

RAND WATER

GENERAL ELECTRICAL SPECIFICATION

FOR THE DESIGN AND SELECTION OF

ELECTRICAL PLANT AND EQUIPMENT

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Record of Revisions

Rev	Date	Details of revision	Approval Team Leader	GMO	GME
A.0	22 August 1994	1st draft	CEE-p		
B.0	12 December 1994	2nd draft	CEE-p		
C.0	25 May 1995	3rd draft	CEE-p		
D.0	22 December 1995	Add to Para 15	CEEe		

Committee responsible for compilation of this document

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1. SCOPE

1.1 This standard covers the general electrical engineering requirements for low voltage electrical systems for Rand Water installations. The scope of the specification is:

1.1.1 Low voltage switchgear including motor starter equipment and panels

1.1.2 Low voltage cable

1.1.3 Lighting and small power installations

1.1.4 Field control devices

1.1.5 The installation of low voltage electrical equipment including, process instrumentation, cable support systems

1.1.6 Testing of low voltage installations and equipment.

1.1.7 Electrical earthing does not form part of this specification, but is covered in RW/00320/S004.

1.2 The specification includes a section on medium voltage cable as a temporary section. This section will be removed once a specification for medium voltage installations is generated.

2. STANDARDS AND REGULATIONS

(a) Mandatory Legislation, Acts and Regulations.

(b) Applicable national and international standards, procedures and codes of practice, for example BS, SABS, ISO, SABS-ISO, DIN etc.

(c) Applicable Rand Water procedures and standards.

This procedure/standard is compiled to meet the requirements of the Occupational Safety and Health Act 85 of 1993 and is not intended to supersede any of the provisions of the afore-mentioned Act and Regulations.

3. DEVIATIONS

3.1 Deviations from this engineering standard will not be permitted without the prior approval of the Chief Electrical Engineer or Chief Electronics Engineer as applicable.

4. LOW VOLTAGE SWITCHGEAR (RAND WATER STANDARD SPECIFICATION RW/00320/S/033)

4.1 Fault level rating

4.1.1 The Engineer assigned to the specific project shall ensure the manufacturer of low voltage switchgear has a test certificate from an approved test authority verifying the panel design is suitable for the fault level specified. Under no circumstances are designs, for which test certificates are not available, acceptable. The test certificate shall also be for the specific design offered and extrapolation of test results to a design are not acceptable.

Approved test authorities are: KEMA
SABS Apollo Test Station
ASTA

4.2 No exception to this requirement will be permitted.

4.3 General constructional features

4.4 Enclosure materials

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- 4.4.1 Enclosure material selection should take the environment into account. Enclosures located outdoors and exposed to rain etc shall be polycarbonate enclosures. Similarly enclosures located in wet plants or chemically corrosive environments (for example chlorine and ammonia plants) shall be polycarbonate enclosures.
- 4.4.2 Metal enclosures shall only be used in dry, covered or controlled environments.
- 4.5 Enclosure classifications
- 4.5.1 Enclosures located outdoors or in corrosive environments shall be at least IP 65 enclosures. Care shall be taken in the installation to ensure that the classification of the enclosure is not compromised through the drilling of holes for mounting the enclosure or for cable terminations.
- 4.5.2 Generally polycarbonate enclosures shall be at least IP 65 with all covers in place and IP2x with enclosure doors or covers removed.
- 4.5.3 Generally metal enclosures shall be IP4x with the doors closed and IP2x with the doors open. Classification lower than this is not acceptable and enclosures not complying shall be upgraded or rejected.
- 4.6 Low voltage power distribution enclosures shall be Form 3 to SABS-IEC 439 and low voltage motor starter enclosures shall be Form 3 or 4. Form 4 is preferred except where starters are less than 22 kW in which case Form 2 enclosures are permitted provided they meet the requirements of Section 4.6.
- 4.7 Enclosure configurations
- 4.7.1 Generally front access, rear termination or front termination enclosures are preferred for floor standing assemblies. However, if space is a limitation, back to back assemblies will be permitted provided the following criteria are met:
- 4.7.2 The access to busbar droppers shall be possible without having to remove starter chassis plates or if this is not possible the starter chassis plates may be of the plug in type but limited to 200 amps unless the Tabula type construction is used in which case ratings up to 600 amps may be used.
- 4.7.3 Busbar compartments
- 4.7.3.1 Busbars shall be generally located at the top of the switchgear in a separate compartment. The busbar covers shall be held in place using square key catches and shall have the facility to lock at least one cover catch. Preferably busbar covers shall be secured using bolts and captive nuts.
- 4.8 Cable compartments and gland plates
- 4.8.1 Cable compartments shall be adequately sized for the cables to be terminated in the compartment. Suitable trunking shall be provided to enclose wiring to keep the compartment neat. The sizing of the trunking shall be of sufficient size such that the trunking in the final installation with all cables installed is not more than 75% full.
- 4.8.2 Covers for cable compartments shall be held in place using square key type catches. The use of domed nuts is not permitted.
- 4.9 Gland plates shall be hot dipped galvanised and sectionalised to facilitate handling. Cadmium plated or painted gland plates are not permitted.
- 4.10 Gland plates shall not be less than 2 mm thick and if cables of cross sectional area greater than 150 mm are to be terminated the thickness shall be increased to at least 4 mm, preferably 5mm. Nonferrous or nonmagnetic material shall be used for gland plates on installations where single core cables are employed.
- 4.11 Gland plates shall be mounted at least 300 mm above floor level to facilitate bending and handling of cables. The distance to the first terminal shall be at least 150 mm above the gland plate for control cables and suitably increased for the larger power cables.

