test. No part of the ASSEMBLY may be populated to exceed the power losses achieved during the temperature-rise tests.

f. The de-rated value of the main circuit-breaker shall be the rated busbar current o the main busbars of the ASSEMBLY.

g. A diversity factor at a minimum of 0,8 shall have been applied on all outgoing circuits during verification of temperature-rise limits of the different configurations of ASSEMBLIES submitted for full type-testing.

3.3.1.3 Short-circuit withstand strength (SANS 60439-1 Clauses 7.5.2, 8.2.3 and 8.2.4.2)

a. Short-circuit testing is necessary to verify the ability of electrical equipment to withstand the forces and thermal effects produced by short-circuit currents. It shall be carried out at an accredited third party testing station which shall issue a certificate detailing the tests that have been completed satisfactorily.

b. The tests that shall be carried out in accordance with SANS 60439-1 may not be repeated for every piece of equipment supplied and are thus carried out on equipment manufactured specifically for testing purposes. Subsequent equipment to be covered by the test certificate in this regard shall be without significant variation in design.

c. At completion of the short circuit tests, minimum of IP protection, creepage and clearance distances, insulation integrity and mechanical capability shall be maintained. Slight deformation of enclosures and busbars is acceptable.

d. The EDS and type-test reports shall fully indicate and describe the short-time short-circuit withstand current, I_{cw} and duration of each configuration of main and distribution busbars inclusive of the conductors connected in the 'Fault-free-zone' in accordance with SANS 60439-1.

e. Extensive conditional short-circuit current applications, I_{cc} shall demonstrate the ASSEMBLY's ability to withstand the forces of emissions on the structure, panels, doors, hinges and closure mechanisms in accordance with SANS 60439-1.

f. The largest size protective gear fitted to the section or sub-section with minimum prescribed free space around protective gear shall be used for the I_{cc} type-tests.

g. Type-test reports shall be comprehensive in explaining the test plant's capability to perform the tests. Real time data acquisition and oscillogram recordings shall prove each current application.

3.3.1.4 Effectiveness of a protective circuit (SANS 60439-1 Clauses 7.4.3.1 and 8.2.4.1)

An examination of the ASSEMBLY shall be carried out to confirm that the constructional requirements to ensure that the effective protective circuit have been met. The following are some of the conditions which shall be examined:

- All exposed conductive parts greater than 50 mm by 50 mm and which can be touched shall be connected to the protective circuit.
- Manual operating handles shall be effectively connected to the protective circuit or adequately insulated.
- The removal of a part from an ASSEMBLY shall not interrupt the protective circuit for other parts.
- Doors and covers shall be effectively bonded.
- Protective conductors are sized in accordance with the standard, SANS 60439-1.
- The resistance between the incoming protective conductor and exposed conductive parts shall not exceed 0,1 Ω.

3.3.1.5 Short circuit withstand of a protective circuit (SANS 60439-1 Clauses 7.4.3.1 and 8.2.4.2)

It shall be verified that the enclosure and its protective circuit (earthing system) are capable of withstanding the thermal and electrodynamic stresses resulting from short-circuit currents up to their rated values.

3.3.1.6 Dielectric properties (SANS 60439-1 Clauses 7.1.2.3 and 8.2.2)

a. Lightning impulse withstand tests shall be done to prove the impulse withstand capacity or Basic Impulse Level (BIL) declared by the supplier.

b. At service entry level, ASSEMBLIES shall be proven by test to withstand a lightning impulse voltage of 8 kV. At component level, a lightning impulse withstand value of 6 kV shall be attained.

3.3.1.7 Clearance and creepage distances (SANS 60439-1 Clauses 7.1.2.3.5 and 8.2.5)

a. It shall be verified that clearances and creepage distances comply with SANS 60439-1 Clause 7.1.2.

b. Clearances and creepage distances that depends on the degree of pollution shall not be lower than the values given in SANS 60439-1, Tables 14 and 16 respectively.

3.3.1.8 Mechanical operation

a. The mechanical operation of the ASSEMBLY shall be verified of a fully populated ASSEMBLY to ensure that their mounting does not impair the ASSEMBLY.

b. Testing of the mechanical operation shall be done in accordance with SANS 60439 Clause 8.2.6.

3.3.2 Special Tests

3.3.2.1 Electromagnetic Compatibility

Where specified, the ASSEMBLY as well as the switchgear and controlgear shall comply with the limits and levels of emission as per the SANS 61000 Series.

3.3.2.2 Glow wire tests

a. Insulating materials in direct contact with current carrying conductors shall be subjected to a glow-wire test at 960 ^{o}C whereas other insulating materials shall be subjected to a glow-wire test at 850 ^{o}C.

b. Glow-wire tests shall have been performed in accordance SANS 60695-2-10.

3.3.2.3 Internal arc testing

Where specified, an internal arc shall be performed in accordance with SANS 1973-7 at the following points of initiating the arc as a minimum:

- At the plug-in points of the smallest functional unit,
- At the tap-off point of the distribution busbars
- At the point of connection between the riser busbars and the main busbars for at least 200 ms with Air Circuit Breaker (ACB) protection disabled at the fault level specified.

  NOTE: Calibration shots shall take arc impedance into account to ensure that current during internal arc test is the same as short circuit withstand current of the assembly.
- For each different withdrawable and/or fixed compartment size fitted with the Short Circuit Protection Device (SCPD) of the highest rating for the compartment size the following test shall be done.

3.3.3 Routine testing of ASSEMBLIES

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

b. Results of routine tests shall comprehensively be reported in accordance with SANS 1973-1 Annexure I 'Routine test certificate'.

c. Unless otherwise specified, routine tests shall also be performed on-site after installation work has been completed. For the Site Acceptance testing (SAT), specific attention shall be given to:

- Inspection of wiring and, if necessary, electrical operation test (SANS 60439 1 Clause 8.3.1).
- Dielectric test (SANS 60439-1 Clause 8.3.2);
- Checking of protective measures and of the electrical continuity of the protective circuit (SANS 60439-1 Clause 8.3.3).

d. In addition to the routine tests specified above, SAT shall include the adjustment, setting, operational checking and electrical injection testing of each relay, functional unit, circuit and accessory.

3.4 SWITCHGEAR AND COMPONENTS

3.4.1 Air circuit breakers

3.4.1.1 General

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

b. ACB's shall be of the triple pole, withdrawable type with built-in switch-disconnector characteristics.

c. A separate compartment shall be provided for the control circuitry, protection equipment and instruments for the ACB.

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

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

f. ACD shall be provided with non-resetable trip counters.

3.4.1.2 Ratings

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

b. ACB's shall, at the maximum voltage specified, be capable of interrupting, making, latching against and withstanding the fault duties stated in Schedule A of an enquiry document. The minimum allowable duration of the fault current shall be 1 s.

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

3.4.1.3 Mechanism

a. 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.

b. 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.

3.4.1.4 Closing Device

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

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

c. The maximum and steady-state current at rated voltage required by each closing device shall be stated in Schedule B of an enquiry document.

3.4.1.5 Tripping devices

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

- shunt release
- under-voltage release
- instantaneous over-current release
- definite time-delay over-current release
- inverse time-delay over-current release
- reverse current release (DC only).

b. Current releases shall be either directly or indirectly connected. If indirectly connected, the current transformer ratio or value of shunt trip release shall be stated in Schedule B of an enquiry document.

c. Electric tripping devices of the shunt release shall be suitable for operation at any voltage under normal system conditions.

d. 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.

e. Two normally-open auxiliary contacts of the early-make late-break type, in parallel, shall be included for each tripping circuit in series with the trip coil.

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

3.4.1.6 Indicating Devices

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

b. The ACB shall be labeled as follows:

- On or I for closed position
- Off or O for open position

c. 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.

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

3.4.1.7 Disconnecting properties of withdrawable units

a. A mechanical device to positively identify the position of the ACB shall be provided to ensure that the ACB is secured in the:
   - connected position
   - test position
   - isolated position

b. The circuit-breaker compartment door shall be capable of being closed with the circuit-breaker withdrawn into a test position.

c. The ACB's main and secondary circuit isolating contacts shall be such that all ACB's of the same type and rating shall be interchangeable.

d. 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.

e. 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.

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

g. Shutters shall not require lubrication.

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

i. Busbar spout shutters shall be labeled with the word 'BUSBARS'.

j. Cable spout shutters shall be labeled with the word 'CABLE'.

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

3.4.1.8 Interlocks

a. Mechanical interlocks shall be provided to ensure that: the circuit-breaker cannot be engaged and disengaged from the connected position unless the circuit-breaker main contacts are fully open the circuit-breaker cannot be closed unless it is in the connected, isolated or test position.

b. Electrical or mechanical interlocks shall be provided for the flexible auxiliary connections so that the action disengaging the flexing auxiliary connections (the multi-pin plug) shall automatically trip the circuit-breaker.

3.4.1.9 Auxiliary contacts

a. Auxiliary contacts shall be provided in accordance with Schedule A of the tender document. Contacts shall be convertible from normally open to normally closed and vice versa and shall be wired to the outgoing control terminals. Auxiliary contacts shall follow positively the action of the main contacts.

b. 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.

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

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

3.4.1.10 Withdrawable unit connections

a. Where auxiliary connections between the withdrawable unit and the ASSEMBLY are made by means of flexible connections, it shall be contained in flexible conduit. If metal conduit is used, the connections shall be covered with an insulating material.

b. Where a flexible connection or removable plug is used, interlocking shall be provided to prevent the circuit breaker from being racked into the connected position without the control circuit connected.

c. Means shall be provided to keep the flexible connection out of the path off the circuit-breaker when the truck is inserted into and removed from the ASSEMBLY compartment.

d. Facilities shall be provided to test the electrical operation of the circuit-breaker whilst isolated from the main circuit (this shall be the test position).

3.4.2 Moulded-case circuit-breakers

3.4.2.1 General

a. Moulded-Case Circuit Breakers (MCCB's) shall be of the plug-in configuration that comply with VC 8036 where applicable, SANS 556-1 and SANS 60947-2.

b. MCCB's shall be single pole, double pole or 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.

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

3.4.2.2 Ratings

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

b. 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.

c. 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.

