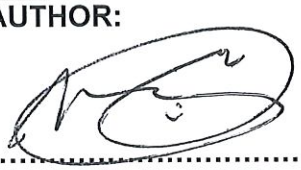
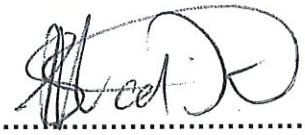
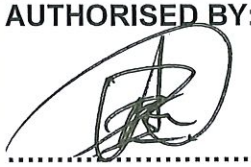
RAND WATER	STRATEGIC ASSET MANAGEMENT ELECTRICAL ASSET MANAGEMENT SPECIFICATION	
TITLE: SPECIFICATION FOR CONTROL PANELS AND FACTORY BUILT ASSEMBLIES OF LOW VOLTAGE SWITCHGEAR AND CONTROL GEAR		DOC NO: SAM EAM 00001 Spec
SECTION: ELECTRICAL ASSET MANAGEMENT	EFFECTIVE DATE: SEPTEMBER 2019	REV. NO: 01
AUTHOR:  ..... ELECTRICAL ASSET MANAGER	FORMAT APPROVAL:  ..... QUALITY MANAGEMENT OFFICER	AUTHORISED BY:  ..... SENIOR MANAGER: MASTER PLANNING

TABLE OF CONTENTS

1 PURPOSE

The purpose of this specification is to provide a specification to which control panels and factory built assemblies (FBAs) of low voltage switchgear and control gear are to be designed, manufactured, installed and commissioned, where required, on Rand Water operational sites.

All control panels shall conform to the same specification as the FBA. For the purpose of this specification, the terms FBA, switchboard and control panel shall mean one and the same thing and the words shall be interchangeable.

The previous electrical specification for control panels has been superseded by this specification and shall no longer be utilized.

2 SCOPE

This specification covers the design, manufacture, testing at works, preparation for delivery, delivery and offloading of Factory Built Assemblies (FBAs) of low voltage switchgear and control gear on Rand Water sites.

3 APPLICABILITY

This specification applies to Rand Water GMSAM and GMO divisions, suppliers and contractors.

4 REFERENCES

Document Title	Document No.	Location
Occupational health and safety management systems - Requirements	ISO 18001	RW Library
The Wiring of Premises Part 1: Low voltage installations	SANS 10142-1	RW Library
Low-voltage switchgear and controlgear assemblies- Part 1: General rules	SANS 61439-1	RW Library
Low-voltage switchgear and controlgear assemblies- Part 2: Power switchgear and control gear assemblies	SANS 61439-2	RW Library
Low-voltage switchgear and controlgear assemblies- Part 3: Distribution boards intended to be operated by ordinary persons (DBO)	SANS 61439-3	RW Library
Low-voltage switchgear and controlgear assemblies Part 4: Particular requirements for assemblies for construction sites (ACS)	SANS 61439-4	RW Library

Low-voltage switchgear and controlgear assemblies Part 5: Assemblies for power distribution in public networks	SANS 61439-5	RW Library
Low-voltage switchgear and controlgear assemblies Part 6: Busbar trunking systems (busways)	SANS 61439-6	RW Library
Enclosed low-voltage switchgear and controlgear assemblies- Guide for testing under conditions of arcing due to internal fault	SANS 61641	RW Library
Low-voltage switchgear and controlgear ASSEMBLIES Part 1: Type-tested ASSEMBLIES with stated deviations and a rated short-circuit withstand strength above 10 kA	SANS 1973-1	RW Library
Low-voltage switchgear and controlgear ASSEMBLIES Part 3: Safety of ASSEMBLIES with a rated prospective short- circuit current of up to and including 10 kA	SANS 1973-3	RW Library
Low-voltage switchgear and controlgear ASSEMBLIES Part 7: Requirements for testing under conditions of arcing due to internal fault	SANS 61641	RW Library
Low-voltage switchgear and controlgear ASSEMBLIES Part 8: Safety of minimally tested ASSEMBLIES (MTA) with a rated short-circuit current above 10 kA and a rated busbar current of up to and including 1 600A AC and DC.	SANS 1973-8	RW Library
Low-voltage switchgear and control gear Part 1: General rules	SANS 60947-1	RW Library
Low-voltage switchgear and controlgear Part 2: Circuit-breakers	SANS 60947-2	RW Library
Low-voltage switchgear and controlgear Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units	SANS 60947-3	RW Library
Low-voltage switchgear and controlgear Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters	SANS 60947-4-1	RW Library
Low-voltage switchgear and controlgear Part 4-2:Contactors and motor-starters - AC semiconductor motor controllers and starters	SANS 60947-4-2	RW Library
Low-voltage switchgear and controlgear Part 4-3: Contactors and motor-starters - A.C. semiconductor controllers and contactors for non-motor loads	SANS 60947-4-3	RW Library

Low-voltage switchgear and controlgear Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices	SANS 60947-5-1	RW Library
Low-voltage switchgear and controlgear Part 5-2: Control circuit devices and switching elements - Proximity switches	SANS 60947-5-2	RW Library
Low-voltage switchgear and controlgear Part 5-3: Control circuit devices and switching elements - Requirements for proximity devices with defined behaviour under fault conditions	SANS 60947-5-3	RW Library
Low-voltage switchgear and controlgear Part 5-4: Control circuit devices and switching elements - Method of assessing the performance of low-energy contacts – Special tests	SANS 60947-5-4	RW Library
Low-voltage switchgear and controlgear Part 5-5: Control circuit devices and switching elements - Electrical emergency stop device with mechanical latching function	SANS 60947-5-5	RW Library
Low-voltage switchgear and controlgear Part 5-6: Control circuit devices and switching elements – DC interface for proximity sensors and switching amplifiers (NAMUR)	SANS 60947-5-6	RW Library
Low-voltage switchgear and controlgear Part 5-7: Control circuit devices and switching elements - Requirements for proximity devices with analogue output	SANS 60947-5-7	RW Library
Low-voltage switchgear and controlgear Part 5-8: Control circuit devices and switching elements - Three position enabling switches	SANS 60947-5-8	RW Library
Low-voltage switchgear and controlgear Part 5-9: Control circuit devices and switching elements - Flow rate switches	SANS 60947-5-9	RW Library
Low-voltage switchgear and controlgear Part 6-1: Multiple function equipment - Transfer switching equipment	SANS 60947-6-1	RW Library
Surge Arresters- Part 1 Non-linear resistor type gapped surge arresters for a c systems	SANS 60099-1	RW Library
Surge arresters Part 5: Selection and application recommendations	SANS 60099-5	RW Library
Low voltage fuses- Part 1: General requirements	SANS 60269-1	RW Library

Low-voltage fuses Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) Examples of standardized systems of fuses A to J	SANS 60269-2	RW Library
Low voltage fuses- Part 4: Supplementary requirements for fuse-links for the protection of semi-conductor devices	SANS 60269-4	RW Library
Degrees of protection provided by enclosures (IP code)	SANS 60529	RW Library
Semiconductor converters- Part 6: Application Guide for the Protection of Semiconductor Converters against Overcurrent by Fuses	SANS 60146-6	RW Library
Busbars	SANS 1195	RW Library
Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 1: General	SANS 1507-1	RW Library
Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 2: Wiring cables	SANS 1507-2	RW Library
Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 3: PVC Distribution cables	SANS 1507-3	RW Library
Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 4: XLPE Distribution cables	SANS 1507-4	RW Library
Instrument transformers Part 1: Current transformers	SANS 60044-1	RW Library
Instrument transformers Part 2: Inductive voltage transformers	SANS 60044-2	RW Library
Galvanising	SANS 121	RW Library
Circuit breakers	VC 8036	RW Library
Rand Water WKS Identification System Pocket Guide	RW/01200/L/012	MC Office
Specification for plant Codification labels	RW Maint 00007 Pr	MC Office
Quality management systems - Requirements	SANS/ISO 9001	RW Library
Quality management systems - Requirements	SANS/ISO 9001	RW Library

5 TERMS, DEFINITIONS AND ABBREVIATIONS

5.1 TERMS

5.1.1 **Contractor:** Refers to a person, company or organisation that is appointed by Rand Water to provide goods or services or perform construction work.

5.1.2 **Rand Water Representative:** Refers to the person appointed by Rand Water to act as the Design Engineer, Project Execution Engineer, Programme Manager, Project Manager or Station representative for the purposes of the Contract and notified to the Contractor.

5.1.3 **OEM:** Means Original Equipment Manufacturer, which is a company that has sole intellectual property rights to equipment that is used by Rand Water. The equipment cannot be sourced from any other supplier / manufacturer other than the OEM.

5.1.4 **Accredited Test House**: Refers to a Third-Party Organization duly authorized by an Accreditation Authority who has the necessary test plant to perform type-tests in accordance with ISO 17025 requirements.

5.1.5 **Data Sheets**: Refers to the drawings, tabulations and sketches, which clearly indicate the technical, electrical and physical requirements of the equipment.

5.2 DEFINITIONS

5.2.1 **Calibration:** Operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication.

5.2.2 **IP Rating:** Is defined in international standard EN 60529 (British BS EN 60529:1992, European IEC 60509:1989). IP Ratings are used to define levels of sealing effectiveness of electrical enclosures against intrusion from foreign bodies (tools, dirt etc.) and moisture.