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- 4.12 Multiple starter panels (single cubicle starter panels)
- 4.13 The application of this configuration will be only after approval of the Chief Electrical Engineer and shall conform to SABS-IEC 439 Form 2 enclosure specification.
- 4.14 The use of the multiple starter configuration in a single large cubicle is to be generally discouraged except in installations where the largest drives do not exceed 22 kW. The configuration may be used as part of a multi-cubicle MCC where all drives up to 22 kW are grouped together in a single large compartment.
- 4.15 This configuration is only permitted if Telemechanique Integral combination contactors and circuit breakers are used. Other devices are not permitted. No exceptions in terms of the equipment used will be permitted as this component configuration has been selected to permit the safe locking off of individual circuits.
- 4.16 Generally this form of enclosure will not be permitted where system fault levels are in excess of 20 kA except with the approval of the Chief Electrical Engineer. Full design details shall be submitted if the approval of this configuration is sought.
- 4.17 The use of a single compartment is also permitted on feeder circuits where the equipment of each circuit is limited to a circuit breaker, earth leakage current transformer, relay and ammeter.
- 4.18 Multiple compartment switchgear
- 4.18.1 Switchgear housing motor starters shall be constructed so that each starter is in its own cubicle that meets Form 3 or Form 4 requirements (as specified in SABS-IEC439). Care shall be taken to ensure that the cubicle meets the following requirements:
- (a) Each compartment/cubicle has its own door that has a suitable circuit breaker operator that can be locked in the off position.
- The compartment is designed so that the gases and heat from an internal fault will be contained within that compartment or cubicle and that the damage to adjacent compartments will be minimised.
- 4.19 Programmable logic controller compartments or cubicles
- 4.19.1 PLCs shall be housed in separate cubicles to switchgear. The PLC cubicle may form an extension to the switchgear panel but shall be a discrete compartment isolated from any motor starter or distribution equipment.
- 4.19.2 The front door of the PLC cubicle shall be provided with a shatterproof glass viewing window sized so that it is possible to observe the status lights of all I/O devices.
- 4.20 Instrumentation compartments
- 4.20.1 Instrumentation that is required to be housed in a switchgear panel shall also be physically separated from equipment rated at 231 V and above by barriers and access shall be via a separate door. The proviso also applies for computer equipment and uninterruptible power supplies.
- 4.20.2 Adequate ventilation shall be provided to ensure overheating of components does not occur.
- 4.20.3 Hinges and catches on switchgear doors
- 4.20.4 Hinges and door catches shall be manufactured from brass, mild steel or other materials subject to the approval of the Chief Electrical Engineer. Aluminium cast hinges or catches are not to be used as they are prone to fail if there is an internal electrical fault, in which case the door can become a dangerous projectile.
- 4.21 Switchgear connected to systems of fault level greater than 20 kA shall have adequate provision for the release of explosion generated gases in a controlled manner either via suitable ducting or through the use of door catches that permit escape of gases without the door actually opening.

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- 4.22 Switchgear base
- 4.22.1 Floor standing panels shall have a substantial channel iron base painted black and running the full length of the panel. Typical height shall not be less than 75 mm.
- 4.23 Panel dimensions and access
- 4.23.1 Panels should not be higher than 2 400 mm for reasons of access to the top compartments.
- 4.23.2 Rear access (free working space) to panels for cable termination purposes shall be not less than 1 000 mm, preferably 1 200 mm. Front access shall be at least 2 000 mm. Back to back panels shall have at least 2 000 mm clear on all sides.
- 4.24 Surface finishes
- 4.24.1 External paint colours shall be Electric Orange, colour B26 of SABS 1091. The final finish for metal enclosures shall preferably be by epoxy coating. Alternatively baked enamel finish will be accepted. Full details of the preparation and paint application procedures shall be obtained from the switchgear manufacturer prior to the award of contract.
- 4.24.2 Final paint thickness shall be not less than 70 micron for epoxy powder and 90 micron for baked enamel finishes.
- 4.24.3 Where hot dipped galvanising is specified it shall be to SABS 763.
- 4.24.4 Interiors of panels may be either painted gloss white or hot dipped galvanised.
- 4.24.5 Equipment mounting and gland plates shall be hot dipped galvanised. The use of cadmium plated components is not acceptable because of the poisonous fumes that are emitted in the event of a fire.
- 4.25 Busbars
- 4.25.1 General
- 4.25.1.1 All switchgear shall have formal busbar systems. The use of jumper conductors from circuit breaker to circuit breaker is not acceptable. Busbars shall be manufactured from hard drawn, high conductivity copper and shall be of constant cross sectional area along their full length.
- 4.25.2 Busbar insulation
- 4.25.2.1 Busbars shall not be covered with insulating materials but shall be fully air insulated. The busbar compartments shall be fully enclosed with either insulating materials or earthed metal shrouds.
- 4.25.2.2 Careful attention shall be applied to the use of busbar supports. Switchgear connected to systems where the fault level is likely to exceed 15 kA shall not use pin type insulators for busbar supports.
- 4.26 Busbar ratings and selection
- 4.26.1 The rating of switchgear busbars shall be not less than the rating of the incomer circuit breaker. This includes the connection from the circuit breaker to the busbars.
- 4.26.2 The minimum rating for busbars shall be 630 amps unless the switchgear is of a minor distribution nature or contains a few small starter panels in which case ratings of less will be considered provided the busbar rigidity under fault conditions is maintained.
- 4.26.3 Busbar droppers onto outgoing circuits shall be solid copper of minimum rating 400 amps except for systems as the above paragraph. The use of flexible, multiple stranded droppers or jumpers is not permitted except where the droppers are very short and may be considered "fault free zones" as defined in SABS-IEC 439.