3.4.2.3 Mechanism

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

3.4.2.4 Operating device

a. MCCB's shall be provided with independent manual closing and tripping devices in accordance with SANS 60947-2. In addition, an automotive tripping device shall be provided.

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

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

d. 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.

e. MCCB's shall be provided with auxiliary contacts where specified in Schedule A of an enquiry document.

3.4.2.5 Releases

a. 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.

b. A shunt trip release shall be provided, when specified in Schedule A of an enquiry document.

3.4.2.6 Isolation

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

b. 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.

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

d. Busbar spout shutters shall be labeled with the word "BUSBARS". Cable spout shutters shall be labeled with the word "CABLE".

3.4.2.7 Indication devices

MCCB's shall have the same indication devices as the ACB's as defined in Section 3.4.1.6 of this Specification.

3.4.2.8 Interlocks

The requirements of Section 3.4.1.8 apply.

3.4.2.9 Auxiliary contacts

Refer to Section 3.4.1.9 of this Specification for the requirements of auxiliary contacts.

3.4.2.10 Integral protection devices

a. Where required, the self-contained MCCB's shall be provided with integral solid-state protection device. The electronics of this installation shall be housed within a metallic enclosure.

b. 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.

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

3.4.3 Miniature circuit breakers

a. Miniature circuit breakers (mcb's) shall comply with the requirements of VC8036, SANS 556-1 and SANS 60947-2.

b. 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.

c. 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

d. 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.

e. Mcb's shall be of the non-adjustable type.

f. 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.

3.4.4 Residual current circuit breakers

a. Residual current (earth leakage) circuit-breakers shall comply with VC8035, SANS 767-1 and SANS 60947-2.

b. Sensitivity of earth leakage protection shall be as specified in Schedule A of an enquiry document.

3.4.5 Switch-disconnectors

3.4.5.1 General

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

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

c. 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 switchdisconnector, the neutral link shall open after and close before the main contacts.

3.4.5.2 Ratings

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

b. They shall be capable of breaking the rated load and making the fault current specified in Schedule A of an enquiry document.

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

3.4.5.3 Operating Devices

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

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

c. 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.

3.4.5.4 Indication devices

a. 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.

b. 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.

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

d. The device shall be labeled as follows:

e. On or I

f. Off or O

3.4.5.5 Circuit disconnection

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

b. 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.

c. 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.

3.4.5.6 Interlocks

The requirements of Section 3.4.2.8 apply.

3.4.6 Fuse-combination units

3.4.6.1 General

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

b. Fuses

c. Fuse switches

d. Switches in series with fuses in separate insulated carriers mounted within a single compartment.

e. Fuse-combination units shall be of the air-break gang operated type, as described for switch-disconnectors in this Specification, with the number of pole specified in Schedule A of an enquiry document. Where links are specified, these shall be of the bolted or withdrawable type, accessible from the front of the unit.

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

3.4.6.2 Ratings

a. Fuse-combination units shall carry the rated current specified in Schedule A of an enquiry document when mounted within their compartments and shall be capable of:

- Making and breaking the rated current in accordance with the utilization category
- Interrupted the rated fused short-circuit current.

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

3.4.6.3 Operating devices

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

b. They shall be operated from the front of the ASSEMBLY by means of a handle. Fuse-combination units and their compartments shall be provided with the interlocks and padlocking devices as described for ACB's in Section 10.1 of this Specification.

3.4.6.4 Indicating device

a. 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.

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

c. The device shall be labeled as follows:

- On or I
- Off or O

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

3.4.7 Contactors

3.4.7.1 General

a. Contactors shall comply with the requirements of SANS 947-4-1.

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

c. 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 and the contactor shall remain closed on energizing the closing coil.

d. Operating coils shall have the voltage rating specified in Schedule A of an enquiry document.

3.4.7.2 Contactor Ratings

a. Contactors are required for the operation of power station auxiliary motors and as such shall be rated, so that the full load current of the circuit as specified is not more than the:

- Rated conventional enclosed thermal current (I_{the}) of the AC or DC contactor for the type of enclosure in which it will be used and:
- 0.75 times the rated operational current (I_e) of the AC contactor for:

i. AC3 utilization category
ii. 1 000 000 on-load operations for I_e less than 17 A or
iii. 300 000 on-load operations for I_e greater than 17 A or;

- 0.625 times the rated operational current (I_e) of the DC contactor for DC 3 utilization category

3.4.7.3 Auxiliary contacts

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

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

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

3.4.8 Motor Starters

3.4.8.1 General

a. Motor starters shall comply with SANS 947-4-1.

b. Motor starters shall incorporate isolation and switching facilities, overload and short-circuit protection, test and remote controls and indication devices as shown on the circuit diagram provided with the tender enquiry.

c. The design shall be such that the combinations of the different components forming a circuit ensure Type 2 coordination.

d. The main isolating and over-current interrupting device shall be a circuit breaker with no back-up fuses. Equivalent combinations (i.e. fault limiters) are acceptable.

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

f. Maximum power rating for the motor starters to be incorporated in the ASSEMBLY is 200 kW for 400V ASSEMBLIES and 300 kW for 690V ASSEMBLIES. Motor starters with larger power ratings shall be accommodated in free-standing enclosures.

g. All main contactors and motor starters, secondary contactors and motor starters, timing relays etc., associated with motor starting circuits shall be rated for the number of starts per hour under full load conditions as specified in Schedule A of an enquiry document.

3.4.8.2 Motor Starter Rating

a. Motor starters shall be rated for the specified motor with the given starting current and starting time.

b. Where the starting current and starting time are not stated, these shall be taken as 8 times full load current for AC motors and 2,5 times full load current for DC motors (with resistive starting) and 10 s starting time in both cases. In the case of heater and lighting circuits the starting current values shall be taken as 1,25 × full load current and 1,5 × full load current respectively.

c. Components and wiring forming a 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.

3.4.8.3 Overload devices

a. An adjustable thermal overload release and an instantaneous trip unit shall be supplied on overload devices.

b. Three phase overload devices shall incorporate single-phase protection and ambient temperature compensation.

c. Motor starting currents and starting times shall be as specified in the switchgear schedules. The overload devices shall not operate under these starting conditions.

d. Overload devices shall be provided with hand reset contacts.

3.4.8.4 Motor starter functional unit design

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

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

c. A current limiting switching device (i.e. circuit-breaker or fuse combination unit) shall be provided for incoming isolation and short-circuit protection.

d. 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.

e. 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.

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

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

h. It is preferred that bare copper busbars are used on both sides of the contactors of larger motor starters to allow efficient dissipation of heat. This design shall be in line with contactor manufacturer requirements.

3.4.9 Fuse-links and carriers

a. Fuses shall be fully type-tested in accordance with SANS 60269-1.

b. For control circuit application fuses shall be mounted on insulated, draw-out carriers which shall hold the fuses positively after withdrawal. Fuse link holders shall be coloured black, and solid link holders white.

c. In all cases, the top terminal shall be the live terminal.

3.4.10 Auxiliary Devices and Accessories

3.4.10.1 Instrument transformers

a. Instrument transformers (i.e. current and voltage transformers) shall comply with IEC 60044-1. The rating of the instrument transformer shall ensure optimum performance of the intended protection and control functions.

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

c. 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.

d. 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.

e. 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.

f. 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.

g. 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.

3.4.10.2 Signal lamps

a. Signal lamps shall be of the multi-LED bayonet coupling type that complies with ESKASAAO4. The lamps shall be adequately rated for the duty specified in Schedule A of the tender enquiry.

b. Signal lamp lenses shall be coloured as follows:

- circuit-breaker closed RED
- circuit-breaker tripped (open) GREEN
- drive running RED
- drive stopped GREEN
- valve closed BLUE
- valve open WHITE
- valve stopped YELLOW
- fault-trip WHITE
- position indication WHITE

c. Signal lamps shall be suitable for operation at the voltages specified in Schedule A of a tender enquiry.

d. 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.

3.4.10.3 Push buttons

a. Push buttons shall comply with ESKASAAO4. The contacts of the buttons shall be adequately rated for the duty specified in Schedule A of the enquiry document.

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

- circuit-breaker closed RED
- circuit-breaker tripped (open) GREEN
- drive start GREEN
- drive stop RED
- valve close BLACK
- valve open WHITE

- valve stop RED
- fault reset BLUE
- lamp test YELLOW

3.4.10.4 Control switches

a. Control switches (TRIP/NEUTRAL/CLOSE) shall be of a rotary type that complies with ESKASAAO4. The contacts of the switches shall be adequately rated for the duty specified in Schedule A of the tender document.

b. In order to facilitate easy operation, the switches shall be installed on the front of the ASSEMBLY.

c. Control switches shall be provided with an operation interlock to prevent inadvertent operation and shall be arranged for spring return to the neutral position. When rotated clockwise, the control switch shall close the associated circuit-breaker.

d. Control switches shall be provided with 'lazy contacts', where specified. 'Lazy contacts' refers to contacts which make when the control switch is turned to the close position and remain closed when the handle returns to the neutral position and only open when the control switch is moved to the trip position.

e. Facilities shall be provided for padlocking control switches in the neutral position when they are mounted on the front door.

3.4.10.5 Starting Resistance and Field Rheostat

a. When specified, the ASSEMBLY shall accommodate starting resistances and field rheostats on top of the ASSEMBLY. Field rheostats shall be accessible for adjustment. Field rheostats and starting resistances shall be clearly identified with labels.

b. The temperature-rise for continuous operation of the rheostats and starting resistances shall not exceed that stated in SANS 60947-1 in conjunction with SANS 60947-4-1, and provision shall be made for adequate ventilation of the rheostats and starting resistances.

3.4.10.6 Measuring Instruments and Accessories

3.4.10.6.1 Type of instruments

- Instruments shall be of the flush-mounting industrial ASSEMBLY type in accordance with ESKASAAO4.
- Instruments shall comply with the requirements of IEC 60051 for indicating instruments of class 1.5 category.

3.4.10.6.2 Instrument scales

- The scale shall have a full-scale movement deflection of not less than 90°.
- Instruments shall have linear scales. All minor scale markings below the lowest major scale marking shall be identified by figures.
- 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.

3.4.10.6.3 AC ammeters

- Unless otherwise specified, ammeters shall be of the flush, ASSEMBLY mounted 1 A instantaneous indicating type.
- Relevant current transformer ratios shall be indicated on each ammeter dial.
- 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.
- Ammeters associated with motor circuits shall have a suitable overload scale to cater for motor starting currents.
- 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.