5.3 ABBREVIATIONS

AC	Alternating Current
A	Amperes
ADS	Application data sheet
AMSL	Above mean sea level
ANSI	American National Standards Institute
BS	British Standards
CACA	Circulated Air Circulated Air
CACW	Circulated Air Circulated Water
CD	Compact Disk
CMR	Continuous Motor Rating
CSI	Current Source Inverter
CT	Current Transformer
DB	Distribution Board

DC	Direct Current
DOL	Direct-on-line
DOM	Design Office Manager
DVD	Digital Versatile Disk
EMC	Electromagnetic Compatibility
FAT	Factory Acceptance Test
FBA	Factory Built Assembly
GMO	General Manager Operations
GMSAM	General Manager Strategic Asset Management
HVAC	Heating, Ventilation and Air-conditioning
Hz	Hertz
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
IP	Ingress Protection
ISO	International Organization for Standardization
kA	kilo Amps
LCD	Liquid Crystal Display
LED	Light Emitting Diode
M	Meters
mA	milli Amps
MCC	Motor Control Centre
MLMST	Multi Level Inverter, Multi Secondary Transformer
mm	Millimetres
MV	Medium Voltage
OEM	Original Equipment Manufacturer
O&M manual	Operation and maintenance manual
PDS	Power Drive System (SANS 61800-4)
PFSC	Process Fail Safe Controller
PLC	Programmable Logic Controller
PWM	Pulse Width Modulation
PQ	Power Quality
PT100	Platinum resistor element with a nominal resistance of 100 Ohm at 0°C
QA	Quality Assurance
QAP	Quality Assurance Plan
QCP	Quality Control Plan
RFQ	Request for Quotation
RMS	Root Mean Square
RW	Rand Water
SABS	South African Bureau of Standards
SANS	South African National Standard
SCPD	Short Circuit Protection Device
SHEQ	Safety, Health, Environment and Quality
SPIR	Spare Parts Interchange-ability Record
TEFC	Totally Enclosed Fan Cooled
TOU	Time Of Use

V	Volts
VSD	Variable Speed Drive
VSI	Voltage Source Inverter
VT	Voltage Transformer
WKS	Water Codification System
Ω	Ohms
°C	Degrees Celsius

6 RESPONSIBILITY AND AUTHORITY

6.1 OWNERSHIP

6.1.1 The Electrical Asset Manager is the custodian of this specification.

6.2 INTERESTED / AFFECTED PARTIES

6.2.1 The specification shall be made available to all interested / affected parties on request; and

6.2.2 Interested / affected parties shall adhere to this specification.

6.2.3 Interested / affected parties shall only use the latest revision of the standards referenced in this specification.

6.3 CONTRACTORS / SUPPLIERS

6.3.1 The contractor or supplier shall ensure that the installations are done in accordance with the external body standards referenced in the document.

6.3.2 Rand Water shall not issue any copies of the external body standards referenced in the document to any contractor; it is the responsibility of the contractor to have their own copies.

6.4 ACCREDITATIONS / VENDOR RESPONSIBILITIES

6.4.1 The FBA manufacturer shall submit proof of coordinated, discriminating, fault-clearing protection schemes for the relevant equipment combinations, in terms of SANS 60947.

6.4.2 No claims for extras in respect of failure by the Contractor to comply with any of the above regulations or specifications will be entertained by Rand Water.

6.4.3 Where conflict exists between any of the above regulations, the said conflict must be referred to the Engineer for a ruling.

6.4.4 Where conflict exists between any Rand Water technical specifications, the above regulations and the detailed technical specification or notes on drawings, the said conflict shall be referred to the Engineer for clarification.

7 ACTION / PROCEDURE / METHOD

7.1 OPERATIONAL REQUIREMENTS

7.1.1 General

7.1.1.1 The FBA shall be capable of continuous operation at full rating without the temperature rise of any component or compartment exceeding the maximum recommended by the supplier of that equipment or those temperatures recommended by the relevant SANS or IEC standard, whichever is the lesser.

7.2 MECHANICAL CONSTRUCTION

400V FBA DESIGN CRITERIA		
POWER SUPPLY DETAILS:		
Supply voltage	400, 3 phase 4 wire	VAC
Supply voltage variations	-15% and +10%	
Supply Frequency	50	Hz
Supply Frequency Variations	± 2.5	%
Phase Rotation	RWBR	
Neutral Earthing (secondary)	Solid	
Negative Phase Sequence Voltage	<2%	
Total Harmonic Content	< 3% up to 25th harmonic	
CURRENT RATINGS:		
Rated Operational Current I_n	≥ the full load current of the supply transformer to an incomer	A minimum
Complete Busbar System Derating Factor	0.85	
Short Circuit Rating I_{cw}	≥ the prospective symmetrical short circuit current from supply transformers during momentary paralleling and must include the motor contribution to the fault current, with all motors running at the same time	kA for 3s
Rated Peak Withstand I_{pk}	2.1 times Short Circuit Rating	kA
Internal arc rating	≥ the prospective symmetrical short circuit current	kA for 0.3s
VOLTAGE RATINGS & INSULATION SYSTEM REQUIREMENTS:		

Rated voltage U_e	400	V
Insulation U_i	1000	V
Impulse Withstand Level	2500	V
BUSBAR SYSTEM:		
Busbars:		
Busbar Nominal Rating	≥ the full load current of the supply transformer to an incomer with de-rating applied	A
Rated Diversity Factor	1	
Busbar Construction	All busbars shall be manufactured from copper and shall be of constant cross sectional area throughout their full length.	
Busbar Maximum Current Density	1,55	A/mm^2
Neutral Busbar Rating	≥ 50% of the full load current of the supply transformer to an incomer with de-rating applied	
TEMPERATURE RISE SPECIFICATION:		
Assembly Temperature Rise Limit	As per SANS 61439	°C
Busbar Support Temperature Rise	As per SANS 61439	°C
Busbar Temperature Rise	As per SANS 61439	°C
OTHER:		
Place of Installation	Indoor and outdoor	
Form	2b & 3b	
IP rating:		
Inside switchgear room	IP4x	minimum
Outside switchgear room	IP65	minimum
Strip heaters required:		
	Indoor	No
	Outdoor	Yes
Type of access	Front and rear	
Type of entry	Bottom cable entry & resin encapsulated bus	

	bar for Incomers	
Minimum tier/cubicle width	800	mm
Minimum clearances around switchboard:		
	Rear clearance with doors closed	1100mm
	Side and front clearances with doors closed	2500mm
Switchboard enclosure material:		
Inside switchgear room	Mild steel	
Outside switchgear room	3CR12	
Door Thickness	1,6	mm minimum
Door latching mechanisms	All front and rear doors shall be **hinged** and provided with a minimum of two 7mm square key locks, of which one shall be pad lockable.	
Chassis Plate Thickness	1,6	mm minimum
Gland plate thickness:		
Incomers	10mm aluminium	mm minimum
All other cubicles	2.5 mild steel	mm minimum
Finish	Powder coated, **structured**	
Colour:		
Normal Section	Electric Orange, B26	To SANS 1091
Essential Services Section	Signal Red, A11	To SANS 1091
231VAC UPS Distribution Section	Royal Blue, F01	To SANS 1091
110V DC Distribution Section	Dark Admiralty Grey, G12	To SANS 1091
Certification required:		
Switchboard	Approved performance to SANS 1973-1	
Fixed MCCBs	Yes	
SCPD / Motor starter coordination	Type II Coordination	
Special environmental conditions:		
Humidity	80% (condensing for switchboards located outdoors)	%

Maximum Ambient Temperature	40	°C
Minimum Ambient Temperature	-10	°C
Altitude	1800 m	aMSL

7.3 GENERAL REQUIREMENTS

7.3.1 A rigid assembly shall be ensured by a suitably profiled base frame to eliminate distortion in lifting, transportation and installation. Suitable and easily accessible lifting lugs must be provided.

7.3.2 Construction Methods and Systems
A fully bolted modular system is preferred, partially type-tested and SANS 61439 certified.

7.3.3 Permitted Enclosure Configurations

7.3.3.1 Front access, rear access and rear termination is preferred

7.3.3.2 Front access, front termination (where rear access is not possible)

7.3.4 Access and Component Layout requirements

7.3.4.1 Sufficient clearances to earth and between phases are to be provided for the safe operation of fault clearing devices. Clearances shall be not less than the manufacturer's recommendations.

7.3.5 Switchboard Construction

7.3.5.1 Multi-cubicle FBAs shall comprise one or more modular, free standing cubicles, bolted together to form a composite board of uniform appearance.

7.3.5.2 All cable/field terminations, associated with the incomers and bus section circuit breakers, are to be wired to terminals. These terminals shall be located in a separate cubicle, in the front of the switchboard, beneath the bus section circuit breaker.

7.3.5.3 The 110V DC, 231V AC UPS and the Essential Services **distribution** sections shall **not** have door interlocked handles on the circuit breakers (this excludes the generator changeover circuit). However, the distribution circuit breakers shall be provided with a cover, through which the circuit breakers shall protrude, and individual circuit breaker lockout facilities.

7.3.5.4 Sections with a large number of distribution circuit breakers shall be provided with a custom type busbar arrangement, on the source side and shall not utilize multiple wire jumpers between the circuit breakers.

7.3.5.5 The doors shall be suitably braced and stiffened, and have the appropriate types and number of hinges to carry the weight of equipment mounted on the door, to prevent distortion.

7.3.5.6 Doors shall be fitted with non-hardening rubber or neoprene seals.

7.3.5.7 All doors shall be bonded to earth with a green with yellow trace, or bare stranded copper earth conductor. Arrangements shall be made to ensure effective metallic contact between the earth conductor and the panel door. The minimum size of the earth conductor shall be 2.5mm^2.

7.3.5.8 The quantity of empty compartments incorporated in any FBA shall comprise at least 30% of the total number of compartments, including spares as specified on design drawings. The empty compartments shall be distributed evenly throughout the switchboard.