- 4.27 Busbar jointing and tee off systems
- 4.27.1 Busbar joints shall be designed to maintain constant cross sectional area of the busbars. Systems requiring the drilling of holes shall be treated as suspect and shall be subjected to a design audit to ensure the cross sectional area is adequate for the current of the busbar.
- 4.27.2 The approved method of busbar jointing is to use pressure clamping systems that do not require drilling of holes in the main busbars. The surface preparation for a busbar joint shall be limited to the sanding of the contact surfaces to a bright finish, cleaning and the application of a silicone, non-hardening paste before the clamping of the busbars. The use of silvering compounds is not to be used as generally the quality is not constant and the chemicals are hazardous to the environment.
- 4.27.3 Bolts used for busbar systems shall be high tensile steel and shall be either sheradized or galvanised. Busbar bolts shall be torqued to the manufacturer's recommendations.
- 4.28 Switchgear wiring
- 4.28.1 General
- 4.28.1.1 The use of untreated conventional PVC wire is to be avoided due to the emission of corrosive HCl gas if the insulation burns. Low halogen or reduced halogen PVC insulated wiring is preferred.
- 4.29 Conductor sizing and stranding
- 4.29.1 The use of single stranded conductors is not permitted. Wiring shall be multi-stranded with at least 19 stranded wire being used on control wiring.
- 4.29.1.1 The use of laminated conductor for power circuits is acceptable.
- 4.29.1.2 The minimum size of conductor to be used on the supply side of a circuit breaker shall be 25 mm². On the down stream side of a protective device the sizing shall be according to SABS 0142 selections.
- 4.29.1.3 For control and protection circuits the following sizing shall apply:
- | | |
|--|---------------------|
| CT circuits (5 amps secondary) | 4 mm ² |
| CT circuits (1 amps secondary) | 2,4 mm ² |
| General 220 V AC and 110 V DC circuits | 1,5 mm ² |
| General 24 V DC circuits | 1 mm ² |
| Earthing of equipment and gland plates | 16 mm ² |
- 4.29.2 The following colours shall apply for wiring insulation:
- | | |
|-------------------------------|----------------------------------|
| Power circuits | Red, white and blue |
| Neutral | Black |
| AC control circuits - live | Brown |
| AC control circuits - neutral | Blue |
| Earth | Green or green with yellow trace |
| 110 V DC | Grey |
| 24 V DC + ve | Pink |
| 24 V DC -ve | Orange |
| 4-20 mA | Purple (or black and white) |
| Other | Yellow |
- 4.30 Terminals
- 4.30.1 Power circuits shall use terminals for conductors up to 6 mm², for larger conductors bolted terminals shall be used. All power terminals shall be shrouded with suitable insulating covers.
- 4.30.1.1 Terminals for control circuits shall be polyamide terminals suitable for conductors up to 4mm². Wiring shall be arranged and suitable jumpers provided such that there is never more than one wire on each side of a terminal.

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- 4.31 Terminal strips in Programmable Logic Control panels.
- 4.31.1 Wiring directly to the PLC I/O cards is not permitted. All wiring shall be by way of two sets of terminals are grouped on a cable by cable basis and the second set of terminals reflect the PLC I/O card. Patch wiring shall be provided between each of the terminal strips as required.
- 4.31.2 Terminals used in PLC cubicles shall be of the knife type, for example Phoenix UK5-MTK-P/P or an approved equivalent.
- 4.32 Electrical equipment
- 4.32.1 Switchgear panel incomer circuit breakers
- 4.32.1.1 For incomers of rating up to and including 630 amps moulded case circuit breakers shall be used. Over 630 amps an air or vacuum circuit breaker shall be used.
- 4.32.1.2 The air or vacuum circuit breakers shall be of the withdrawable pattern. They shall be fitted with electrical tripping and closing coils for operation by external circuits and shall also have electronic programmable over current, short circuit and earth fault protection. Manual closing of the circuit breaker shall not be possible, however, manual tripping facility shall be provided. Power source for the electrical closing shall be derived from the incomer terminals (live side of the circuit breaker by way of a suitably fused circuit).
- 4.32.1.3 Air or vacuum circuit breakers shall have a suitable panel door with appropriate cut-outs and seals around the operating mechanism. The ACB or VCB shall have facility for locking in the off position and for locking in the racked out position. The ACB or VCB shall be provided with interlocks to prevent the breaker being withdrawn or interested when in the closed position.
- 4.32.1.4 The compartment housing the air circuit breaker shall have suitable air clearance around and above the arc chutes to enable the safe discharge of ionised gases that are generated under short circuit conditions.
- 4.32.1.5 Circuits rated up to and including 630 amps shall use moulded case circuit breaker (CCBs) fitted with shunt tripping only. Remote electrical closing shall not be provided on MCCBs. MCCBs shall be equipped with a door mounted operator to permit operation of the breaker when the door is closed. The mechanism shall incorporate a locking facility to enable the MCCB to be locked in the off position. Should remote closing be required on ratings of less than 630 amps ACBs or VCBs shall be used to a minimum circuit rating of 400 amps.
- 4.32.1.6 Income breakers shall be equipped with at least one change over contact for open, closed indication and a tripped contact, opening in the tripped position for connection to monitoring PLCs.
- 4.32.1.7 The incomer panel shall be provided with a neutral link. The link shall be bolted for incomer ratings above 300 amps.
- 4.32.1.8 On switchgear equipped with two incomers and a busbar section switch protection shall be provided to prevent the incomers being left in the paralleled position. A control circuit shall be provided that shall permit momentary paralleling of the incomers but shall cause either an incomer to be tripped or the busbar section switch to be tripped depending upon the selection made. This control circuit shall be hard wired control. Use of PLCs for this function is not permitted.
- 4.33 Motor starter circuits
- 4.33.1 Motor starter circuits shall be equipped as follows:
- (a) MCCB rated for the fault level expected at the panel.
 - (b) Earth leakage protection relay.
 - (c) AC-3 rated contactor.
 - (d) Motor overload relay.