3.4.10.7 Ammeter selector switches

- Ammeter selector switches shall be of the four-position rotary type that complies with ESKASAAO4 Clause 4.2.6.12. 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.
- The selector knob shall be of the insulated type with an engraved arrow indication the switch position.
- 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.
- The indicator plate shall have the positions R, W, B and "off" engraved on it in 5 mm high lettering.

3.4.10.7.1 DC Ammeters

- 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.
- Ammeter scales shall be direct reading and the full-scale deflection shall be first standard value above the rated current of the circuit.
- The meter shall be calibrated at 20 °C and shall have a temperature co-efficient not exceeding 0, 15 % / °C of the scale.

3.4.10.7.2 Voltmeters

- 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.
- The rated voltage shall be marked with a red line and the scale shall be fully expanded around the rated voltage.
- Moving-iron instruments shall be as open as possible at the upper end of the scale.
- Voltmeters shall have the overload rating as recommended in IEC 60051 and shall be protected by fuses.

3.4.10.7.3 Voltmeter selector switches

- Voltmeter selector switches shall be of the four-position rotary type that complies with ESKASAAO4 Clause 4.2.6.12. 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.
- Selector knobs shall be of the insulated type with an engraved arrow indicating the switch position.
- 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.
- The indicator plate shall have the positions "R-W", "W-B", "B-R" and "off" engraved on it in 5 mm high lettering.

3.4.10.7.4 Running hour recorders and operations counters

- 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. The incorporation of this function in the IED shall be considered.
- Both the running hour recorders and the operation counters shall be activated by switching on a power supply to the recorder.
- Where the electromechanically type is used, it shall have either a legible rotating wheel or flap display. No resetting facility shall be provided.
- 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.

3.4.10.7.5 Auxiliary relays

- Auxiliary relays shall be of the electromagnetic type with continuously rated coils and auxiliary contacts suitably rated for the application.
- They shall be suitable for the voltage specified in schedule A of an enquiry document. Auxiliary relays shall be capable of picking-up at a minimum supply voltage of 85 % and shall withstand 110 % supply voltage continuously.
- The coil shall not drop out for coil voltages exceeding 75 % of nominal voltage but must drop out if the coil voltage falls below 10 % of nominal voltage.
- Relays shall be able to ride through a voltage dip lasting for a period of up to 20 ms in the system.

3.4.10.7.6 Current transducers

Transducers shall comply with IEC 60688 and ESKASAAN3. Input and output values shall be in accordance with the requirements specified in Schedule A of an enquiry document.

3.4.10.8 Terminals and lugs

- The types of terminals and lugs for all auxiliary circuits shall be selected in accordance with ESKASAAO4 for the different voltage and current rating application.

- 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 mm2 cable.
- 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.
- Lugs are of the compression type. All lugs and their application with different types of terminals are as detailed on Eskom standard drawing 0.00/10335.
- Terminals shall be provided for all cables entering the cubicle. Such cables shall not be made off directly onto other components in the cubicle.

3.4.10.9 Stabilised power supply units

a. The control supply to a ASSEMBLY shall be regulated by means of a stabilised power supply unit in order to limit the voltage fluctuations to the values specified in Schedule A of an enquiry document, during transient system conditions.

b. The stabilised power supply unit shall be in the form of the Uninterruptible Power Supply (UPS) or Voltage Dip Proofing Inverter and Line Filter (DPI) as indicated on the switchgear schedule of the tender enquiry.

c. The stabilised power supply unit shall have a sinusoidal output at the same frequency as the input irrespective of the load conditions. It shall have a fast response time to voltage and load fluctuations.

d. Where required, each UPS unit shall be mounted in a dedicated compartment within an ASSEMBLY to enable easy replacement in the event of failure.

e. When required, the DPI unit shall be provided with the ASSEMBLY to provide voltage dip proof control supply to the drive circuits.

f. The DPI's shall be installed in such a way that they constitute one functional unit, with easy access to all their terminals.

g. Each unit shall be mounted in a dedicated compartment within the ASSEMBLY to enable easy replacement in the event of failure.

h. Each DPI unit shall be fitted with a normal/bypass selector switch. This selector switch is fitted inside the ASSEMBLY shall have make-before-break contacts.

i. The stabilised power supply units shall have evidence of being reliable, well proven and type tested and shall be of the air-cooled static type, employing magnetic and capacitive components.

j. On-line test facility shall be provided with each DPI unit that indicates the following as a minimum:

- Model
- Supply voltage
- Recent dips
- Days in service
- Days since the last test
- Test results (pass/fail)
- Output voltage
- Run time

- Capacitor condition

k. The DPI units shall feature the following visual indications as a minimum:

- Capacitor voltage
- AC voltage OK
- DC power OK
- Inverter running
- Synchronised

l. Provision shall be made in the design of the DPI unit for a remote alarm indication facility with potential free contacts for the following (as a minimum):

- System failure (DPI failure)
- Inverter running (DPI activated)

3.4.10.10 Mechanical key interlock

a. Where specified, a mechanical key interlock shall be provided on locally operated incomer and bus-section switching devices (circuit-breakers, switches, switch-disconnectors etc.).

b. The interlocking system shall prevent switching of the two independent supply feeders onto any particular ASSEMBLY. In the case of a ASSEMBLY with two incomers and a bus-section, it shall not be possible to close more than two of the three switching devices during normal operation (connected position).

c. In the case of circuit-breakers, provision shall be made for closing of the third circuit-breaker in the

3.4.10.11 Earth fault detection

Where specified, earth fault relays shall be used on the incomers of the DC ASSEMBLIES to provide the necessary protection against faults.

3.5 TESTING OF COMPONENTS

3.5.1 Type testing of components

a. The supplier shall provide proof that specific components installed in the ASSEMBLY complies with relevant specification as tested by an authorized testing authority.

Eskom requirements are tabled in Appendix C of this Specification.

3.5.2 Type testing of stabilized power supply units

a. Type tests shall be performed on a sample of each type of stabilized power supply unit manufactured to the same design. All the tests shall be conducted at an average ambient temperature of 35 °C with the unit mounted in its compartment in the ASSEMBLY.

b. Type tests already made by an authorised testing authority on similar equipment may, subject to Eskom's approval, be acceptable if proof of conformance is provided. The following tests shall be performed as a minimum:

- The unit shall be subjected to operational tests sufficient in number and scope to prove that the equipment fully complies with the operational requirements. The manufacturer of the unit shall advise on operational requirements.

c. Short-circuit withstand strength and conditional short-circuit current rating

3.5.3 Routine testing of components

a. In addition to the routine tests done on production ASSEMBLIES during Factory Acceptance Testing (FAT) the supplier shall perform some tests on switchgear and controlgear components.

b. Eskom's requirements for the tests that will be performed as a minimum are described in Appendix D.

3.5.4 Special tests for components

Where specified, components and stand-alone units may need to be subjected to special tests as stated in Schedule A.

3.6 PROTECTION, CONTROL, MONITORING AND COMMUNICATION SYSTEMS

3.6.1 Protection

a. Protective devices shall be employed to protection against overcurrent, overload, phase imbalance, earthfault and undervoltage conditions in accordance with GGS 0803. Protection against short circuit current will be provided by circuit breakers and fuses described in this Specification.

b. Unless otherwise specified, all protection devices shall be provided with manual reset operation indicators for each function of the protection device. These shall not operate until the protection devices have operated. Resetting shall be accomplished without opening the relay housing

c. Protection relays shall be used together with ACB's on all LV transformer incomers circuits/ panels and feeders to downstream ASSEMBLIES. The protection relays shall be of the electronic or microprocessor-based technology that conforms to ESKASAA04.

d. All protection relays shall be provided with suitable test facilities for VT and/or CT circuits to enable tests carried out on the protective devices while in position inside the panel without disconnecting any wiring or links. Test blocks for the VT and CT circuits shall be provided in accordance with standard ESKASAAO4 Clause 4.2.16.

e. The protection relays shall have a self-monitoring function of both hardware and software that is done on a continuous basis. Any fault or irregularity shall be immediately alarmed to an output contact.

f. IED's installed on the transformer incomer circuits shall be equipped with screen or display facility to allow for human interface. The contents shall be clearly visible from a distance of 2 m and at an angle of 30° from either side. This display shall be of the Liquid Crystal Display (LCD) or plasma type with anti-glare and non-blinking properties. The IED's display shall make it possible for the mimic of the circuit protected by the device to be illustrated on the display. The mimic shall show as a minimum the status of circuit breakers (ON or OFF), status of earth switches, position of circuit breaker (connected or isolated) and electrical parameters (voltage, current, power, etc.) for a particular circuit. Light Emitting Diodes (LED) could also be installed on the device to provide an indication function.

g. Each protection scheme shall have at least two output contacts for tripping and two output contacts for external alarms.

h. All protection relays shall be pre-programmed with the logic that enables the scheme to comply with the specification as provided during the engineering phase and provided as part of the scheme drawings. No logic programming will be required after delivery, only the application of conventional functional settings.

i. Protection relays supplied from DC supply as well as the associated components shall be capable of operating continuously at extreme tolerances of the supply voltage. Any internal battery requirements for protection devices (i.e., battery lifetime, type of battery etc.) shall be stated on a label attached to the front of the numerical device.

j. All indications shall be non-volatile, which implies that if the DC supply fails, then on restoration of the DC supply the indication resumes its status that it had before the supply failed.

k. Self-contained MCCB's shall be provided with integral solid state protection devices. MCCB's shall be arranged such that an external source of power is not required for tripping the MCCB during short-circuit or overload conditions. Electronic circuits for these components shall be housed within a metallic enclosure. Protective devices shall be easily accessible, removable and capable of being subjected to tests and calibration without removal from its housing.

l. In certain cases specified in the switchgear schedule of the tender enquiry, the temperature inputs for the motor thermal overload protection will be obtained from the thermistors embedded in the motor windings. The protection devices shall have suitable interfaces with adequate input terminals to facilitate such an operation. The units shall be of the self-resetting type, capable of accepting thermistors with a wide range of temperature/resistance characteristics

m. The protection devices and associated equipment to be used has to be evaluated, tested and approved by the Eskom as per 240-56357346.