7.3.6 FBA mounting

7.3.6.1 FBAs may be either free standing or wall mounted. Wall mounted units shall be provided with suitable brackets or external lugs for securing to the wall. Drilling and mounting schemes that necessitate the use of holes in the rear of the cubicle shall not be accepted.

7.3.7 Equipment Mounting Plates (Chassis Plates)

7.3.7.1 Chassis plates shall be sufficiently rigid to carry the components mounted thereon without deflection.

7.3.7.2 The drilling and tapping of holes for the mounting of components or "hank" captive nuts shall be used to secure components. Loose bolt and nut arrangements shall not be accepted.

7.3.7.3 Chassis plates manufactured from mild steel shall be powder coated white, galvanized or aluzinc coated.

7.3.7.4 To prevent circulating currents, where a 3 phase supply passes through a chassis plate, all three phases shall pass through a common slot in the chassis. The 3 phases shall not be split into individual phases each passing through a separate hole/slot.

7.3.7.5 The holes/slots shall be suitably sized and shall have grommets installed around the openings to prevent chafing of the conductors.

7.3.8 Gland Plates

7.3.8.1 Sectionalised removable gland plates shall be provided and secured by means of "hank" captive nuts or screws and so located that ample space is afforded for the satisfactory entry and termination of cables. Cable entry shall normally be from the bottom. Top entry will only be permitted at the discretion of the Engineer.

7.3.8.2 Gland plates shall be mounted at least 300 mm above floor level.

7.3.8.3 Gland plates shall be manufactured from mild steel, with a minimum thickness of 2.5mm and shall be galvanised. Painted cable gland plates are not acceptable.

7.3.8.4 Where single core cables are specified, non-ferrous or non-magnetic materials shall be used for the gland plates. These gland plates shall be a minimum thickness of 10 mm.

7.3.8.5 Gland plates shall be adequately sized for the expected number of cables to be installed in that tier.

7.3.8.6 The distance between the connection point of the single core cables, on the load side bus bar of the incomers and the gland plate, shall be adequate to meet installation and minimum cable bending requirements.

7.3.9 Screws, nuts and bolts

7.3.9.1 All screws, nuts and bolts shall be hexagonal to ISO metric, commercial standards and shall be rust proof. Nuts protruding from exterior surfaces shall be domed, and either chrome or cadmium plated.

7.3.9.2 Self tapping screws shall not be utilised for any purpose.

7.3.10 Painting of sheet metal fabrications

7.3.10.1 The final paint finish shall be epoxy powder. The minimum final paint thickness shall be 120 micrometres' and shall be measured at various points as indicated by the Engineer.

7.3.10.2 The FBA manufacturer shall provide a calibrated test instrument capable of accurately determining the final paint thickness. This instrument shall be made available at the FBA painted, sheet metal inspection.

7.3.10.3 A test sample plate shall be produced for each batch of powder coating.

7.3.11 Colours

7.3.11.1 The normal section of the FBA shall be powder coated Electric Orange B26, to SANS 1091 and the final finish shall be structured.

7.3.11.2 The 110VDC distribution section shall be powder coated Dark Admiralty Grey G12, to SANS 1091 and the final finish shall be structured.

7.3.11.3 The 231VAC UPS distribution section shall be powder coated Royal Blue, F01, to SANS 1091 and the final finish shall be structured.

7.3.11.4 The 400VAC essential services distribution section shall be powder coated Signal Red A11, to SANS 1091 and the final finish shall be structured.

7.3.11.5 If the FBA Incomer is fed from an Essential Services supply, then only the Incomer door shall be powder coated Signal Red A11, to SANS 1091 and the remainder of the panel shall be Electric Orange B26, to SANS 1091.

7.3.11.6 If the FBA Incomer is fed from a 110VDC supply, then only the Incomer door shall be powder coated Dark Admiralty Grey G12, to SANS 1091 and the remainder of the panel shall be Electric Orange B26, to SANS 1091.

7.3.11.7 If the FBA Incomer is fed from a 231VAC UPS supply, then only the Incomer door shall be powder coated Royal Blue F01, to SANS 1091 and the remainder of the panel shall be Electric Orange B26, to SANS 1091.

7.3.12 Quality of Final Finish

7.3.12.1 The application of the paint shall be uniform so as to prevent running or excessive "orange peel". Careful attention shall be applied to the application of paint to sharp edges and corners to prevent cracking or peeling of paint.

7.3.12.2 Any surfaces exhibiting these symptoms shall be rejected and shall be stripped and completely repainted.

7.3.13 Safety Features

7.3.13.1 Access to Compartments Containing Live Electrical Equipment

7.3.13.2 Compartments containing multiple live circuits shall not be provided with an isolating device that is mechanically interlocked with the access door of that compartment.

7.3.13.3 Single circuit compartments containing live electrical equipment shall be provided with an isolating device that shall be mechanically interlocked with the access door of that compartment such that it shall not be possible to open the door unless the device is in the OFF position. The interlock shall be provided with a mechanism that requires a conscious effort to override the interlock. Access to this interlock override shall be blocked in the event of the device being locked in the OFF position.

7.3.13.4 Busbar Chambers and Incomer Cubicles

7.3.13.4.1 Covers to these chambers shall, in addition to any other fixing devices, have at least one catch that permits the application of a lock to prevent unauthorised access. The covers shall have locating pins/devices to ensure that the covers stay in position even when the catches/latching devices have been released. Labelling shall be provided on each cover.

7.3.13.5 Safety Barriers

7.3.13.5.1 Busbars, connectors and live wiring that cannot normally be isolated in compartments when the compartment isolator is switched off, shall be shielded by removable robust insulating barriers. The barriers shall be fitted with the yellow triangle and lightning warning label.

7.4 ELECTRICAL CONSTRUCTION

7.4.1 Busbar construction

7.4.1.1 The FBA shall be provided with three phase busbars, a neutral busbar and an earth busbar for an earthed three phase, four wire system. All busbar dimensions are to be submitted to the Engineer for approval before the commencement of manufacture.

7.4.1.2 All busbars shall be manufactured from copper and shall be of constant cross sectional area throughout the entire length.

7.4.1.3 Other profiles such as rods and tubes are not acceptable. Aluminium busbars and laminated busbars are not acceptable.

7.4.1.4 Busbars shall be installed with the RED phase being the first busbar, as viewed from the front of the switchboard, followed by White, Blue and Neutral busbars.

7.4.1.5 At the rear of the switchboard the busbar droppers shall be installed with the Red phase situated on the utmost right hand side, followed by White, Blue and then Neutral. If this arrangement cannot be achieved it shall be referred to the Engineer, before the busbars are installed in the switchboard.

7.4.1.6 The maximum permissible temperature rise of any part of the assembly shall be 30°C above an ambient temperature of 35°C.

7.4.1.7 Busbars and busbar droppers shall be identified by means of approved colour-coded heat-or air-shrink sleeves at intervals of not less than 400mm with a minimum length of 50mm each.

7.4.1.8 The busbar riser from an incomer circuit breaker shall be rated not less than the maximum current that can be supplied by the source. The ratings are subject to the approval of the Engineer.

7.4.1.9 Vertical dropper busbars shall be provided on each tier, at the rear of the switchboard, and shall be situated to the extreme left hand side. Flexible cable droppers from the main busbars shall not be accepted. Vertical dropper busbars shall have the same current rating as the main horizontal busbars up to 800A. At higher horizontal busbar ratings all vertical droppers shall be rated at 1000A.

7.4.1.10 Joints and connections in main busbars and dropper busbars shall be made by means of suitable bolted pressure systems. Drilled and bolted busbar joints are acceptable provided that the effective cross sectional area of the busbar is not reduced.

7.4.1.11 All bolts used for busbar connections shall be high tensile and sheradised or cadmium plated.

7.4.1.12 Busbar sections overlapping at joints shall be either electrolytically silver plated or sanded to a bright, rough finish and sealed with a non-hardening silicone grease.

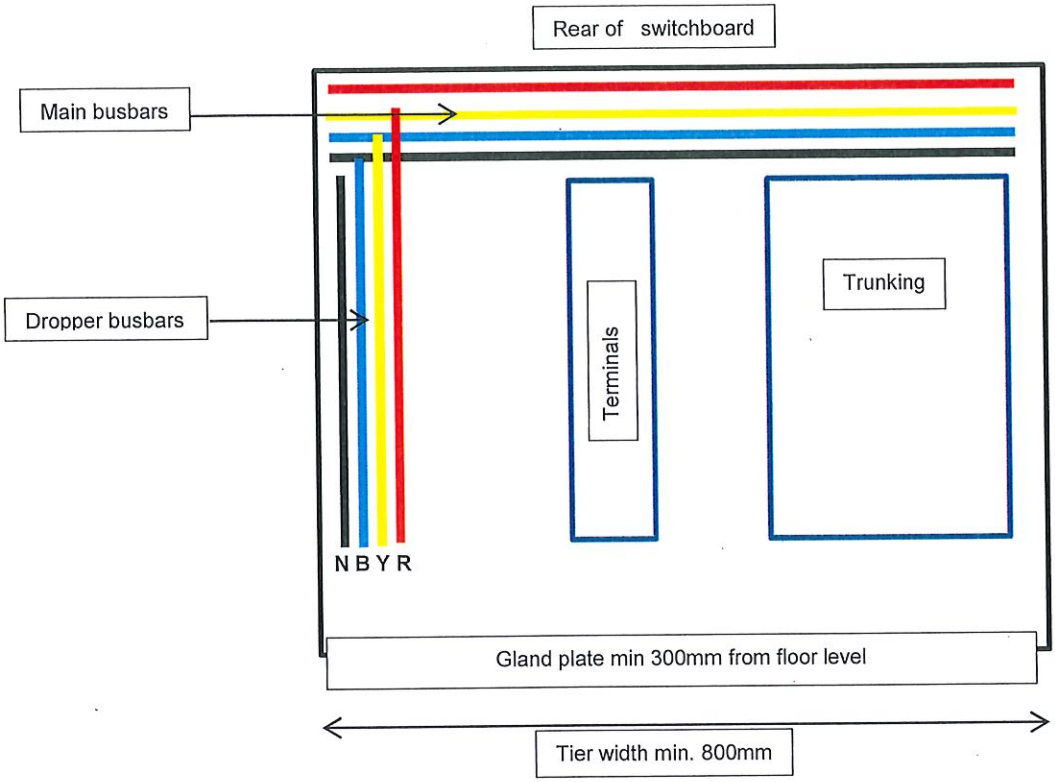
7.4.1.13 The length of the overlapping section shall not be less than twice the width of the busbars and shall maintain the same cross-sectional area as the main busbars. The busbars shall be prepared to allow for addition of extra tiers if so required in the future.