- (e) CT and ammeter. CT not required for circuits rated <20amps.
- (f) On/off/tripped LED indication lamps.
- (g) Control voltage circuit breaker and fuses.
- (h) If PLC controlled an automatic/off/maintenance selector switch.
- (i) Test push-button.
- (j) Under current relay if the starter is for a pump other than an intermittent duty sump pump.

4.33.2 Approved MCCB and contactor combinations are as follows and as detailed in the Appendix A1.

<u>Circuit breaker</u>	<u>Contactor</u>
CBI/Siemens	Siemens
Mitsubishi	Mitsubishi
Merlin Gerin	Telemecanique

4.33.3 Alternative combinations will not be considered. The combinations shall be adhered to as they have been selected for Group 2 coordination according to IEC 947. The minimum sized contactor to be used shall be that of a 30 kW starter, for smaller ratings the Telemecanique Integral 32 and 63 shall be used.

4.33.4 Motor overload relays shall be selected from the approved manufactures listed in Appendix A1. For drives up to and including 22 kW the overload shall be of the terminal bimetallic type and above 22 kW shall be the electronic Multilin 301, above 75 kW with suitable current transformers. Where terminal relays are used they shall be from the same manufacturer as the contactor.

4.34 Feeder circuits

4.34.1 Feeder circuits shall be equipped with the following:

- (a) MCCB rated for the fault level expected at the panel.
- (b) Earth leakage protection relay.

4.34.2 Feeder circuits supplying fixed equipment that is not connected using a plug and socket shall be equipped with a facility for locking the circuit breaker in the off position.

4.35 Earth leakage relays

4.35.1 Motor starter circuits up to and including 22 kW shall be protected with 250 mA instantaneous earth leakage relays, EPC type Elsec-X.

4.35.2 For starters rated 30 kW and above the earth leakage relay shall be 375 mA with time delay, EPC Elsec-T.

4.35.3 Feeder circuits shall have graded earth leakage protection with the downstream circuits. Therefore the protection should be either 500 mA or 375 mA Elsec-T as appropriate.

4.35.4 Earth leakage protection on small power socket outlets for "domestic" applications shall be 30 mA instantaneous.

4.36 Surge suppression

4.36.1 A surge arrester shall be fitted to the incomer terminals and shall be rated for the potential energy let through of the system being protected.

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- 4.37 Indicator and metering devices
- 4.37.1 Incomers shall be fitted with a volt meter with a seven position selector switch, kWh meter of the cyclometer type and one ammeter in each phase (with appropriate current transformers).
- 4.37.2 Meters shall be 90 degree movement (on incomer panels) and for motor circuits ammeters shall have 240 degree movements. Ammeters on incomers shall be fitted with maximum demand indicators.
- 4.37.3 If the incomer metering is to be integrated into a supervisory system then the Rand Water's H₂pOwer modules shall be installed at the incomer.
5. LOCAL CONTROL DEVICES
- 5.1 General requirements
- 5.1.1 Each electrical drive shall have a local stop/start station adjacent to the drive. The enclosure housing the stop/start station shall be a GRP or die cast aluminium enclosure IP 65 rating. The control stations shall be equipped with splash covers manufactured from 1,6 mm sheet steel and shall be either galvanised or painted in accordance with Clause 4.13.
- 5.1.2 The push-buttons shall be IP 65 devices and the following equipment is acceptable:
- Cutler hammer
Telemacanique
Siemens
- 5.1.3 Stop push-buttons shall be of the latching, twist to release type with mushroom heads of at least 40 mm diameter.
- 5.1.4 The stop/start stations shall be located within 2 metres of the device controlled by it. Where the control stations are grouped for a number of drives they shall be arranged in a logical manner so that it is obvious which control station is applicable to which motor.
- 5.1.5 Motors positioned in sumps that may flood, making access to the control station difficult may have their control stations positioned at a convenient dry position, provided that an additional stop station is located a the drive for safety reasons.
- 5.1.6 Specific requirements for medium voltage motor-driven pump sets.
- 5.1.7 Large potable water pump sets shall be controlled from a control desk located on the walkway. They shall however have two emergency stop stations located on diagonally opposite corners of the pump set and positioned immediately adjacent to the drive.
- 5.2 Specific requirements for motorised valves
- 5.2.1 Motorised valves shall have a local control facility whereby it will be possible to open and close the valve. The valve control panel shall have a local/remote selector switch as well as open and close push-buttons. These devices shall be either integral to the motor mechanism or located within two metres of the valve mechanism.
- 5.3 Control of sump pumps - level control
- 5.3.1 Sump pump level switches shall be provided where it is necessary to automatically stop and start the sump pumps.
- 5.3.2 For sumps that have relatively small level differences between stop and start conductivity type level switches using the three probe system shall be installed. Only where the differences in levels are too great for this system shall the teardrop type level switches be used. Approved types are the Flygt or Kari teardrop switches.
- 5.3.3 Sump pumps shall also have an auto/manual selector switch and stop/start station to allow the sump to be pumped dry manually.