3.6.2 Control

a. If required, the numeric protection device or Intelligent Electronic Device (IED) shall have the capability to perform control functions via a communication bus. The devices shall also have the capability to be interfaced with the process control communication network (e.g. DCS, SCADA, PLC) via hard wiring with binary and analog outputs.

b. If hardwiring is preferred, the transfer of control signals to the process equipment shall be done via interposing relays or potential free contacts. The interposing relays shall be designed to withstand the rated current of the closing coil for two times the longest possible closing time. The interposing relay is also designed to withstand the making of the closing coil current at maximum system voltage rating.

3.6.3 Monitoring and Communication

a. Where the monitoring functionality is required, the Intelligent Electronic Device shall be provided that conforms to ESKASAAO4. All IED's shall have continuous self supervision, DC fail with indication and trip circuit supervision functions.

b. The IED's installed on transformer incomer circuits shall have event and fault recording capability with the data storage capability. This storage medium shall have non-volatile memory. The data shall be stored in a COMTRADE format.

c. All IED's shall be equipped with serial interfaces whereby fault recordings, sequence of events, settings and marshalling can be accessed with the engineering tool. The interfaces shall be made available as it is deemed to be an integral part of the required scheme functionality.

d. All marshalling/ configuration and settings software for IED's shall be contained in one engineering software package. All software and firmware shall be backward and forward compatible. Any change in the software and firmware versions shall be evaluated for interoperability and approved by Eskom.

e. Facilities shall be provided to allow for the software to be downloaded and uploaded locally from the IED via a port or remotely from an engineering station through a communication link. The interface protocol shall be suitable to transfer maximum data between the IED and the local workstation without any restrictions that might limit speed, capacity and quality of data transferred.

f. In case the metering functionality is required as part of the monitoring system, the IED shall enable the circuit current and voltage quantities to be displayed locally on the device and also remotely on the engineering station via the communication link. The requirements for the metering functionality shall be indicated in the switchgear schedule provided with the tender enquiry.

g. Intelligent devices used for protection against motor overload conditions shall have monitoring and communication capability similar to the ones defined for the IED's above.

3.7 REQUIREMENTS FOR ENGINEERING DRAWINGS

3.7.1 General

a. Reproducible drawings shall be provided in an English language. All drawing shall be in at least A3 size. All detail drawings are drawn and prepared on software format as specified in the tender enquiry. The standard Eskom Drawing Office practices shall be adhered to.

3.7.2 General arrangement drawings

3.7.2.1 General arrangement drawings shall be completely dimensioned, showing:

- Arrangement of equipment
- Top, front, and side views and cross-sections of the ASSEMBLY.
- Position of each functional unit and their compartments.
- Clearances for opening doors.
- Locations of busbars and distributions.
- Details on the required openings for the power cables
- Incoming and outgoing cable termination positions and details.
- Cable slot positions.
- The height of all cable glands above floor level
- Instrument transformers (i.e. VT's and CT's) physical positions.
- Terminal block locations.
- Earthing or bonding connections.
- Mass of transportable sections of equipment
- Details and position of the holding down bolts
- Magnitude and disposition of all loads imposed on foundations

3.7.3 Single line diagram

3.7.3.1 Single line diagram shall show the following:

- Configuration of the circuits (i.e. incomers and feeders) on the ASSEMBLY.
- Electrical connection of VT's and CT's
- Section or sub-section numbers of the different functional units.
- Mechanical key interlocking design.

3.7.4 Schematic Drawings

3.7.4.1 Schematic wiring diagrams shall show the following:

- All protection and control devices and their contacts, each of which shall be labeled with its correct ANSI device function number (i.e. protection and control scheme).
- Device terminal numbers, terminal block numbers and terminal numbers.
- All wiring within each functional unit.
- All internal interconnections, bus wiring, inter ASSEMBLY wiring and connections to external equipment.
- All control and protection switches
- Power supply connections
- Component schedule for each circuit

3.8 INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTION MANUALS

a. Instruction manuals shall comply with the requirements laid down in the tender enquiry. The number of copies is as specified in Schedule A.

b. The manuals that cover all equipments forming part of the ASSEMBLY shall be complete with:

- Power station name and order number;
- Content list;
- List of reference drawings;
- Details of all components.

c. 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.

d. 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.

e. 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.

f. 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.

3.9 ENGINEERING DESIGN SYSTEM (EDS)

a. The EDS is the source document of design, type-testing, manufacturing, routine testing and commissioning of an LV Switchgear and Controlgear System. The engineering design system shall as a minimum cover stated deviations, proven by test, from a TTA with stated deviations, and shall include, where relevant, information on the following deviations:

- the modularity of the complete ASSEMBLY, the sections and the subsections;
- the method of future extension,
- design requirements applied in the case of the chassis, doors, covers, hinges, handles, locking mechanisms, and the ability of each alternative selection to withstand a short-circuit;
- the method of changing internal partitions to suit the required form of separation;
- entries or exits of cables and busbars;
- conditions for applying ventilation;
- descriptions of different designs of ASSEMBLIES for specific industrial environments;
- the degree of protection (IP rating);
- protection against corrosion of the ASSEMBLY and the busbar system;
- design and selection requirements of main busbars and supports;
- design and selection requirements of distribution busbars and supports;
- design requirements for protective and neutral busbars and supports;
- the method of establishing the maximum distance between supports by calculation of short-circuit forces acting on the respective busbar systems;
- a specification of support material for each short-time rating of the range of ASSEMBLIES;
- the method of calculation of maximum allowable power losses of functional units per section and subsection;
- the effects of internal arcing in each configuration of ASSEMBLY;
- the maximum temperature ratings of internal conductors, wiring and functional units;
- the range of ASSEMBLY sections, subsections, cable sections and busbar chambers;
- the properties of all materials used in the ASSEMBLIES;
- the method of connecting busbars and the torque values for connection bolts for each current rating;

- foundations and fixing mechanisms;
- the suitability of terminals in the case of copper or aluminium connections;
- insulation design requirements with specific reference to minimum creepage distances and connections between busbar systems and functional units in the fault free zone.

b. The engineering design system shall specify stated deviations from the following:

- limits of operation;
- service conditions;
- rated current of circuits and current densities;
- rated voltage;
- rated short-circuit withstand strength (magnitude and duration);
- rated conditional short-circuit current (magnitude at rated voltage);
- temperature-rise limits at specific IP rating and forms of separation;
- change of system earthing;
- degree of protection; and
- forms of separation.

3.10 TRANSPORTATION REQUIREMENTS

a. 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.

b. 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.

c. 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
	Document Approved by TDAC ROD 27 February 2013

5. REVISIONS

Date	Rev.	Compiler	Remarks
November 2012	0	DW Monyane	Draft document for Review created from GGSS 0456
May 2013	1	DW Monyane	Final document for Publication

6. DEVELOPMENT TEAM

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

- None

7. ACKNOWLEDGEMENTS

- None

APPENDIX A: TECHNICAL REQUIREMENTS

1 General

The technical requirements of this section specified under 'Schedules A and B' shall form part of the Employer's enquiry documentation. Schedule B shall be completed by the Contractor and submitted with his tender.

2 Schedules A and B

Schedule A: Particular of Employer's Requirements

Schedule B: Guaranteed technical particulars of equipment offered (in response to Schedule A requirements) by the Contractor.

3 Instructions for filling in Schedule B

3.1 Where the Contractor does not fully comply with the Employer's requirement, any deviation must be clearly indicated in Schedule B and listed in the Deviation Schedule (Appendix B).

3.2 Where there is a need to substantiate or further describe an item in Schedule B, especially in instances of non-compliance with Schedule A, particulars are furnished on a separate sheet clearly marked with the notation of the Schedule A item referred to.

3.3 If a blank space is left in Schedule B next to certain requirement specified in Schedule A, this constitutes a confirmation that the tender does not comply with that specific requirement.

3.4 Where *** is indicated for an item in Schedule A, the Contractor is required to fill in the appropriate information in Schedule B, for the equipment offered.

Schedule A: Particulars of Eskom's requirements

Schedule B: Guarantees and technical particulars of equipment offered

Item	Description	Units	Schedule A	Schedule B
1	**General**			
1.1	Name of ASSEMBLY Manufacturer		***	
1.2	Location of the ASSEMBLIES		Indoors	
1.3	Life Expectancy Period	Years	20	
1.4	KKS or Plant Coding required		Yes	
2	**ASSEMBLIES**			
2.1	**Withdrawable versus fixed**			
2.1.1	Minimum current rating for fixed pattern units	A		
2.1.2	Minimum motor power rating for fixed pattern units	kW		
2.1.3	Maximum motor power rating for withdrawable units	kW		
2.2	**Dimensions of largest transport unit**			
2.2.1	width	mm	2 400	
2.2.2	depth	mm	800	
2.2.3	height (including base frame)	mm	2 176	
2.3	**Dimensions of the ASSEMBLIES**			
2.3.1	Maximum overall length		***	
2.3.2	Maximum overall height mm		***	
2.3.3	Maximum overall dept mm		***	
2.3.4	Withdrawable unit space required mm			
2.4	**Floor Loading**			
2.4.1	Overall mass of complete ASSEMBLY	kg		