7.4.1.14 All busbar bolts shall be correctly sized and shall be tightened using a torque wrench. The manufacturer shall demonstrate that he has an acceptable quality control procedure to ensure that busbar bolts are tightened to the correct torque.

7.4.2 Busbar Location

7.4.2.1 The FBA busbars shall only be located at the top of the assembly.

7.4.2.2 Recommended busbar layout of switchboard tier as viewed from the rear of the panel with the door open:



7.4.3 Encapsulated busbar systems

7.4.3.1 When the current rating of the incomer circuit breaker exceeds 1000A, an encapsulated busbar system shall be designed and installed from the low voltage connections of the supply transformer to the FBA incomer. The encapsulated busbar system shall replace the multiple cables required to achieve the desired current rating.

7.4.3.2 The encapsulated busbar system shall be routed such that it follows the contours of the interior building walls and shall not obstruct the rear incomer door, or the main busbar chamber at the top of the switchboard.

7.4.3.3 Alternatively, where there is sufficient space in the cable duct, the encapsulated busbar system may be installed and anchored to the interior wall of the duct.

7.4.3.4 The encapsulated busbar system shall enter from the bottom of the incomer tier at the rear of the switchboard. The connections between the encapsulated busbar system and the incomer circuit breaker, as well as the transformer low voltage connections, shall be via suitably rated flexible tails.

7.4.3.5 The contractor shall liaise with the transformer manufacturer to establish the connection requirements between the transformer low voltage connections and the encapsulated busbar system. This shall also include any additional requirements with respect to the connection of copper to aluminium busbars.

7.4.3.6 The encapsulated busbar design, including routing and connection details shall be presented to the Engineer for approval, before the procurement of any items.

7.4.3.7 Encapsulated busbar design requirements:

Requirement	Description
Applicable Standard	SANS 61439
Continuous Rating (I_e) to maximum 55˚C	To match current rating of Source
Short Circuit Rating (3 seconds)	To match FBA design
Busbar Maximum Current Density	1,7 A/mm^2
Operating Voltage (V)	400
Insulation Voltage (V)	1 000
Dielectric Voltage (V)	3 500
RMS Withstand Voltage (kV) (1 minute)	5
Impulse Voltage Withstand (kV) (1,2/50µs)	8
Acceptable bus way types	Epoxy Insulated or Resin Encapsulated
IP rating for Epoxy Insulated	43 minimum
IP rating for Resin Encapsulated	68
Busbar material specification	High Conductivity Copper- 99,98% composition >98% ICAS Conductivity
Busbar Configuration	Three phase plus 100% neutral and 50% rated protective earth bars
Epoxy coated conductor specification:	
Insulation temperature rise	Class H (180˚C)
Dielectric strength	14kV/mm
Surface adhesion	Impermeable to liquid (IP 68)
Fire resistance of insulation system	Self extinguishing
Air pocket elimination	Thixotropic powder
Environmental	Indoor
Busbar enclosure	Material extruded aluminium alloy
Busbar enclosure thickness	3 mm minimum
Joints	Sandwich type with compression joint,

Requirement	Description
	Bellville washers and double headed bolts. Phase to phase dielectric strength equal to that of busbar system.

7.4.4 Internal Arc Compliance Requirements

7.4.4.1 The entire FBA shall be internal arc compliant.

7.4.4.2 The FBA shall be internal arc tested for a fault duration of 0,3 secs.

7.4.4.3 In terms of SANS 61641, the FBA shall be classified to provide PERSONAL and ASSEMBLY protection under arcing conditions, and shall meet criteria of SANS 61641.

7.4.5 Power Circuit Wiring

7.4.5.1 Power circuit wiring shall be carried out using copper cabling which has flame retardant, self-extinguishing insulation material, or other approved insulation material. The insulation shall be suitable for 1 000 Volts AC.

7.4.5.2 Hard drawn copper busbar shall be used for circuits with nominal circuit current ratings of 800A or above. The use of conventional PVC insulation copper cabling is not permitted.

7.4.5.3 The wiring shall be connected to the busbars using hydraulically compressed solid crimping lugs which shall be bolted to the busbars using sheradised or cadmium plated bolts, nuts, spring washers and washers. No drilling and tapping of busbars is allowed.

7.4.5.4 Connections between components may be carried out without the use of crimped lugs where components utilise pressure pad type connections. Where connections are screwed or bolted, compression crimp lugs shall be used.

7.4.5.5 Conductors shall be sized to suit the prospective maximum continuous current and the I^2t energy let-through characteristics of the circuit protection devices. The minimum size of conductor on the busbar side of circuit protection devices shall, however, be based on the fault level withstand capabilities or the maximum size wire that the circuit breaker can accommodate.

7.4.5.6 All power conductors shall be securely fastened/supported and shall be colour coded to identify the phase. For this purpose, a minimum of 50mm heat shrink shall be utilized from point of connection, on each conductor end.

7.4.5.7 All conductors shall be secured/strapped by means of saddles or wash lines that are securely attached to the chassis plate. Wiring saddles that utilize an adhesive tape shall not be utilised.

7.4.5.8 All connectors and other live parts shall be shrouded to avoid inadvertent contact when servicing/accessing the panel

7.4.6 Control and Instrument Wiring

7.4.6.1 Control and instrument wiring shall be carried out using 600 V grade flame retardant PVC insulated, multistranded wire with a minimum of 19 strands. The minimum wire sizing for control circuits shall be 1 mm^2.

7.4.6.2 All wires shall be terminated using compression crimp lugs unless the wire terminates in a pressure pad type terminal in which case compression ferrules shall be used.

7.4.6.3 All wires shall be numbered at both ends utilising an international colour coded clip on number or a plastic tag and clear sleeve numbering system. Numbering shall be strictly in accordance with the relevant schematic diagrams.

7.4.7 Colour Coding of Wiring

7.4.7.1 Power circuits

7.4.7.1.1 Power circuits shall be phase colour coded and identified for red, white and blue phases respectively and **black** for the neutral.

7.4.7.2 Control Circuits

AC live	-	brown or red
AC neutral	-	black
110V DC positive	-	grey
110V DC negative	-	grey
24V DC positive	-	pink
24V DC negative	-	orange
4-20 mA	-	purple
Earth	-	green with yellow trace
110V AC phases	-	red, white and blue phases respectively

7.4.8 Terminals for Control and Instrument Wiring

7.4.8.1 10% spare terminals shall be provided for each group of terminals and shall be numbered in numerical sequence following the main terminals.

7.4.8.2 A maximum of two wires per side of each terminal is permitted and terminal bridging devices shall be used where more than two wires are required to be connected.

7.4.8.3 Terminals shall be arranged in a logical, numerical sequence. Random organisation of terminals is not permitted.

7.4.8.4 Each terminal shall carry a number on both input and output side and each terminal strip shall be numbered in accordance with the relevant schematic diagrams. Each circuit shall have a separate group carrier identification label.

7.4.8.5 **No terminals** shall be mounted on the sides of the switchboard and such terminals shall only be mounted on chassis plates.

7.4.8.6 All cable/field terminations, associated with the incomers and bus section circuit breakers, are to be wired to terminals. These terminals shall be located in a separate cubicle, in the front of the switchboard, beneath the bus section circuit breaker.

7.4.8.7 All live conductors shall be terminated on protection devices (terminals) which pass the standard finger test (SANS 60529) to give IP2x protection. Bolted terminals for larger conductors that cannot comply with this requirement shall be provided with robust insulating shrouds or a clear protective barrier.

7.4.9 Terminals for Power Circuits

7.4.9.1 Terminals shall be provided for the termination of power circuit wiring. The terminals shall be rated for the maximum continuous circuit current. Pressure pad terminals may be used up to a conductor size of 16 mm^2 and terminals for larger conductors shall be the bolted type requiring the use of crimp lugs.

7.4.9.2 All live conductors shall be terminated on protection devices (terminals) which pass the standard finger test (SANS 60529) to give IP2x protection. Bolted terminals for larger conductors that cannot comply with this requirement shall be provided with robust insulating shrouds or a clear protective barrier.

7.4.9.3 **No terminals** shall be mounted on the sides of the switchboard and such terminals shall only be mounted on chassis plates.

7.4.10 Trunking and the Control of Wiring

7.4.10.1 Wiring trunking shall be used for the control of wiring in the FBA Trunking situated in the rear of the switchboard shall be adequately sized for the expected number of cable tails, such that the trunking is not more than 75% occupied when all cabling has been installed and connected.

7.4.10.2 Wiring to devices mounted on cubicle doors shall be so arranged that when the door is opened, a twisting rather than bending motion is imparted to the wires.