5.3.4 Level switches of the teardrop type shall be installed in stilling wells.

6. CABLES

6.1 General

6.1.1 Cables shall comply fully with the relevant SABS specification. Cables not bearing the SABS mark are not acceptable and shall be rejected.

6.1.2 Medium voltage cables (included in this specification until such time as a specification for medium voltage equipment is developed).

6.1.3 All 6,6 and 11 kV cabling systems shall be carried out using XLPE insulated cables and shall be three core copper with individual phase screened, single steel wire armoured with low halogen, flame retardant PVC outer sheath, type A construction to SABS 1339. The cable voltages shall be 12,7/22 kV and 6,35/11 kV for 11 kV and 6,6 kV systems, respectively.

6.1.4 Alternatively 6,6 kV and 11 kV cables may be heavy duty three core copper, belted, paper insulated, lead alloy covered, single steel wire armoured, low halogen, flame retardant PVC sheathed, unearthed construction in accordance with SABS 97. The paper insulated cable voltages shall be 12/12 kV or 7,2/7,2 kV or 12/12 kV for 11 kV and 6,6 kV systems respectively, i e for unearthed systems.

6.1.5 Single core XLPE cables may be used provided they are installed in trefoil configuration, have aluminium wire armouring and have screens earthed at one end only. If there is a likelihood that the screens are earthed at both ends reference shall be made to the manufacturer for the reduced current rating under such conditions.

6.1.6 Cable ratings are specified in Appendix A2 and are for the conditions specified. If the installation location is different to the standard conditions specified then the cables shall be derated as specified in Appendix A3.

6.2 Low voltage cables

6.2.1 Low voltage cables for normal power and control applications shall be 600/1000 volts PVC, PVC, SWA, PVC construction with copper conductors and complying with SABS 1507. The cables shall have low halogen, flame retardant outer sheaths. Cable outer sheath shall carry a blue stripe in accordance with SABS 1507.

6.2.2 Cable ratings in air shall be as detailed in SABS 0142. Care shall be taken to ensure the correct table is used and that the derating factors as specified are applied.

6.2.3 Cables for motor circuits shall be four core for cable sizes up to and including 120 mm² and three core for larger cables. The fourth core shall be used to earth the motor and where three core cables are used a separate earth cable shall be run.

6.2.4 The minimum size cable for motor power circuits shall be 2,5 mm².

6.2.5 Cables for motor starting shall be selected from the table in Appendix A4. The criteria for the sizing in Appendix A4 is:

Supply voltage	= 400 V
Voltage regulation - running conditions	= 5%
Voltage regulation - starting conditions	= 20%
Ambient temperature	= 40 degrees Celsius
Group derating	= 0,85

6.2.6 The ratings are suitable for pumping installations, the sizing is conservative and could be reduced if the mechanical absorbed power is considerably less than 85% of motor name plate rating. In such cases the calculations shall be submitted to the Chief Electrical Engineer for approval. For heavy duty starting applications individual calculations shall be provided to determine the correct cable selections. Examples of applications considered to be heavy duty are crushers and conveyors or any other application that has a constant torque/speed characteristic or a higher breakaway torque.

6.3 Control cables

6.3.1 Control cables, ie cables used for 231 V AC and 110 V DC circuits, shall be standard SABS 1507 cables PVC, PVC, SWA, PVC construction with blue stripe on the outer sheath and with cores sizes of 1,5 mm². The number of cores will be chosen to suit the application, provided that at least 10% spare cores are provided. The conductors shall be multi-stranded, three strand conductors are not permitted.

6.4 Instrumentation cables

6.4.1 Instrumentation cables are defined as cables used for 4-20 mA and 24 V DC circuits. 4-20 mA circuits shall be run in twisted pair cables with individual pairs screened and overall screened, steel wire armoured or aluminium-polythene laminate (APL) armoured. 24V DC circuits shall be run using twisted pair cables, alternatively conventional cable as 6.3 above may be used provided interference is not problematic to the circuits being controlled and specific approval from the Engineer has been obtained.