2.5	**Minimum material thickness**			
2.5.1	Gland Plates	mm	3	
2.5.2	Supporting Structures	mm	2	
2.5.3	Cover Plates	mm	2	
2.5.4	Removable Covers	mm	2	
2.5.5	Doors	mm	2	
2.5.6	Equipment Mounting Panels	mm	2	
2.5.7	Minimum center line height above floor level of the lowest functional unit	mm	250	
2.5.8	Maximum centre-line height above floor level of the highest functional unit	mm	1900	
2.6	**Degree of Protection**			
2.6.1	Enclosure		IP3X	
2.6.2	Operating Doors Open		IP2X	
2.7	**Power supply conditions**			
2.7.1	Normal power supply conditions (extremes of these parameters can occur simultaneously)			
2.7.2	Voltage	V		
2.7.3	Voltage range	Per unit	0.85 - 1.1	
2.7.4	Frequency Range	Hz	48 – 51	
2.7.5	Voltage imbalance; negative sequence voltage as a percentage of the normal sequence voltage.	%	2	
2.7.6	Waveform; maximum amplitude deviation from sine wave phase voltage	%	5	
2.7.6.1	Abnormal power supply conditions prevailing simultaneously for up to 6 hours, unless otherwise indicated.			
2.7.6.2	Rated voltage	V		
2.7.6.3	Voltage range	Per unit	0,8 - 1,1	
2.7.6.4	Frequency range	Hz	48 – 52	
2.7.6.5	Voltage imbalance: Negative phase	%	3	

	sequence voltage as a percentage voltage			
2.7.6.6	Depression to 0,85 of nominal for up to one hour with further drops to 0,7 of nominal for up to 10 seconds		Yes	
2.7.6.7	Complete loss of supply for one second		Yes	
2.8	**Electrical characteristics**			
2.8.1	Rated operating Voltage (U_e)	V	1000	
2.8.2	Rated Insulation Voltage (U_i)	V	50	
2.8.3	Rated Frequency	Hz		
2.8.4	Short-circuit withstand for 1 second	kA		
2.8.5	Number of Phases and Neutral		3 + N	
2.8.6	Neutral Earthing		Solid	
2.8.7	Conditional short-circuit current	kA @ U_e + 10%		
2.9	**ASSEMBLY operation and cable access**			
2.9.1	Front operation		Yes	
2.9.2	Cable access	Front or rear	***	
2.9.3	Cable entry from above or below	Above or below	***	
2.10	**Compartments**			
2.10.1	separate horizontal main busbar compartments		Yes	
2.10.2	separate vertical busbar compartment per section		Yes	
2.10.3	separate control bus-wiring compartment		Yes	
2.10.4	separate cable compartment		Yes	
2.11	**Base frame**			
2.11.1	maximum height	mm		
2.11.2	minimum material thickness	mm	5	

2.12	**Barrier thickness**			
2.12.1	within compartments	mm	2	
2.12.2	between compartments	mm	2	
2.12.3	terminal shrouding	mm	Yes	
2.12.4	barrier material	mm	***	
2.13	**Door fasteners**			
2.13.1	fixed functional units		Square key Drawing No. 0.52/1037	
2.13.2	latches		< 450 mm - 2 < 800 mm - 3 > 800 mm - 4	
2.13.3	make		***	
2.13.4	type		***	
2.14	**Door hinges**			
2.14.1	make		***	
2.14.2	type		Surface	
2.15	**Cable securing arrangement**			
	gland plates provided		Yes	
	gland plate height above floor level, below the lowest functional unit	mm	250	
2.16	**Busbars**			
2.16.1	**General**			
2.16.1.1	number of phases (poles)		3	
2.16.1.2	neutral busbar required		Yes	
2.16.1.3	neutral cross sectional area (100 % of phases busbar cross sectional area)	mm^2	***	
2.16.1.4	number of bars per phase (pole)		***	
2.16.1.5	busbar insulation		No	
2.16.1.6	busbar material		HD copper	

2.16.1.7	busbar profile		Rectangular	
2.16.2	**Minimum clearance in air**			
2.16.2.1	phase to earth (pole to earth)	mm	25	
2.16.2.2	phase to phase (pole to pole)	mm	25	
2.16.2.3	creepage distance to earth over supports or insulators	mm	25	
2.16.3	**Supports for main and distribution busbars**			
2.16.3.1	manufacturer		***	
2.16.3.2	type		***	
2.16.3.3	material (mechanical properties required)		***	
2.16.4	**Electrical parameters of main and distribution busbars**			
2.16.4.1	rated current (all ASSEMBLIES)	A	See switchgear schedules	
2.16.4.2	Maximum current density for copper busbars (temperature-rise tested) I_n < 630 A 630 < I_n < 1 600 A 1 600 < I_n	A/mm^2	 2,0 1,6 1.1	
2.16.4.3	rated short-time withstand current for a period of one second	kA		
2.16.4.4	rated insulation voltage	V	1 000	
2.16.5	**Cross-sectional area of main distribution and equalising busbars**			
2.16.5.1	main phase busbars	mm^2	***	
2.16.5.2	main neutral busbar	mm^2	***	
2.16.5.3	distribution phase busbars	mm^2	***	
2.16.5.4	distribution neutral busbar	mm^2	***	
2.16.5.5	equalising busbar	mm^2	***	

2.17	**Connecting busbars**			
2.17.1	**Busbars between the main busbars and supply side of individual functional units**			
2.17.1.1	type		Fixed busbars	
2.17.1.2	material		Hard – drawn copper	
2.17.2	**Supports for connecting busbars**			
2.17.2.1	Manufacturer		***	
2.17.2.2	Type (e.g. insulator)		***	
2.17.2.3	Material		***	
2.17.2.4	Rated insulation voltage	V	1 000	
2.17.3	**Electrical parameters of connecting busbars**			
2.17.3.1	Rated current for all ASSEMBLIES	A		
2.17.3.2	Rated short-time withstand current for a period of one second	kA		
2.17.3.3	Rated insulation voltage	V	1 000	
2.17.4	**Conductors between main / distribution busbars and the supply side of the functional unit**			
2.17.4.1	Type		***	
2.17.4.2	Material		***	
2.17.4.3	Method of bracing		***	
2.17.4.4	Rated peak withstand current		***	
2.17.4.5	Rated insulation voltage	V	1 000	
2.18	**AC control busbars (conductors)**			
2.18.1	**General**			
2.18.1.1	Number of phases and neutral		1 + N	
2.18.1.2	Busbar insulation		Yes	
2.18.1.3	Busbar material		Copper	

2.18.1.4	Cross-sectional area of busbar (conductor) tested for 20 Amps and 1% volt drop			
2.18.1.5	Supplied from DPI or UPS	mm^2	***	
2.18.2	**AC control busbar supports**			
2.18.2.1	Manufacturer		***	
2.18.2.2	Type		***	
2.18.2.3	Material		***	
2.18.3	**PE conductor**			
2.18.3.1	Minimum cross sectional area	mm^2	150	
2.18.3.2	Method of identification		Marked GREEN/YELLOW	
2.18.3.3	Method of fastening to sections		***	
2.19	**Power and control wiring**			
2.19.1	**General**			
2.19.1.1	Flame retardant outer sleeving		Yes	
2.19.1.2	Rated insulation voltage		1 000V	
2.19.2	**Power conductors**			
2.19.2.1	Make		***	
2.19.2.2	Type		***	
2.19.3	**Power conductors**			
2.19.3.1	Make		***	
2.19.3.2	Type		***	
2.20	**AC Control Supply (DPI or UPS output voltage)**			
2.20.1	Nominal voltage	V	230	
2.20.2	Maximum voltage	V	253	
2.20.3	Minimum voltage	V	195.5	

3	**Air Circuit Breakers (ACB's)**			
3.1	**General**			
3.1.1	manufacturer		***	
3.1.2	designation		***	
3.1.3	number of poles		3	
3.1.4	neutral link		Yes	
3.1.5	type of disconnection		Withdrawable	
3.1.6	heat dissipation from the circuitbreakers W			
3.1.7	short circuit performance category (to IEC 60947-2)		B	
3.1.8	number of trolleys per ASSEMBLY			
3.1.9	tool cabinet for special tools per ASSEMBLY			
3.2	**Minimum Ratings**			
3.2.1	**Rated voltage**			
3.2.1.1	rated operational voltage (U_e)	V		
3.2.1.2	rated insulation voltage (U_i)	V	1 000	
3.2.2	**Rated currents**		See switchgear schedules	
3.2.2.1	Rated current (I_n)	A	***	
3.2.2.2	Conventional enclosed thermal Current (I_{the})	A	***	
3.2.3	**Rated frequency**	Hz	50	
3.2.4	**Rated duty**		Uninterrupted	
3.2.5	**Short circuit characteristics**			
3.2.5.1	rated short-circuit making capacity (I_{cm})	kA	***	
3.2.5.2	rated short-circuit breaking capacity (power factor and time constant	kA	***	

	according to IEC 60947-2)			
3.2.5.3	rated ultimate short-circuit breaking capacity – one second (I_{cu})	kA	50	
3.2.5.4	rated service short-circuit breaking capacity (I_{cs})	kA	50	
3.2.6	**Operating Times**			
3.2.6.1	opening time	ms	***	
3.2.6.2	arcing time at rated short circuit breaking capacity	ms	***	
3.2.6.3	break time	ms	***	
3.2.6.4	make time	ms	***	
3.2.6.5	break-make time	ms	***	
3.3	**Mechanism**			
3.3.1	Manner of storing energy		spring	
3.3.2	Origin of energy	V AC	electrical	
3.3.3	Manner of releasing energy	W	electrical	
3.3.4	Motor voltage (if applicable)		195 - 253	
3.3.5	Motor power (if applicable)		***	
3.4	**Closing device**			
3.4.1	Manual – mechanical latch		Yes	
3.4.2	Electrical		Yes	
3.4.3	steady state current of closing device	A	***	
3.5	**Tripping device**			
3.5.1	A – Mechanical			
3.5.2	B – Electrical			
3.5.2.1	earth fault trip mechanism			
3.5.2.2	sensitivity IΔn (range)			
3.5.2.3	sensitivity (IΔn) type			
3.5.2.4	time delay type(Δt - ms)			
3.5.2.5	time delay range (Δt - ms)			