7.4.10.3 Wiring to the doors shall be secured and controlled using spiral bindings where it passes over the door opening.

7.4.10.4 All conductors shall be secured/strapped by means of trunking, saddles and/or wash lines that is/are securely, mechanically, attached to the chassis plates or doors. Adhesive tape shall not be utilised.

7.4.10.5 All trunking shall be suitably braced to avoid any deflection/distortion.

7.4.11 Earthing and Earth Leakage Protection

7.4.11.1 Earthing Busbar

7.4.11.1.1 The FBA shall be provided with an earth bar manufactured from hard drawn, high conductivity copper of minimum cross section 40 mm x 6 mm. The earth bar shall be located at the bottom of the FBA to match the designated cable entry location and shall run the full length of the FBA. The bar shall be pre-drilled and prepared to allow for the addition of extra tiers if so required in the future.

7.4.11.2 Earthing of Components

7.4.11.2.1 All sheet metal work shall be bonded to the earth bar and shall include:

- Each tier's metalwork
- Each removable chassis plate
- Each gland plate
- Fixed chassis of withdrawable air circuit breakers

7.4.11.2.2 All current transformers shall have one leg of the secondary earthed. This shall be through a post type slide link terminal to enable testing to be carried out. Voltage transformers and control transformers shall have one leg of the secondary earthed via a removable link.

7.4.11.2.3 All earthing conductors shall have green with a yellow trace insulation.

7.4.12 Earth Leakage Protection

7.4.12.1 Where indicated on the single line and schematic diagrams, earth leakage protection with the indicated sensitivity and time delays shall be provided.

7.4.12.2 The earth leakage units shall be integral and operate on the core balance principle for motor circuits of greater than 22 kW, the earth leakage relay shall have a sensitivity of 375 mA with an IDMT tripping characteristic, with adjustable facilities for both sensitivity and trip time delay.

7.4.12.3 Where called for on low voltage single phase circuits, earth leakage breakers of 30 mA sensitivity shall be employed.

7.4.12.4 Welding plugs and sump pumps shall also be fed from an earth leakage unit with a sensitivity of 30 mA.

7.4.12.5 The main supply to the UPS shall be via a non-earth leakage supply, protected by a double pole or four pole circuit breaker, for single phase and three phase UPSs, respectively. The UPS circuit shall also contain a maintenance bypass circuit to enable the UPS to be removed for maintenance purposes. This circuit shall prevent the output of the UPS to be paralleled with the normal/bypass supply under all circumstances.

7.4.13 Auxiliary Power Supplies

7.4.13.1 Control Voltage Supplies

7.4.13.1.1 For incomer and bus section control circuits, where an 110V DC supply is not available, these shall be 231V AC derived from a supply taken from the Uninterruptible Power Supply (UPS) distribution section in the FBA.

7.4.13.1.2 110V DC control supplies shall be taken from the DC distribution section in the FBA or a separate DC distribution board.

7.4.13.1.3 The control circuits, for sump pumps and flood alarms, shall be 24V DC only and shall be installed in local control panels situated within 1m of the sump pump or level sensors.

7.4.13.1.4 Each sump pump local control panel shall have a 400V AC to 24V DC power supply where the 400V AC supply shall be derived from below the main circuit breaker feeding the sump pump local control panel.

7.4.13.1.5 Each flood alarm local control panel shall have a 231V AC to 24V DC power supply where the 231V AC supply shall be derived from below the main circuit breaker feeding the flood alarm local control panel.

7.4.13.2 DC Power Supplies (24 V and 110 V DC)

7.4.13.2.1 Where required, 24V DC power supplies shall be provided and shall have voltage regulation characteristics, current limiting on its output and suitable output short circuit protection.

7.4.13.2.2 The 24V DC power supplies shall be rated at a minimum of 2 Amps and the output of each shall be connected to a suitably rated double pole miniature circuit breaker.

7.4.13.2.3 MCB's shall be DC rated, to trip at their nominal current ratings at 24V or 110V DC and shall be connected with the correct polarity.

7.4.13.2.4 Where the minimum required rating of the DC circuit breaker is below the minimum rating available, fuses of the correct rating shall be employed.

7.4.13.3 Metering Supplies

7.4.13.3.1 The voltage circuit for voltmeters and power meters shall be derived directly from the dropper busbars. A 20A, HRC fuse, in each phase, shall be provided mounted directly on the busbars at the take-off point and an additional fuse rated 2A shall be provided in each phase.

7.4.14 Electrical Equipment

7.4.14.1 All electrical equipment and components selected shall comply with the respective IEC or, SANS Standards and Recommendations. Equipment selected shall be rated for the more onerous of the continuous or intermittent duty within the manufacturer's recommendations.

7.4.14.2 Consideration shall be given to supplying the make of electrical equipment to meet the standardisation requirements of the Rand Water site for which it is supplied.

7.4.14.3 Non paralleling of incomer circuit breakers

7.4.14.3.1 On boards fitted with two incomers and a bus section, interlocking and tripping circuits are required to prevent the closing of the bus section circuit breaker when both incomers are in service, ie. paralleling of both incomers.

7.4.14.3.2 However, this circuit shall not be utilized for engine room designs but the circuit shall be as indicated by the relevant schematic diagrams.

7.4.14.4 Air Circuit Breakers (ACBs)

7.4.14.4.1 ACBs shall only be used on incomer and feeder circuits rated in excess of 630 amps. The bus section and incomer circuit breakers shall be identical and shall be fully interchangeable.

7.4.14.4.2 Air Circuit Breakers (ACBs) design requirements:

EQUIPMENT	REQUIREMENTS
INCOMER, FEEDER AND BUS SECTION AIR CIRCUIT BREAKERS:	
Ratings and Configuration	
Rated Operational Voltage (U_e)	690 V
Rated Insulation Voltage (Ui)	1000 V
Rated Impulse Withstand Voltage (U_e)	12 kV
Rated Uninterrupted Current (I_u) at 40˚C	As specified by the Engineer
Rated Ultimate Short Circuit Breaking Capacity (I_{cu})	As specified by the Engineer
Rated Service Short Circuit Breaking Capacity (I_{cs})	100% of I_{cu}
Rated Short Time Withstand Current (I_{cw}) (1 sec)	As specified by the Engineer
Poles	Four
Neutral Pole Current Carrying Capacity (%I_{cu})	100% of I_{cu}
Circuit Breaker Type	Selective (B)
Mounting configuration	Horizontal Drawout
Safety Features	
Complete through the door interface	Yes
Total segregation between power and front shield with double insulation	Yes
Visual indication of connected, test and isolated positions	Yes
Accessories	
Shunt Trip	Yes 110 V DC
Spring Charge Motor	Yes 110V DC
Closing coil	Yes 110V DC
Manual Spring Charge Handle	Yes
Undervoltage Coil (DC No volt release)	Yes 110V DC
Auxiliary Contacts (minimum quantity)	Two NO and NC each Two NO in Test Position Two NO in Isolated Position Spring Charged Indication
Mechanical Operations Counter	Yes
Design Operations	
Mechanical life at a frequency of 60 operations/hour	>12 000 operations

Electrical life at a voltage of 440 V AC (with a frequency of at least 10 operations/hour)	>5 000 operations
Protection:	
Power for protection shall be from current transformers and shall operate at currents as low as 5% of the nominal rating. (In addition to this requirement a backup 24VDC source must be wired to the input of the integral on-board protection device).	Yes
Overload Protection adjustable for current and time	Yes
Thermal memory for overload protection	Yes
IDMT Short Circuit Protection adjustable for time and current	Yes
Instantaneous Short Circuit Protection adjustable in several thresholds	Yes
Ground Fault Protection adjustable for time and current	Yes
Protection against unbalanced currents and voltages	Yes
Programming of protection unit (Where an external device is required to programme the protection unit, all propriety software, hardware and communication devices must be supplied with each protection unit).	Keypad or RS232 or USB interface
Measurement:	
Power for protection unit shall be from current transformers and shall operate at currents as low as 5% of the nominal rating. (In addition to this requirement a backup 24VDC source must be wired to the input of the integral on-board protection device).	Yes
Parameters to be measured:	
All three phase currents and neutral current	Yes
All three phase voltages and phase to neutral voltages	Yes
Apparent power (kVA)	Yes
Reactive power (kVAr)	Yes
Active power (kW)	Yes

Power factor	Yes
Frequency	Yes
Reactive energy (kVArh)	Yes
Active power (kWh)	Yes
Energy measurements resettable from digital contact, keypad, RS232 or USB interface	Yes
Power quality measurement	
Voltage spikes	Yes
Voltage sags	Yes
Individual or total harmonic distortion up to 25th harmonic for voltages	Yes
Individual or total harmonic distortion up to 25th harmonic for currents	Yes
Breaker condition measurements	
Number of operations	Yes
Contact Wear	Yes
Opening and closing times for at least the last 100 operations	Yes
Event Recording:	
Trip events time and date stamped	Yes
Pre and post trip currents and voltages	Yes
Export data to a spreadsheet	Yes
User Interface and HMI	
Programming from RS 232, USB port or from the keypad on the interface unit	Yes
Password protection	Yes
Protection settings	Yes
Control and configuration settings	Yes
Indication of all measured parameters	Yes
Display of all protection and configuration settings with password protection	Yes
Visual Indication	
Trip indication of all protection elements and breaker trips	Yes
Watchdog alarm	Yes
Facility for a remote display of real time measurements	Yes
Communication:	

Facility to communicate on Modbus TCP/IP and Profibus	Yes

7.4.14.4.3 The ACBs shall be provided with mechanical interlocks to prevent the circuit breaker being inserted or withdrawn while in the closed condition. Only ACBs with spring assisted opening and closing mechanisms will be preferred. The ACBs shall be provided with busbar shutters that shall automatically cover live busbar stubs when the ACB truck is withdrawn.