6.4.2 Screens shall be earthed at one end only and insulated at the other end of the cable. The earthed end shall be at the primary earth "source". Drain wires shall be earthed at one end only and insulated at the other end.

6.4.3 Cable cores shall be 1 mm² and the number of cores or pairs to suit the application with 10% spare capacity.

7. ELECTRIC MOTORS

7.1 Detailed requirements for low voltage electric motors are provided in Specification RW/00320/S/035.

8. TRANSFORMERS

8.1 Detailed requirements for transformers are provided in Specification RW/00320/S/032.

8.2 All transformers with ratio MV to 400 V or 550 V shall have star connected secondary windings which shall be solidly earthed through a 100/5 current transformer connected to a backup earth fault relay with IDMT characteristic curve to provide definite time tripping backup earth fault tripping for the primary circuit breaker. The time delay shall be typically two seconds to allow low voltage devices the opportunity to clear any earth faults before the primary circuit breaker is tripped.

8.3 The connection for the neutral shall be via an insulated conductor from the star point of the transformer to the low voltage switchgear and the neutral conductor shall not be passed through the earthing current transformer.

9. PLANT LIGHTING

9.1 Illumination levels

9.1.1 The illumination level in plant, switchgear rooms and control rooms shall comply with the general requirements of SABS 0114, and specifically the following illuminations levels shall apply after the application of manufacturer's deterioration and maintenance factors for the type of fitting and lamp used:

Engine rooms and boiler houses	320 lux
General plant areas	320 lux
Control rooms	400 lux
Switchgear rooms	320 lux
Conveyor walkways	50 lux

- 9.1.2 Illumination levels operating with emergency light fittings shall be not less than 10 lux in general plant areas and 20 lux in control and switchgear rooms. Lighting circuits in control rooms shall be fitted with dimmer switches.
- 9.1.3 Illumination levels operating with emergency light fittings shall be not less than 10 lux in general plant areas and 20 lux in control and switchgear rooms. Lighting circuits in control rooms shall be fitted with dimmer switches.
- 9.2 Light fittings
- 9.2.1 The following fittings shall be used:
- | | |
|---------------------|---|
| Control rooms | Decorative fluorescent |
| Switchgear rooms | Open channel fluorescent |
| General plant areas | 110 watt Xenon-Sodium bulkhead (Magnitech Mag 22) |
| Engine rooms | 360 or 960 watt Xenon-Sodium high bay (Magnitech) |
| Area lighting | 960 watt Xenon-Sodium floodlights (Magnitech) |
- 9.2.2 In general plant areas 10% in number of fittings shall be IP 55 enclosure fluorescent fittings to provide light immediately after power is restored following a power supply failure.
- 9.2.3 Fluorescent fittings shall be semi-resonant type with 40 watt (1,2 metre) or 75 watt (2,4 metre) tubes.
- 9.2.4 The bulkheads and high bay fittings shall be supplied with remote mounted ballasts positioned so as to facilitate maintenance without having to handle the ballasts in elevated positions. The ballast housings shall be IP 65 enclosures manufactured from die cast aluminium with hinged covers. The remote mounted ballasts shall be equipped with a double pole 10 amps miniature circuit breaker integral to the ballast housing.
- 9.3 Light fittings should be selected in consultation with the responsible architect in the case of lighting in public areas for example outside engine rooms, foyers etc.
- 9.4 Power supplies for emergency fittings shall be derived from the standby generator busbars. In switchgear rooms at least one emergency fitting of the internal rechargeable batter type (50% light output for 30 minutes) shall be positioned above the incomer circuit breakers and one at the standby generator.
10. LIGHTING AND SMALL POWER DISTRIBUTION SYSTEMS
- 10.1 Lighting shall be supplied from centrally located distribution boards. The arrangements of the circuits shall be balanced such that in any plant area the loss of a phase shall not cause the loss of more than a third of the illumination in that area.
- 10.1.1 Lights shall be fed from miniature circuit breakers rated for 5 kA and the maximum load on any one circuit shall not exceed 2 000 watts for a 16 amps single phase circuit. The lighting circuits shall not be protected by earth leakage protection.
- 10.1.2 The wiring of the lighting shall comply fully with SABS 0142. The cabling used for lighting shall generally be 2,5 mm², except for that supplied to distant fittings in which case the cable shall be sized to provide voltage regulation not exceeding 5% at the fitting when starting.
- 10.2 Control of lighting circuits
- 10.2.1 External lighting shall be controlled by means of photoelectric cell operating a contactor in the lighting distribution board. A photoelectric cell bypass switch shall be provided to enable testing of lighting circuits.
- 10.2.2 Interior lighting in continuous operation plants shall be controlled only from the lighting distribution board, i.e. the fittings shall be left on continuously. In control rooms and switchgear rooms and offices lighting shall be controlled by suitable light switches. Light dimmer switches shall be provided for control room lighting.