3.5.2.6	test routine button			
3.5.2.7	reset button after earth fault trip			
3.5.2.8	over-current trip mechanism	s	***	
3.5.2.9	overload protection (long time) tripping time			
3.5.2.10	short circuit protection (short time)	ms	***	
3.5.2.11	short circuit protection (instantaneous)	ms	***	
3.6	**Auxiliary contacts**			
	(utilization category AC 14 or DC 13 to IEC 60947-5-1)			
3.6.1	Number of auxiliary contacts (including spares)		See schematic diagrams	
3.6.1.1	normally open		***	
3.6.1.2	normally closed		***	
3.6.2	Maximum rating capacity of auxiliary contacts			
3.6.2.1	AC			
	Make	A	***	
	Break	A	***	
	Continuous	A	***	
3.6.2.2	DC			
	Make	A	***	
	Break	A	***	
	Continuous	A	***	
3.6.3	Anti-pumping provided		Yes	
4	**Moulded-case circuit breakers (MCCB's)**			
4. 1	**General**			
	manufacturer		***	
	type		***	
	number of poles		3	
	utilization category (IEC 60947-2)		A or B	

	heat dissipation from the circuit breaker	W	***	
4.2	**Ratings**			
4.2.1	**Rated voltages**			
4.2.1.1	rated operating voltage (U_e)	V		
4.2.1.2	rated insulation voltage (U_i)	V	1 000	
4.2.2	**Rated currents**		See switchgear schedules	
4.2.2.1	rated current (I_n)	A	***	
4.2.2.2	conventional enclosed thermal current (I_{the})	A	***	
4.2.3	**Rated frequency**	Hz	50	
4.2.4	**Rated duty**		Uninterrupted	
4.2.5	**Short circuit characteristics**			
4.2.5.1	rated short-circuit making capacity (power factor to be specified by Contractor)	kA	***	
4.2.5.2	rated short-circuit breaking capacity (power factor and time constant to comply with SANS 60947-2)	kA	***	
4.2.5.3	rated ultimate short time withstand breaking current (I_{cu}) – one second	kA	***	
4.2.5.4	rated service short-circuit breaker breaking capacity (I_{cs})	kA	***	
4.2.6	**Operating Times**			
4.2.6.1	opening time	ms	***	
4.2.6.2	arcing time at rated short circuit breaking capacity	ms	***	
4.2.6.3	break time	ms	***	
4.2.6.4	make time	ms	***	
4.2.6.5	break-make time	ms	***	

4.3	**Mechanism**			
4.3.1	Manner of storing energy		4	
4.3.2	Origin of energy	V AC	electrical	
4.3.3	Manner of releasing energy	W	electrical	
4.4	**Closing device**			
4.4.1	Manual – mechanical latch		Yes	
4.4.2	Electrical		Yes	
4.4.3	steady state current of closing device	A	***	
4.5	**Tripping device**			
4.5.1	A – Mechanical			
4.5.2	B – Electrical			
4.5.2.1	earth fault trip mechanism			
4.5.2.2	sensitivity IΔn (range)			
4.5.2.3	sensitivity (IΔn) type			
4.5.2.4	time delay type(Δt - ms)			
4.5.2.5	time delay range (Δt - ms)			
4.5.2.6	test routine button			
4.5.2.7	reset button after earth fault trip			
4.5.2.8	over-current trip mechanism	s	***	
4.5.2.9	overload protection (long time) tripping time			
4.5.2.10	short circuit protection (short time)	ms	***	
4.5.2.11	short circuit protection (instantaneous)	ms	***	
4.6	**Auxiliary contacts**			
	(utilization category AC 14 or DC 13 to SANS 60947-5-1)			
4.6.1	Number of auxiliary contacts (including spares)		See schematic diagrams	
4.6.1.1	normally open		***	

4.6.1.2	normally closed			
4.6.2	Maximum rating capacity of auxiliary contacts:		***	
4.6.2.1	AC			
	Make	A	***	
	Break	A	***	
	Continuous	A	***	
4.6.2.2	DC			
	Make	A	***	
	Break	A	***	
	Continuous	A	***	
4.6.3	Anti-pumping provided		Yes	
5	**Miniature circuit breakers**			
5.1	**Single phase miniature circuit breakers (mcb's)**			
5.1.1	**General**			
5.1.1.1	manufacturer		***	
5.1.1.2	type		***	
5.1.1.3	neutral pole		Link	
5.1.1.4	utilization category (IEC 60947-2)	AC	A & B	
5.1.1.5	heat dissipation from the circuit-breaker	W	***	
5.1.2	**Ratings**			
5.1.2.1	**Rated voltages**			
5.1.2.1.1	rated operating voltage (U_e)	V		
5.1.2.1.2	rated insulation voltage (U_i)	V	1 000	
5.1.2.2	**Rated currents**		See switchgear schedules	
5.1.2.2.1	rated current (I_n)	A	***	
5.1.2.2.2	conventional enclosed thermal	A	***	

	current (I_{the})			
5.1.2.3	**Rated frequency**	Hz	50	
5.1.2.4	**Rated duty**			
5.1.2.5	**Short circuit characteristics**			
5.1.2.5.1	rated short-circuit making capacity (I_{cm}) (power factor to be specified by supplier)	kA	***	
5.1.2.5.2	rated short-circuit breaking capacity (power factor and time constant according to IEC 60947-2)	kA	***	
5.1.2.5.3	rated ultimate short-circuit breaking capacity – one second (I_{cu})	kA	***	
5.1.2.5.4	rated service short-circuit breaking capacity (I_{cs})	kA	***	
5.1.3	**Operating Device**			
5.1.3.1	closing – manual		Yes	
5.1.3.2	tripping - on over current		Yes	
5.1.4	**Auxiliary contacts**			
	(utilization category AC 14 or DC 13 to IEC 60947-5-1)			
5.1.4.1	Number of auxiliary contacts (including spares)		See schematic diagrams	
5.1.4.1.1	normally open		***	
5.1.4.1.2	normally closed		***	
5.1.4.2	Maximum rating capacity of auxiliary contacts		***	
5.1.4.2.1	**AC**			
	Make		***	
	Break		***	
	Continuous		***	
5.1.4.2.2	**DC**			
	Make		***	

	Break		***	
	Continuous		***	
5.2	**Three phase miniature circuit breakers**			
5.2.1	**General**			
5.2.1.1	manufacturer		***	
5.2.1.2	type		***	
5.2.1.3	neutral pole		Link	
5.2.1.4	neutral pole		A or B	
5.2.1.5	heat dissipation from the breaker	W	***	
5.2.2	**Ratings**			
5.2.2.1	Rated voltages			
5.2.2.1.1	rated operating voltage (U_e)	V		
5.2.2.1.2	rated insulation voltage (U_i)	V	1 000	
5.2.2.2	**Rated currents**		See switchgear schedules	
5.2.2.2.1	rated current (I_n)	A	***	
5.2.2.2.2	conventional enclosed thermal current (I_{the})	A	***	
5.2.2.3	**Rated frequency**	Hz	50	
5.2.2.4	**Rated duty**		Uninterrupted	
5.2.2.5	**Short circuit characteristics**			
5.2.2.5.1	rated short-circuit making capacity (power factor to be specified by Contractor)	kA	***	
5.2.2.5.2	rated short-circuit breaking capacity (power factor and time constant to comply with SANS 60947-2)	kA	***	
5.2.2.5.3	rated ultimate short time withstand breaking current (I_{cu}) – one second	kA	***	

5.2.2.5.4	rated service short-circuit breaker breaking capacity (I_{cs})	kA	***	
5.2.3	**Operating Device**			
5.2.3.1	closing: manual		Yes	
5.2.3.2	tripping: on over-current		Yes	
5.2.4	**Auxiliary contacts**			
	(utilization category AC 14 or DC 13 to SANS 60947-5-1)			
5.2.4.1	Number of auxiliary contacts (including spares)		See schematic diagrams	
5.2.4.1.1	normally open		***	
5.2.4.1.1	normally closed		***	
5.2.4.2	Maximum rating capacity of auxiliary contacts:			
5.2.4.2.1	AC			
	Make	A	***	
	Break	A	***	
	Continuous	A	***	
5.2.4.2.2	DC			
	Make	A	***	
	Break	A	***	
	Continuous	A	***	
6	**Switches, disconnectors, switch-disconnectors and fuse-combination units**			
6.1	**General**			
6.1.1	manufacturer		***	
6.1.2	type		***	
6.1.3	number of poles		3	
6.1.4	neutral pole type		Link	
6.1.5	utilization category (IEC 60947-3)		AC-23B	
6.1.6	heat dissipation from the breaker	W	***	

6.2	**Ratings**			
6.2.1	**Rated voltages**			
6.2.1.1	rated operating voltage (Ue)	V		
6.2.1.2	rated insulation voltage (Ui)	V	1 000	
6.2.1.3	rated impulse voltage withstand(U_{imp})	kV	***	
6.2.1.4	control voltage			
6.2.2	**Rated currents**		See switchgear schedules	
6.2.2.1	rated operational current (I_e)	A	***	
6.2.2.2	conventional free-air thermal current (I_{th})	A	***	
6.2.2.3	conventional enclosed thermal current (I_{the})	A	***	
6.2.2.4	rated uninterrupted current (I_u)	A	***	
6.2.3	**Rated frequency**	Hz	50	
6.2.4	**Rated duty**		Uninterrupted	
6.2.5	**Rated making capacity**	A	***	
6.2.6	**Rated breaking capacity @ rated voltage**	kA @ U_e	***	
6.2.7	**Rated conditional short-circuit current (to SANS 1973-1)**	kA		
6.2.8	**Operating device**			
6.2.8.1	closing: manual		Yes	
6.2.8.2	opening: manual		Yes	
7	**Contactors**			

7.1	**General**		***	
7.1.1	manufacturer		***	
7.1.2	manufacturer's type (provide rating and type for each load current)			
7.1.3	utilization category (to IEC 60947-4-1)		AC3	
7.1.4	type		Held-in	
7.1.5	recovery voltage	%	***	
7.1.6	on-load operations		- 1 000 000 for I_e <17A - 300 000 for I_e >17A	
7.1.7	type of contact and contact material (e.g. butt/silver)		***	
7.2	**Operating coil (for held-in contactors) or closing coil (for latched contactors)s**			
7.2.1	Rated burden	VA	***	
7.2.2	Control supply voltage (Us)	V	230	
7.2.3	Maximum continuous voltage	V	253	
7.2.4	Minimum closing voltage as percentage of Us	%	85	
7.2.5	Maximum drop-out voltage as percentage of Us (held-in contactors only)	%	75	
7.2.6	Minimum drop-out voltage as percentage of Us (held - in contactors only)	%	***	
7.3	**Contactor ratings**			
7.3.1	**Rated voltages**			
7.3.1.1	rated operational voltage (U_e)	V		
7.3.1.2	rated insulation voltage (U_i)	V	1000	
7.3.1.3	rated impulse withstand voltage (U_{imp})	kV	2	