7.4.14.4.4 The incomer and bus section ACB auxiliaries, PLC inputs/outputs and auxiliary wiring shall be wired to terminals, situated in a separate cubicle, beneath the bus section circuit breaker. The relevant terminal strips shall be clearly differentiated by group carrier labels.

7.4.14.5 Moulded Case Circuit Breakers (MCCBs)

7.4.14.5.1 MCCBs will generally be used on feeder or motor starter circuits. The MCCBs shall be selected so that their tripping characteristics provide discrimination between the FBA incomer circuit breaker, the circuit MCCB and the motor starter overload relay where applicable.

7.4.14.5.2 MCCBs rated between 300A and below 630A and used in incomer and bus section circuits shall be motorized and shall be fitted with auxiliary contacts and integral closing and shunt trip coils, as depicted in the schematic diagrams.

7.4.14.5.3 MCCBs shall be fitted with an integral shunt trip coil when used with external earth leakage tripping devices and shall be continuously rated for power circuit phase to phase voltage.

7.4.14.5.4 MCCBs shall have fixed trip and time delay characteristics.

7.4.14.5.5 All MCCBs shall have an auxiliary contact wired to terminals for "ON" status indication purposes which shall be wired to a terminal strip, at the rear of the switchboard. These auxiliary contacts shall be potential free contacts and shall switch a voltage supply obtained from the PLC panel, as dictated by the automation design.

7.4.14.5.6 MCCBs are only to be mounted on chassis plates, arranged in a vertical orientation; no horizontal or upside-down mounting configurations shall be accepted.

7.4.14.5.7 All MCCBs shall be wired with the power source connected to the top connections of the MCCB ie. Power in at the top and power out at the bottom.

7.4.14.6 Miniature Circuit Breakers (MCBs)

7.4.14.6.1 The use of MCBs shall be limited to control circuits and feeder circuits fed from a subcircuit. A subcircuit is defined as a circuit that is fed from a fault limiting device such as an HRC fuse or a suitable fault limiting circuit breaker.

7.4.14.7 Combined Fuse Switches (CFS)

7.4.14.7.1 CFS units will not be used.

7.4.14.8 Contactors

7.4.14.8.1 Contactors shall be rated for AC-3 duty. AC-4 rated contactors shall be used in crane applications. Contactors shall have inherent no voltage release characteristics and motor starting contactors shall be non-latching.

7.4.14.8.2 Contactors shall have auxiliary contacts as indicated on the relevant schematic diagrams.

7.4.14.8.3 Mechanically interlocked, dual, four pole contactors shall be utilized instead of the integral changeover unit, in generator changeover circuits.

7.4.14.9 Disconnectors/Isolators

7.4.14.9.1 All isolators shall be utilized as shown on the relevant schematic diagrams, shall comply with the requirements of SANS 60947-3 and shall have an additional normally open auxiliary contact wired to terminals.

7.4.14.9.2 Isolators must be utilized in circuits associated with sump pumps, cranes, dosing pumps, valve actuators, cooling water pumps, flood alarms, etc.

7.4.14.9.3 The isolator shall be located in the local control panel and shall isolate the three phase power supply to the relevant motor/load.

7.4.14.10 Motor Starter Circuits

7.4.14.10.1 All motors shall be fed from a MCCB rated for motor starting duty.

7.4.14.10.2 MCCBs used in motor protection circuits shall be provided with an auxiliary trip contact that shall be operated by the tripping bar and shall not change state if the circuit breaker is switched off.

7.4.14.10.3 All motors with a nominal rating of 44kW and below:

7.4.14.10.3.1 Where MCCBs are selected to provide motor overload protection, the thermal tripping characteristic shall match the thermal characteristic of the motor. The MCCB shall provide Type 2 co-ordination to SANS/IEC 60947 with the contactor and thermal overload relay. Certification of Type 2 co-ordination by an independent third party test authority shall be submitted for approval before proceeding with the procurement of any equipment.

7.4.14.10.3.2 Shall be provided with a thermal overload relay that shall have a manual reset facility, the auto reset facility shall be inhibited.

7.4.14.10.3.3 Shall have a single ammeter on the white (yellow) phase driven by a suitable Class 1 current transformer.

7.4.14.10.4 All motor circuits with a nominal rating of 45 kW and above shall be provided with:

7.4.14.10.4.1 Main MCCB fitted with a shunt trip coil device to enable tripping from the protection relay. This is as an additional protection function to provide for a welded contactor condition.

7.4.14.10.4.2 Digital Motor Protection Relays

7.4.14.10.4.2.1 An approved digital motor protection relay, as per the motor protection relay specification incorporated in this document, shall be installed and connected to three current transformers.

7.4.14.10.4.3 Protection Current Transformers

7.4.14.10.4.3.1 Three current transformers shall be utilized for protection, as well as metering functions, connected to the motor protection relay. The current transformers shall therefore be selected for protection, but shall also have a metering accuracy of not less than Class 0,5.

7.4.14.10.4.4 Metering Current Transformers

7.4.14.10.4.4.1 In addition to the three protection current transformers connected to the protection relay, all pump drive circuits, nominally rated at 70kW and above shall be equipped with an additional three (3) Class 0,5 metering current transformers (red, white and blue phases) for measuring the pump power drawn for pump efficiency calculations.

7.4.14.10.4.5 Metering Test Socket

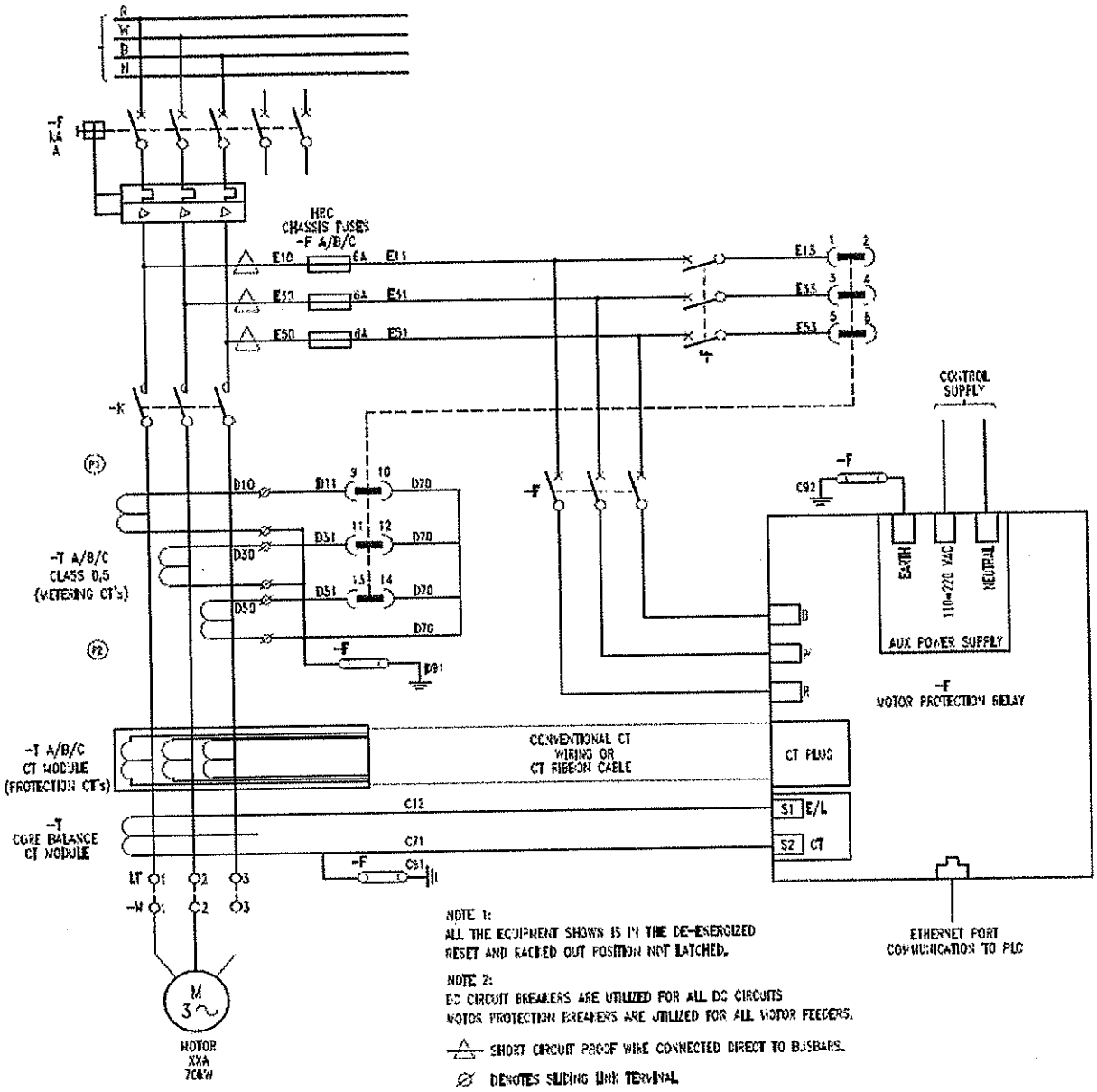
7.4.14.10.4.5.1 To conduct pump efficiency calculations, a separate dedicated 12-way metering test socket and matching male plug shall be provided. The three metering current transformers and all three phase voltages shall be wired to one metering test socket.