- 10.3 230 V switched socket outlets
 - 10.3.1 A sufficient number of 230 V single phase socket outlets shall be provided throughout the plant and adjacent equipment that requires regular servicing. Socket outlets in plant areas shall be weatherproof and shall be of the 16 amps three round pin type. Wiring to socket outlets shall be carried out using 4 mm² wire.
 - 10.3.2 Circuits deriving power from an uninterruptible power supply (UPS) shall use socket outlets with half round earth pins to prevent the use of drilling machines etc on these circuits.
- 10.4 Cabling installation for lighting and small power outlets
 - 10.4.1 In architecturally designed buildings wiring shall be carried out in chased conduit. Surface mounted conduit and cabling over plastered or face brick installations is not acceptable. In plants where the extent of cabling dictates the use of racking, lighting and small power wiring may be carried out using PVC, PVC, SWA, PVC cables mounted on the cable racking.
 - 10.4.2 The use of bus trunking for supplying the high bay light fittings in an engine room or equivalent structures is acceptable provided that each tap off is protected by a suitable moulded case circuit breaker with facility for being padlocked in the off position.
11. WELDING AND POWER OUTLETS
 - 11.1 Three phase four pole welding sockets shall be installed at appropriate locations for supplying power for portable welding machines. The positioning of outlets shall be such that all points of the plants can be reached with a 30 metre extension cable.
 - 11.2 Welding socket outlet feeders shall be protected with 375 mA Elsec-T protection relays tripping the supply circuit breaker.
 - 11.3 Particular attention shall be paid to ensure standardisation of welding socket outlets at the different plants. The specific station requirements are:

Zuikerbosch	Reyrolle Catalogue 10230
Zwartkopjes	Reyrolle Catalogue 10230
Vereeniging	Ampco 4 pin (flat) with integral 30 mA earth leakage relay
12. CABLE SUPPORT SYSTEMS
 - 12.1 General
 - 12.1.1 Cables shall be installed in such a way that they are fully supported in a robust manner. Unsupported cable installations are not permitted. The selection of materials and finishes for cable support systems shall be chosen to suit the chemical environment in which the racking is to be installed.
 - 12.2 Cable racking
 - 12.2.1 On cable runs involving three or more cables a formal cable rack system shall be installed. For normal, non-corrosive environments the following types of cable racking are permitted:
 - 12.3 Galvanised racking
 - 12.3.1 Galvanised racking shall be heavy duty construction with 50 mm or 76 mm sides and shall be of the ladder type. Only hot dipped galvanised (to SABS 736) sections will be acceptable, electroplated galvanised systems are not acceptable. Cable tray or light duty ladder racking is not acceptable except for the installation of instrumentation impulse lines.
 - 12.4 Fabricated ladder type racking
 - 12.4.1 Fabricated ladder racking manufactured from flat bar and angle sections is acceptable. The racking may be either hot dip galvanised or painted to the paint specification detailed below in Section 12.6.

- 12.4.1.1 The following size angle iron shall be used:
- | | |
|----------------------------|----------------------|
| Racking up to 300 mm wide | 25 mm x 25 mm x 4 mm |
| Racking > 300 mm to 600 mm | 40 mm x 40 mm x 6 mm |
| Racking > 600 mm to 900 mm | 50 mm x 50 mm x 6 mm |
| Racking > 900 mm | 75 mm x 75 mm x 6 mm |
- 12.4.1.2 The flat bar rungs shall be 25 mm wide and the same thickness as the respective angle section. Alternatively top hat sections may be used.
- 12.5 Cable racking in chemically corrosive areas
- 12.5.1 For highly corrosive areas either stainless steel, aluminium, GRP or fibreglass ladder racking shall be used. The selection of the material shall be made in consultation with the Chief Electrical Engineer and Chief Process Engineer.
- 12.5.2 A corrosive area includes chlorine and ammonia dosing plant environs where, although the chemicals are not freely present, they could be present in small amounts in the atmosphere.
- 12.6 Painting specification for fabricated cable racking
- 12.6.1 Surface preparation
- 12.6.1.1 All oil, scale etc shall be removed by means of shot or sand blasting to Swedish Specification SA 2½ and thereafter pickled and zinc phosphates. No more than 12 hours shall elapse between pickling and coating.
- 12.7 Coating
- (a) Primer
- | | |
|----------------------------|---------------------|
| Paint type | Zinc phosphate |
| Thickness of coating | Minimum 5 micron |
| Application method | Zinc phosphate bath |
| Location | Shop |
| Maximum drying time/curing | 24 hours |
- (b) Intermediate coat
- | | |
|----------------------------|--|
| Paint type | Epoxy powder |
| Trade name | Plascon Mobilox Fusion Bonded pipe coating/PL series |
| Thickness of coating | 150 to 250 microns |
| Application method | Fluidised bed or spray |
| Location | Shop |
| Maximum drying time/curing | Post cure may be required depending upon metal thickness |
- (c) Final coat
- | | |
|----------------------------|--|
| Paint type | Modified epoxy amine powder |
| Trade name | Plascon Plastic Epoxy Repair Coating/EPR 1/3 |
| Thickness of coating | Final thickness 150/250 microns |
| Application method | Spray |
| Location | Shop or site |
| Maximum drying time/curing | 48 hours at 25EC |
- 12.8 Installation requirements
- 12.8.1 Racks shall be installed in the vertical plane. Horizontal racking will only be permitted where there are space limitations or in cable basements. The maximum distance between supports for the cable racking shall be 2 metre for vertically mounted racking and 1,5 metre for horizontally installed racking.