7.3.2	**Rated currents**		See switchgear schedules	
7.3.2.1	conventional enclosed thermal current (I_{the})	A	***	
7.3.2.2	rated operational current (I_e)	A	***	
7.3.3	**Rated making capacity**	A	***	
7.3.4	**Rated breaking capacity**	A	***	
7.3.5	**Rated frequency**	Hz	50	
7.4	**Auxiliary contacts**			
	(utilisation category AC 14 or DC 13 to IEC 60947-5-1)			
7.4.1	Number of auxiliary contacts (including spares)		See schematic diagrams	
7.4.1.1	normally open		***	
7.4.1.2	normally closed		***	
7.4.2	**Maximum rating capacity of auxiliary contacts**			
7.4.2.1	**AC:**			
	make		***	
	break		***	
	continuous		***	
7.4.2.2	**DC:**			
	make		***	
	break		***	
	continuous		***	
8	**Motor starters**			
8.1	**General**			
8.1.1	Switching device / contactor / overload relay combination		Yes	
8.1.2	Heat dissipation from motor starters	W	***	

8. 2	**Overload devices**			
8.2.1	Manufacturer		***	
8.2.2	Type.		***	
8.2.3	Tripping current as percentage of set value	%	***	
8.2.4	Operating time at 105 % of set value (hot)	s	***	
8.2.5	Operating time at 600 % of set value(hot)	s	***	
8.2.6	Tripping characteristic curve to be provided		Yes	
8.2.7	Condition monitoring functionalities		Yes	
8.2.8	Data communication functionalities		Yes	
8. 3	**Special requirements for withdrawable functional and fixed units**			
8.3.1	- position of withdrawable functional units		Accessible	
8.3.2	- position of fixed functional units		Lowest	
8.3.3	- number of trolleys and associated lifting equipment required			
8.3.4	- number of special testing equipment for withdrawable units			
8.3.5	- power plug full load current rating	A		
8. 4	**Number of start-ups/hour**		***	
8.4.1	- No. of operating cycles – fixed drives		***	
8.4.2	- No. of operating cycles – withdrawable drives		***	
9	**Accessories**			
9.1	**Fuse Links and Carriers**			
9.1.1	**Power circuit fuses**			
9.1.1.1	**Fuse base**			
9.1.1.1.1	manufacturer		***	
9.1.1.1.2	designation		***	
9.1.1.1.3	type		Knife edge	

9.1.1.2	**Fuse carrier**			
9.1.1.2.1	manufacturer		***	
9.1.1.2.2	designation		***	
9.1.1.3	**Fuse link**			
9.1.1.3.1	manufacturer		***	
9.1.1.3.2	designation		***	
9.1.1.3.3	rated current	A	See switchgear schedule	
9.1.1.3.4	rated voltage	V	See switchgear schedule	
9.1.1.3.5	rated short-time withstand current	kA	***	
9.1.2	**Control circuit fuses**			
9.1.2.1	**Fuse Base**			
9.1.2.1.1	manufacturer		***	
9.1.2.1.2	designation		***	
9.1.2.1.3	type		Knife edge	
9.1.2.2	**Fuse carrier**			
9.1.2.2.1	Manufacturer		***	
9.1.2.2.2	designation		***	
9.1.2.3	**Fuse link**			
9.1.2.3.1	manufacturer		***	
9.1.2.3.2	type		***	
9.1.2.3.3	rated current	A	***	
9.1.2.3.4	rated voltage	V AC	230	
9.1.2.3.5	rated short-time withstand current	kA		
9.2	**Current transformers for metering**			
9.2.1	Applicable to Incomer circuits only:			
9.2.1.1	manufacturer		***	
9.2.1.2	type		***	
9.2.1.3	rating		***	
9.2.1.4	accuracy class		***	
9.2.1.5	calibration certificate		***	

9.3	**Current transformers for protection**			
9.3.1	manufacturer		***	
9.3.2	type designation		***	
9.3.3	rating		***	
9.3.4	accuracy class	VA	***	
9.4	**Signal lamps - LED's**			
9.4.1	Manufacturer		***	
9.4.2	Type designation		MAC 22	
9.4.3	Supply voltage type		230V AC Cluster	
9.5	**Control switches**			
9.5.1	Manufacturer		***	
9.5.2	Type designation		***	
9.6	**Selector switches**			
9.6.1	Manufacturer		***	
9.6.2	Type designations		***	
9.7	**Protection relays**			
9.7.1	**Large motor feeders**		See switchgear schedules	
9.7.1.1	Manufacturer		***	
9.7.1.2	Type		IED	
9.7.1.3	Current setting range I_F		0.2 to 1.5 x I_n	
9.7.1.4	Nominal current I_N	A	1	
9.7.1.5	Overload pick up point		1,05 x I_{FL} ±3%	
9.7.1.6	Thermal model		Preferably 2-body equivalent.	
9.7.1.7	Adjustable heating time constant	minute s	1 to 100 minutes	
9.7.1.8	Adjustable cooling (zero speed)		1 to 4 x heating time constant	
9.7.1.9	Resetting after trip		Reset when thermal model cooled to 60% of trip temperature	

9.7.1.10	Start up supervision		Yes, I^2t	
9.7.1.11	Thermal alarm		Yes	
9.7.1.12	Thermal trip (hot and cold start)		Yes	
9.7.1.13	Thermal memory		Non-volatile	
9.7.1.14	Phase failure protection IDMT		Trip for I^2t = 5 - 50	
	Phase failure protection Instantaneous		30 to 70 % x I_n	
9.7.1.15	True NPS		Yes	
9.7.1.16	Undercurrent protection		Yes	
9.7.1.17	Over current protection (definite time)		2 to 16 x I_n Delay < 50 ms	
9.7.1.18	Earth Fault Protection:			
9.7.1.18.1	Current		10 to 60% x I_n	
9.7.1.18.2	Time		0.05 to 1.0 second	
9.7.1.19	Stalling and Prolonged Starting		Start time 2 to 100 seconds with 2 x I_n current interlock.	
9.7.1.20	Number of starts			
9.7.1.21	Under-voltage:			
9.7.1.21.1	Rated input voltage	V	400	
9.7.1.21.2	Setting range		60 to 120% x V_N	
9.7.1.21.9	Timing range	s	0 - 10	
9.7.1.21.4	Drop off/pick up ratio of measuring element		Greater than 95%	
9.7.1.21.5	Maximum burden	VA	2	
9.7.1.22	Load Indication		Digital display	
9.7.1.23	General Indication		The indicators shall be by means of light emitting diodes (LED's) or digital display.	
9.7.1.24	Contacts for tripping:			
9.7.1.24.1	Number		2	
9.7.1.24.2	Make and carry for 3 seconds at 220V DC	A	10	
9.7.1.25	Power Supplies		220 V DC ± 20%	
9.7.1.25.1	Quiescent current maximum	mA	250	
9.7.1.25.2	Operating current maximum	mA	500	
9.7.1.26	Over current ratings (CT circuits) for 1 s continuous		50 x I_n	

			2 x I_n	
9.7.1.27	Communication protocols		IEC 61850 / IEC 60870-5- 103/ Modbus	
9.7.1.28	Wiring diagram drawing number		***	
9.7.1.29	Programmable alarm contacts		4	
9.7.1.30	Communication ports:			
9.7.1.30.1	Front			
9.7.1.30.2	Rear			
9.7.1.31	Binary inputs (220 V DC)		2	
9.7.2	**Main incomer**		See switchgear schedules	
9.7.2.1	Manufacturer		***	
9.7.2.2	Type		Digital	
9.7.2.3	Connection		3 - Phase and 1 - phase	
9.7.2.4	IDMT Curve selection		SI,VI, EI	
9.7.2.5	IDMT current setting range	% of I_n	20 to 250	
9.7.2.6	IDMT earth fault setting range	% of I_n	10 to 80	
9.7.2.7	Time multiplier setting range at 10 times setting current (IEC 60225-4 Curve A)	s	3	
9.7.2.8	Definite time over-current protection			
9.7.2.8.1	Current settings range	% of I_n	100 to 2000	
9.7.2.8.2	Time settings range	s	0 to 10	
9.7.2.9	Definite time earth fault protection	e		
9.7.2.9.1	Current settings range	% of I_n	10 to 100	
9.7.2.9.2	Time settings range	s	0 to 10	
9.7.2.10	Accuracy of settings		within ±5%	
9.7.2.11	Maximum burden	VA	2	
9.7.2.12	Short time rating for 1 second	A	50	
9.7.2.13	Contacts for tripping:			
9.7.2.13.1	Number of fault-make		2	
9.7.2.13.2	Make and carry for 3 seconds at 220V DC	A	10	
9.7.2.14	Power Supplies		220V DC ±20%	
9.7.2.14.1	Quiescent Current (max per element)	mA	250	

9.7.2.14.2	Operating Current (max per relay)	mA	500	
9.7.2.15	Communication protocols		IEC 61850 / IEC 60870-5- 103/ Modbus	
9.7.2.16	Wiring diagram drawing number		***	
9.7.2.17	Programmable alarm contacts		4	
9.7.2.18	Communication ports:			
9.7.2.18.1	Front			
9.7.2.18.2	Rear			
9.7.2.19	Binary inputs (220 V DC)		4	
9.8	**Special relays**			
9.8.1	**Phase failure relay as per standard schematic diagram.**			
9.8.1.1	Manufacturer		***	
9.8.1.2	Type designation		***	
9.8.1.3	Percentage unbalance drop-out voltage		***	
9.8.1.4	Type II Coordinated		SANS 60947-4-1	
9.8.1.5	Short Circuit Protection Device		Refer switchgear schedule	
9.8.2	**Under-voltage relay**		See schematic diagram	
9.8.2.1	Manufacturer		***	
9.8.2.2	Type designation		***	
9.8.2.3	Supply voltage		***	
9.8.2.4	Drop-out voltage		***	
9.9	**Indicating Instruments**			
9.9.1	**AC Ammeter**			
9.9.1.1	manufacturer		***	
9.9.1.2	type designation		***	
9.9.1.3	mounting		Flush	
9.9.1.4	Size:			