7.4.14.10.4.5.2 The three voltage phases shall each be protected by a 6A HRC fuse.

7.4.14.10.4.5.3 The 12 way metering test socket shall be able to accommodate a plug-in male plug for connection to external current and voltage test instruments. The requirement for wiring changes, or changing of link positions on the test socket, to connect external instruments is not acceptable. The wiring of current signals shall be such that outgoing and return connections, which are short circuited in the socket, are diverted to the test instrument when inserting the matching male plug into the socket.

7.4.14.10.4.5.3.1 The metering test socket must be wired as per the figure below:

Figure 1: Metering Test Socket Wiring Configuration



7.4.14.11 Soft starter and variable speed drive circuits

7.4.14.11.1 All soft starter and variable speed drive circuits, nominally rated at 70kW and above shall be equipped with:

7.4.14.11.2 An additional three (3) Class 0,5 metering current transformers (red, white and blue phases) for measuring the pump power drawn for pump efficiency calculations.

7.4.14.11.3 Metering Test Socket

7.4.14.11.3.1 To conduct pump efficiency calculations, a separate dedicated 12-way metering test socket and matching male plug shall be provided. The three metering current transformers and all three phase voltages shall be wired to one metering test socket.

7.4.14.11.3.2 The three voltage phases shall each be protected by a 6A HRC fuse.

7.4.14.11.3.3 The 12-way metering test socket shall be able to accommodate a plug-in male plug for connection to external current and voltage test instruments. The requirement for wiring changes, or changing of link positions on the test socket, to connect external instruments is not acceptable. The wiring of current signals shall be such that outgoing and return connections, which are short circuited in the socket, are diverted to the test instrument when inserting the matching male plug into the socket.

7.4.14.11.4 Adequate ventilation, in the form of louvers and fans, shall be installed to prevent excessive heat retention.

7.4.14.12 Motor Protection Relay Specification

7.4.14.12.1 Motor protection relays shall have the following functionality, as a minimum:

MOTOR PROTECTION RELAY SPECIFICATION
Current and Voltage Inputs:
Three phase current inputs (1A inputs)
Three phase voltage inputs
Inputs and Outputs:
Dedicated start and stop inputs
7 programmable inputs
4 programmable outputs
3 winding temperature RTD inputs
Protection Functions:
Thermal Overload (51)
Thermal Memory (51)
Locked Rotor on Start (51)
Locked Rotor When Running (51)
Phase Loss (46)
Earth Fault Core Balance (50G)
Short Circuit (50)
Phase Rotation (47)
Overvoltage (59)
Undervoltage (27)
Negative Sequence- Unbalance (46)
Successive Starts (66)

Undercurrent (37)
Phase Current Unbalance (60P)
Measurement Functions:
All three phase currents and neutral current
All three phase voltages and phase to neutral voltages
Apparent power (kVA)
Reactive power (kVAr)
Active power (kW)
Power factor
Frequency
Reactive energy (kVArh)
Active energy (kWh)
User Interface and display:
Modbus TCP/IP rear port
USB Interface or RS 232 front port
LED Alphanumeric display for instantaneous measurements, alarms and settings. Minimum 40 characters. (Protection relay display to be mounted in panel door)
Front navigation buttons to view measurements and settings and firmware information.
Stop/start facility to operate control circuit in maintenance mode
Relay shall also be programmable from the front keys. Password protection for this feature to be available.
LED Indication:
Dedicated Trip Indication.
Relay healthy Indication.
4 programmable LED indicators.
Fault Event Recording:
Display events and trips, which are non-resettable. Events to be date and time stamped. At least 100 events and trips, which are recorded in a FIFO format.
Ability to trend up to nine parameters simultaneously at a sampling rate of not less than 10 Hz.
Oscillography:
The traces of all three phase voltages and currents to be available for each event. 10 pre-event and 5 post event cycles to be available at a sampling rate of at least 500Hz. Trigger threshold for each event to be configurable. Minimum of 20 events to be stored based on the highest trigger threshold based on FIFO basis.
The software shall incorporate a "learn" feature to be able to adapt initial protection settings with actual running performance of the circuit.

Maintenance and Operations Parameters:
Running hours
Highest current interrupted by contactor
Cumulative I^2t let through in power circuit
Longest motor standing time
Longest motor starting time
Cumulative number of starts

7.4.14.13 High Inertia Loads

7.4.14.13.1 Unless otherwise stated motor starter circuits shall be rated for a class 10 start duration. The starting of high inertia loads eg. Crushers and fans will require a class 20 or 30 rated starter.

7.4.14.14 Incomer and Feeder Circuits

7.4.14.14.1 An integrated digital Power Meter (PM), with back-lit LCD, must be utilized for all incomer and feeder circuits and must be mounted in the incomer/feeder door.

7.4.14.14.2 The PM shall be driven by three Class 0.5 metering current transformers, with 1 amp secondaries and shall have all three phase voltages connected.

7.4.14.14.3 The three voltage phases shall each be protected by a 6A HRC fuse connected to the supply side of the incomer circuit breaker, or the load side of the feeder circuit breaker, as the case may be.

7.4.14.14.4 The power meter (PM) must be capable of measuring and displaying the following parameters, as a minimum:

POWER METER SPECIFICATION
Current and Voltage Inputs:
Three phase current inputs (1A inputs)
Three phase voltage star connection (400VAC)
Control power: 110 V DC or 231VAC (as shown on schematics)
Instantaneous RMS Values:
Current per phase, neutral and ground
Voltage Total, per phase , phase to phase and phase to neutral
Frequency
Real, reactive, and apparent power total and per phase Signed, Four Quadrant
True Power Factor Total and per phase Signed, Four Quadrant
Displacement PF Total and per phase Signed, Four Quadrant
% Unbalanced I per phase and total,
% Unbalanced Voltage phase to neutral, phase to phase
Energy Values:
Accumulated Active, Reactive and Apparent Energy Received/Delivered; Nett and absolute

POWER METER SPECIFICATION **Demand Values:**
Current average Present, Last, Peak and Peak Date and Time
Active power Present, Last, Peak and Peak Date and Time
Reactive power Present, Last, Peak and Peak Date and Time
Apparent power Present, Last, Peak and Peak Date and Time
Peak demand with date and time stamping for current and powers
Power Quality Measurements:
Total Harmonic Distortion, Current per phase and Total, Voltage Total, phase to phase and phase to neutral
Individual harmonics (odds) up to the 15th Current per phase and Total, Voltage Total, phase to phase and phase to neutral
True RMS sampling rate: 64 samples per cycle
Phase rotation
User Interface and Display:
Modbus TCP/IP rear port (Each PM must be cabled, via a Cat 6 Ethernet cable and RJ45 connectors, to the bus section cubicle)
LCD Alphanumeric display for instantaneous measurements, alarms and settings. Minimum of four parameters displayed at a time. (Power Meter to be mounted in panel door)
Front navigation buttons to view measurements and settings and firmware information.
Navigate instantaneous and cumulative/minimum/maximum values
Alarm log with date and time stamping
EMC Compatibility:
IEC 61000
Compliance:
IEC 61557-12 Class 0,5

7.4.14.15 Indication lamps, Push Buttons and Selector Switches

7.4.14.15.1 Indication lamps shall be of the LED type, with voltage ratings as indicated on the schematic diagrams and must be rated for continuous operation.

7.4.14.15.2 The colour of the equipment shall be as listed below:

Equipment	Colour
Push buttons	
Emergency stop push buttons shall be of the latching, twist to release type	Red
Stop push buttons	Red
Start push buttons	Green
Reset push buttons	Black

Lamp test push buttons	Black
Control circuit test push buttons shall be of the latching, twist to release type interlocked with the cubicle door position.	Red
Indication LEDs	
Running indication LEDs	Red
Stopped indication LEDs	Green
Tripped indication LEDs	Orange
On indication LEDs	Red
Off indication LEDs	Green
Ready indication LEDs	White
Test position indication LEDs	Blue
Healthy indication LEDs	White
Interlocks correct indication LEDs	Yellow
Anti-parallel trip indication LEDs	Orange
Selector switches	
Auto/manual selector switches	Black
Remote//local selector switches	Black
Auto/off/manual selector switches	Black
Remote/off/local selector switches	Black
Service/Maintenance selector switches	Black
Service/Off/Maintenance selector switches	Black

7.4.14.16 Surge Arresters

7.4.14.16.1 Class 2 surge arresters (SPDs) shall be fitted on each phase and neutral of the incoming supply, **after** the incomer circuit breaker.

7.4.14.16.2 The SPDs shall be fail-safe, plug-in, modular types with individual end-of-life indicators, and preferably thermal disconnecting mechanisms.

7.4.14.16.3 The SPDs shall be rated for a minimum nominal discharge current of 10kA and peak discharge current of at least 20kA, for an 8/20 microsecond waveform, in a Type 1 connection (three phase SPDs and one neutral SPD all connected to earth).

7.4.14.16.4 The neutral SPD in a Type 2 connection (three phase SPDs all feeding into a neutral SPD then to earth) shall be rated for a minimum nominal discharge current of 20kA for an 8/20 microsecond waveform. Type 2 connection is preferred.

7.4.14.16.5 An overcurrent protection device (OPD) shall be installed in series with each phase SPD to protect against a fault to earth; this OPD may be in the form of HRC fuses (minimum rating 125A) or an SPD-supplier-approved circuit breaker that will pass the surge current without tripping.

7.4.14.16.6 The total wiring length from the phase or neutral to the OPD, SPD and then to earth shall not exceed 0.5m in length, to minimize additive volt drops. This wiring shall be the maximum cross-sectional area that the OPD/SPD can accommodate, with a minimum allowed cross-sectional area of six square millimeters.