9.9.1.4.1	incomer		96 x 96	
9.9.1.4.2	other circuits		72 x 72	
9.9.1.5	colour and finish		Bright black	
9.9.1.6	shape	mm	Square	
9.9.1.7	range	mm	***	
9.9.1.8	peak current indication for incomer		Yes	
9.9.1.9	instrument face glass		Anti-static	
9.9.2	**AC Voltmeter**			
9.9.2.1	manufacturer		***	
9.9.2.2	type designation		***	
9.9.2.3	mounting		Flush	
9.9.2.4	size		96 x 96	
9.9.2.5	colour and finish		Bright black	
9.9.2.6	shape		Square	
9.9.2.7	range		0-500V	
9.9.2.8	instrument face glass		Anti-static	
9.10	**Auxiliary Relays**			
9.10.1	As per standard schematic diagram		Yes	
9.10.2	Manufacturer		***	
9.10.3	type designation		***	
9.10.4	number of contacts		As per diagram	
9.10.5	supply voltage		230	
9.10.6	Drop out voltage	V AC	***	
9.10.7	Contact rating (utilization category AC14)		***	
9.11	**Interposing relays**			
9.11.1	Manufacturer		***	
9.11.2	type designation		***	
9.11.3	coil pick-up voltage	V DC	17 – 27	
9.11.4	minimum coil resistance at 20 ^{O}C	Ω	400	
9.11.5	permissible ambient temperature	^{O}C	0 – 50	
9.11.6	switching duty		***	

9.11.7	pull-in time		< 20	
9.11.8	drop-out time	ms	< 10	
9.11.9	life expectancy (no. of operations)	ms	1×10^6	
9.11.10	test voltage (coil cont.)		2500	
9.12	**Current transducer**			
9.12.1	manufacturer		***	
9.12.2	type designation		***	
9.12.3	input current	A	1	
9.12.4	output current	mA	4 – 20	
9.12.5	supply voltage	V AC	230	
9.13	**Voltage transducer**			
9.13.1	manufacturer		***	
9.13.2	type designation		***	
9.13.3	input voltage	V	3 x 400	
9.13.4	output current	mA	4 – 20	
9.16.5	supply voltage	V AC	230	
9.14	**Terminals and lugs**			
9.14.1	**Power terminals**			
9.14.1.1	manufacturer		***	
9.14.1.2	type designation		***	
9.14.2	**Control terminals (normal)**			
9.14.2.1	manufacturer		***	
9.14.2.2	type designation		***	
9.14.3	**Control Terminals (spring loaded)**			
9.14.3.1	manufacturer		***	
9.14.3.2	type designation		***	
9.14.4	**Lugs**			

9.14.4.1	**Power wiring/cable lugs**			
9.14.4.1.1	manufacturer		***	
9.14.4.1.2	type designation		***	
9.14.4.2	**Control wiring/cable lugs**			
9.14.4.2.1	manufacturer		***	
9.14.4.2.2	type designation		***	
9.15	**Stabilized power supply units**			
9.15.1	**Voltage Dip Proofing Inverter with Line Filter**			
9.15.1.1	Manufacturer		***	
9.15.1.2	Type		***	
9.15.1.3	Line filter		***	
9.15.1.4	nominal input voltage	V	230V AC	
9.15.1.5	nominal output voltage	V	230V AC	
9.15.1.6	power rating	kVA	***	
9.15.1.7	setting range	s	0 - 1	
9.16	**Uninterruptible Power Supply**			
9.16.1	Manufacturer		***	
9.16.2	Type		***	
9.16.3	nominal input voltage	V AC	230V AC	
9.16.4	nominal output voltage	V AC	230V AC	
9.17	**Thyristor heater control**			
9.17.1	manufacturer		***	
9.17.2	type		***	
9.17.3	Protection on thyristors			
9.17.3.1	Maximum Voltage RMS.		2.8 x Normal	
9.17.3.2	Maximum Current RMS (repetitive peak)		1.8 x I_{FL}	
9.17.4	Type of protection for system transient voltages (voltage spikes)		***	

9.17.5	Protection for thyristors:			
9.17.5.1	Against over voltage		***	
9.17.5.2	Against over current		***	
9.17.6	RF interferences guaranteed		***	
9.17.7	Thyristor data sheet details			
9.17.7.1	water cooling		No	
9.17.7.2	type isolator and rating		***	
9.17.8	number of thyristors in parallel		***	
9.17.9	Maximum continuous operating temperature at full load at 40°C ambient temperature			
9.17.9.1	Heat sink	^{O}C	***	
9.17.9.2	Thyristor	^{O}C	***	
9.17.10	Lifetime at maximum full load temperature years			
9.17.11	Alarms			
9.17.11.1	High Temp		Yes	
9.17.11.2	Trip Temp		Yes	
9.17.12	Expected component lifetime		10 Years	
9.17.13	Air flow required at full load		***	
9.17.14	Maximum continuous load at 400V	kW		
9.17.15	Maximum continuous input current at			
9.17.15.1	-10% V		***	
9.17.15.2	+10% V		***	
9.17.16	Other alarms available		***	
10	**Testing and inspection**			
10.1	**Type testing**			
10.1.1	Type testing of ASSEMBLIES		As per IEC 60439-1	
10.1.2	Type testing of components		As per table in Appendix C	
10.1.3	Type testing of stabilized power supply units		***	
10.1.4	Type test certificates required		Yes	
10.1.5	Type test report required		Yes	

10.1.6	Comprehensive EDS which substantiates all stated deviations and type-tests of performance claims		Yes	
10.1.7	Claimed and verified type-tested performance of ASSEMBLIES		SANS 1973-1 Annex A	
10.1.8	Third Party Test House(s) for typetesting		ISO 17025 registered	
10.2	**Routine testing**			
10.2.1	Inspection and routine testing of ASSEMBLIES		As per SANS 1973-1 Annexure I	
10.2.2	Inspection and routine testing of components		As per table in Appendix C	
10.2.3	Routine test certificates required		Yes	
11	**Installation, special tools and spares**			
11.1	**Installation**			
11.1.1	**General**			
11.1.1.1	off-loading from transport vehicle required		***	
11.1.1.2	crane for off-loading required		No	
11.1.1.3	erection on prepared foundations		***	
11.1.1.4	construction power supply available		***	
11.1.1.5	area of cable slots	mm		
11.1.1.6	floor finish requirements		Screeding	
11.1.1.7	floor tolerance		***	
11.1.2	**Sub-*Contractors***			
11.1.2.1	sub-*Contractor* to be engaged in erection and commissioning		***	
11.1.2.2	sub-*Contractor* to be engaged in delivery and off-loading		***	
	other sub-*Contractors*		***	
11.2	**Tools**			
11.2.1	number of tool sets required		1 set per ASSEMBLY	

12	**Manuals**			
12.1	number of copies of instruction manuals to be supplied		4	
13	**Training**			
13.1	number of *Employer's* personnel to be trained			
	trained		***	
13.2	venue		***	
13.3	training duration		***	
14	**Accessories**			
14.1	Standard Isolator padlock		(0.00/2839)	
15	**Surface preparation**			
15.1	Reference SCSSCAAP9			
15.2	Abrasive blast clean to Grade Sa 2,5 or		***	
15.3	Degrease, rinse, pickle and phosphate		***	
16	**Corrosion protection**			
16.1	Reference SCSSCAAP9			
16.2	Preferred System or Alternative System		***	
			***	
17	**Compliance with OHS requirements**			
17.1	RCC Certificates available for all components and cables		Yes	

APPENDIX B: DEVIATION SCHEDULE

1. Any deviations/modifications/alternatives offered to standard specification 240-56227516 shall be listed below with reasons for the departures.

2. No deviations/modifications/alternative offered to the specification will be recognized unless listed on this schedule.

3. If no deviations/modifications/alternatives are offered, this schedule must be marked N/A.

Specification/ schedule page number	Specification/ Schedule/ or clause number	Proposed deviation/ modification/ alternative	Cost of deviation or alternative

APPENDIX C: SWITCHGEAR AND CONTROLGEAR TYPE-TESTING REQUIREMENTS

Type-tests	Component Description and Applicable SANS Standard				
	Air circuit breaker + moulded case circuit breaker	**Air- break switch**	**Switches, disconnectors, switch-disconnectors and fuse-combination units**	**Contactor**	**Motor starters**
	SANS 60947-2 + SANS 60947-1	SANS 60947-3 + SANS 60947-1	SANS 60947-3 + SANS 60947-1	SANS 60947-4-1 + SANS 60947-1	SANS 60947-4-1 + SANS 60947-1
Temperature-rise	X	X[6]	X[6]	X	X
Dielectric properties	X	X[7]	X[7]	X	X
Degree of protection				X[4]	X
Performance under short- circuit conditions		X[2]		X	X
Rated short-time withstand current[1]	X[4]	X			
Mechanical properties of terminals				X	X
Tripping limits and characteristic	X				
Short circuit breaking capacity	X				
Rated making and breaking capacities		X	X	X	X
Overload performance	X[4]				
Rated conditional short-circuit current		X	X		
Performance of integrally fused circuit-breakers	X[4]				
Ability to withstand overload current				X	
Operation and operating limits				X	X
Conventional operational performance				X	X
Change-over ability and reversibility [4]					X
Operational performance capability	X	X	X		
Electromagnetic compatibility (EMC)	X	X	X	X	X

LEGEND

[1] Test duration - 1s; [2] Making capacity only; [3] Test duration - 60 s; [4] Where applicable;
[5] Circuit-breakers with electronic overcurrent protection shall additionally be tested according to SANS 60947-2 amendment 2; [6] Temperature-rise verification test shall be conducted in addition;
[7] Dielectric verification test shall be conducted in addition.

APPENDIX D: ESKOM DOCUMENT HIERARCHY

Routine tests	Component Description and Applicable SANS Standard				
	Air circuit breaker + moulded case circuit breaker	**Air- break switch**	**Switches, disconnectors, switch-disconnectors and fuse-combination units**	**Contactor**	**Motor starter**
	SANS 60947-2 + SANS 60947-1	**SANS 60947-3 + SANS 60947-1**	**SANS 60947-3 + SANS 60947-1**	**SANS 60947-4-1 + SANS 60947-1**	**SANS 60947-4-1 + SANS 60947-1**
Wiring and electrical operation test					X
Dielectric properties	X	X	X	X	X
Operation and operating limits (functional checks)				X	X
Mechanical operation		X	X	X	
Calibration of releases	X				

APPENDIX E: SERVICE CONDITIONS

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 SANS 10142-1 prior to being connected to a power system with the characteristics and neutral point earthing arrangements as detailed in Schedule A of an enquiry document.

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.

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.

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.

2 Conditions for DC systems

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

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

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.