7.5 LABELING

7.5.1 All labeling must comply with the Rand Water WKS identification system requirements and specifications.

7.5.2 Every door and/or removable cover giving access to a compartment shall be fitted with a suitable designation label, including all rear switchboard doors. These labels shall be engraved on white/black/white sandwiched traffolyte.

7.5.3 Equipment and component labels shall be engraved on white/black/white sandwiched traffolyte or utilizing the M-Print marking system.

7.5.4 All equipment and component labeling must be fixed to the chassis plate, or the switchboard, where it is legible after all wires are connected, and not to the actual piece of equipment or component.

7.5.5 All equipment and component labeling shall be secured with "3M", or equivalent, adhesive tape.

7.5.6 Every motor starter circuit installed complying to Type 2 co-ordination, to SANS IEC 60947, shall be given a label fixed to the front of the panel door to the effect that the circuit is of Type 2 co-ordination and that components in the main circuit are to be replaced by identical components, to retain the Type 2 co-ordination certification of the starter. The label shall be engraved with white lettering on a red background on sandwiched traffolyte.

7.5.7 Every circuit installed complying with a cascaded system, to SANS 1973, shall be given a label fixed to the front of the panel door and shall have the following wording:

WARNING

This is a series-connected (cascaded) system. Except when recommended by the circuit breaker or SCPD manufacturer, do not replace any circuit breaker (fuse link) in the system with a circuit breaker (fuse link) that is not of identical type and rating.

7.5.7.1 The label shall be engraved with white lettering on a red background on sandwiched traffolyte.

7.5.8 Labelling of pushbuttons and selector switches shall be via separate white/black/white traffolyte labels and shall not be integral to the device itself. The description of the device shall be as per the schematic diagrams.

7.5.9 An engraved aluminium manufacturer's label shall be installed and fixed to the outside of the incomer door and shall contain the following information, as a minimum:

- Manufacturer's details including name, contact number and manufacturer's order number
- Date of manufacture
- Switchboard kA rating
- Switchboard IP rating
- Voltage rating
- Main busbar current rating
- Incomer control circuit voltage
- Incomer cable sizes and quantities
- Type tested standard
- Rand Water contract number and order number

7.5.10 Safety Labels

7.5.10.1 Safety and warning triangle labels shall be fitted to all removable covers that will expose/give access to live busbars/equipment once removed.

7.6 DRAWINGS AND DOCUMENTATION

7.6.1 All drawings shall be completed according to Rand Water's drawing standard.

7.6.2 Prior to the commencement of manufacture of the FBA, all drawings for construction shall be of Rev.0 and shall have been accepted by Rand Water and approved by the contractor.

7.6.3 The following drawings shall be submitted to Rand Water for acceptance:

7.6.4 Single line diagrams and schematic drawings.

7.6.5 Panel general arrangement drawing(s) showing overall dimensions and positions and dimensions of busbars.

7.6.6 Front and rear panel layout drawings showing mounting positions of all equipment, chassis layouts, terminals, trunking, busbar droppers etc and free space between equipment, with the switchboard doors in the open position.

7.6.7 Panel door layouts showing relative positions and dimensions of equipment mounted on the panel doors.

7.6.8 Schedule of all labels showing size of label and letters and the wording of the label.

7.6.9 Material list containing make and model number of all equipment, ratings and manufacturer/supplier contact details to enable re-ordering of equipment as required.

7.6.10 Failure to comply with this requirement timeously may result in rejection of the FBA.

7.6.11 Prior to the delivery of the FBA, the following drawings and documentation shall be submitted to Rand Water for acceptance:

- Data sheets
- "As Built" drawings to Rev.1
- Test certificates

7.6.12 The following post commissioning drawings and documentation shall be submitted to Rand Water for acceptance:

- "As Commissioned" drawings to Rev.2
- Operations and Maintenance manuals as per Rand Water's guideline
- All programming and configuration software requirements
- Any additional documentation as required

7.7 QUALITY ASSURANCE REQUIREMENTS

7.7.1 Quality Assurance Plan and Procedures (QAP)

7.7.1.1 All inspection and testing procedures shall be developed and controlled under the guidelines of the Supplier's quality system. This system must be registered to ISO 9002 and regularly reviewed and audited by a third party registrar.

7.7.1.2 All incoming material shall be inspected and/or tested for conformance to quality assurance specifications.

7.7.1.3 All sub-assemblies shall be inspected and/or tested for conformance to Supplier's engineering and quality assurance specifications.

7.7.1.4 The manufacturer shall submit to Rand Water a short form copy of its Quality Assurance Procedures manual for appraisal by the Engineer at time of tendering.

7.7.1.5 After award of the tender, the manufacturer shall submit a full Quality Assurance Plan for approval by the Engineer. Rand Water shall be given the opportunity to indicate hold and witness points on the plan.

7.7.1.6 Such QAP in association with a manufacturing programme shall be submitted to Rand Water within the time periods specified in tender documents after award of the contract, at which time the Engineer shall indicate witness and inspection points required.

7.7.2 Inspection During Manufacture

7.7.2.1 The Engineer or his appointed representative shall be permitted to carry out, during normal working hours, periodic inspections of the FBA and equipment covered by this specification over and above the witness and hold points indicated on the QAP. Inspections shall include but shall not be limited to:

7.7.2.2 Checks to determine that the FBA steelwork and painting fully and strictly comply with this specification.

7.7.2.3 Checks to determine that the FBA and components fully and strictly comply with this specification.

7.7.3 Factory Acceptance Testing

7.7.3.1 The Engineer or his appointed representative shall be invited to witness final Factory Tests of the FBA and equipment before delivery will be permitted. Tests shall include but shall not be limited to:

7.7.3.2 Checks to determine that the FBA and components fully and strictly comply with this specification, and all relevant design drawings.

7.7.3.3 Comprehensive primary injection tests of all current transformers and associated circuitry.

7.7.3.4 Comprehensive dielectric strength tests, to prove the integrity of the insulation.

7.7.3.5 Full functional tests of all mechanical and electrical components and electrical circuits.

7.7.3.6 The manufacturer shall provide all power supplies, testing equipment, means of simulating related remote devices and competent personnel to conduct the tests.

7.7.3.7 The manufacturer shall give at least ten (10) working days' notice of readiness for final inspection and factory tests.

7.7.3.8 A list of defects and deviations will be provided by the Engineer, or his appointed representative, during the inspections. The issue of such list does not relieve the manufacturer of his responsibility to ensure full compliance with this specification.

7.7.3.9 Items considered as deviations, by the contractor, from this specification shall be dealt with as per the contractual requirements.

7.7.3.10 All test results shall be recorded on the manufacturer's standard test certificates, three copies of which, duly approved, shall be supplied to Rand Water as per the contractual requirements.

7.7.3.11 Equipment may not be delivered to site until the manufacturer has cleared all defects listed by the Engineer and the Engineer has re-inspected the FBA to confirm rectification of work on the defect list.

7.7.4 Preparation for Delivery

7.7.4.1 FBAs to be transported to site shall be wrapped in suitable materials to prevent damage during shipment, both from mechanical and environmental damage.

7.7.4.2 The contractor shall ensure that the site is ready for offloading and installation prior to delivery.

7.7.5 Offloading

7.7.5.1 Only suitably qualified personnel and certified equipment shall be utilized for lifting the FBA onto and off the transport vehicle and positioning it in the final installation location. The Contractor shall ascertain the exact position of the FBA before delivery.

7.7.6 Installation on Site

7.7.6.1 Site installation shall include for all suitable skilled labour, lifting apparatus and materials necessary for the complete installation and readying for service of the FBA. It shall include all shims, hold down bolts and nuts and connection of busbars and reconnection of any wiring disturbed for shipment. It shall also include the checking and re-torquing, where applicable, of all connections.

7.7.6.2 The re-torquing of all busbars shall be witnessed by a RW representative.

7.7.7 Site Acceptance Testing

7.7.7.1 Tests shall include as a minimum:

7.7.7.2 Comprehensive primary injection tests of all current transformers and associated circuitry.

7.7.7.3 Full checks on the functioning of mechanical and electrical components and electrical circuitry. Circuits that have been disconnected for transportation shall, however, be subjected to full functional tests.

7.7.7.4 Comprehensive insulation resistance tests to prove that the quality of the insulation has not deteriorated.

7.7.7.5 Particulars of these tests and checks and the results shall be recorded and incorporated in the Operations and Maintenance (O&M) manuals.

7.8 SERVICE TOOLS

7.8.1 Two sets (per FBA) of any special tools or devices required for the operation and maintenance of the FBA, shall be provided.

7.9 SPARES

7.9.1 The following spares, as a minimum, shall be supplied with each completed FBA:

Equipment	Quantity
ACB Undervoltage (NVR) coil	1
ACB Shunt trip coil	1
ACB Closing coil	1
LED of each colour	3
Pushbutton of each colour	1
Fuses	2 of each rating and type
Surge arrestors	4 of each rating
Motor protection relay	1 of each model
Motor contactor for motors rated at 90kW and above	1 of each rating

8 REFERENCES

Record Document	Form/Doc Number	Location
SANS standards	As per Item 4: References	Rand Water Library

9 DOCUMENT CHANGE HISTORY

The following table contains the history of this document with a description of each revision.

Date	Previous Revision Number	New Revision Number	Description of Each Revision
September 2019	None	01	Converted RC 01441: STANDARD SPECIFICATION FOR CONTROL PANELS AND FACTORY BUILT ASSEMBLIES OF LOW VOLTAGE SWITCHGEAR AND CONTROL GEAR, to new standard ISO template.