- 12.8.2 Low voltage (up to 1 000 volts) power and control cables may run on the same racks. A minimum of 300 mm shall be provided between cables carrying 50 Hz power and those carrying control voltages, communication, digital and analogue instrumentation signals.
- 12.8.3 Medium voltage cables shall run on separate racks to those carrying cables. The minimum spacing to communication and analogue cables shall be increased to 500 mm and it is preferable that communication and analogue cables be routed on a completely different route to that of medium voltage cables.
- 12.8.4 Racking shall be filled to a maximum of 66% capacity, or up to a fraction of capacity allowing for known future plant expansion, whichever is the lesser. Racks for control cables only may be filled to capacity. Racks for power or lighting shall not have more than one layer of cables installed on them.
- 12.8.5 Cable routes with a maximum of 2 cables on that route may be carried out using angle iron supports. The surface preparation may be either hot dipped galvanising or painting as per Section 12.6 above. The sizing of the angle iron shall be such that the cables do not extend beyond the square formed by the sides of the angle iron.
- 12.8.6 Alternatively cables may be supported in galvanised conduit of adequate size for the cable. If conduit is used it shall be mounted using hospital saddles and the ends shall be reamed and bushed.
- 12.8.7 Cable penetrating floors shall be protected by a robust enclosure for at least 500 mm above the floor.
- 12.8.8 Cables shall be secured to supports using Bowthorpe-Hellermann cable ties or an approved equivalent. The cable ties shall be UV resistant. Medium voltage cable may be secured using bandit strap or preferably "U" clamps. If bandit strapping is used additional protection shall be applied to prevent damage to the outer sheath due to creepage.
- 12.8.9 All cables shall be numbered at both ends using colour coded, PVC cable numbering systems.
- 12.8.10 Specific requirements for communication cables.
- 12.8.11 Cables used for supervisory and PLC communication (optical fibre or twisted pair etc) shall be unarmoured and within plant areas shall be run in galvanised conduit along their full length. The conduit shall be identified by means of a mauve strip painted on the conduit at every change of direction and every 5 m along the conduit run.
- 12.8.12 The design of the conduit shall be such that optical fibre cable may be pulled into position without excessive stress being placed on the fibres.
13. CONDUIT
- 13.1 Installations of an architectural nature or that have face brick walls shall have conduits installed when the walls are built, surface mounted conduit is not permitted.
- 13.2 Chased conduit shall be mild steel black conduit. Surface mounted conduit shall be hot dipped galvanised and shall be mounted using hospital saddles. Where hospital saddles are used to mount surface conduit they shall be mounted using an approved rawl bolt (minimum 6mm), wooden or plastic plugs and screws are not acceptable.
- 13.3 PVC conduit may be used in chased applications with the approval of the Chief Electrical Engineer.
- 13.4 The use of wiring installed directly in plaster is not acceptable.
14. TRENCHING
- 14.1 Cables run external to plant buildings shall be installed in cable trenches.
- 14.1.1 Main cable routes shall be formalised and concrete or brick lined ducts shall be constructed with concrete plank covers. The sizing of these ducts shall be carefully designed and shall be approved by the Chief Electrical Engineer.

- 14.1.2 Only minor cable routes cables may be laid directly in the ground provided the following criteria are complied with:
- 14.1.3 Cables burying depth shall be at least 800 mm below final ground level for low voltage cables and 1 000 mm for medium voltage cables.
- 14.1.3.1 Cables shall be bedded on a layer of 100 mm deep of sifted, stone free soil or river sand and covered by a further layer 150 mm deep of sifted, stone free soil or river sand.
- 14.1.4 An electric cable warning tape shall be laid 200 mm below the surface, which shall be made from yellow PVC tape with the wording "Electrical Cables" along its length.
- 14.1.5 Every 50 m, at every change in direction or at road crossings a robust concrete cable route marker shall be planted bearing a stainless steel or brass marker with the wording "Electric Cable Route" with direction arrows engraved on it.
- 14.1.6 Communication cable routes shall have a permanent mauve stripe painted on the cable route marker.
- 14.2 The Engineer responsible for the project shall ensure that all cable routes are marked up correctly and comprehensively on the respective plant layout drawings. The use of the Survey Department should be employed to ensure the routes are accurately plotted.
15. INSTRUMENTATION
- 15.1 Instrumentation - General
- 15.1.1 Process instrumentation shall be selected, supplied and installed generally as indicated on the Process and Instrumentation diagrams. The Contractor shall submit all the proposed instrumentation data sheets and schedules to the Chief Electronics Engineer for approval prior to the issue of any purchase orders. All instrumentation shall be procured using formal data sheets that shall specify the full process performance requirements expected of that instrument.
- 15.2 Instrumentation power supplies
- 15.2.1 Instrumentation power supplies shall be derived from stabilised sources such as uninterruptible power supplies or switches mode 24 V DC power supplies.
- 15.2.2 The mains power supply for each instrumentation loop shall be protected by its own circuit breakers or fuses. The combining of power supplies for more than 1 loop is not permitted.
- 15.2.3 All instrumentation mounted in the field and powered from 231 VAC power supplies shall be provided with a local isolator and suitably mounted within a direct line 1 m off the instrument.
- 15.2.4 Power and control cables may be run on the same racks. A minimum of 300 mm separation shall be provided between cables carrying 50 Hz power and those carrying low voltage analogue or digital instrumentation, communication or control signals.
- 15.2.5 Two different services shall not share the same cable. Low voltage signals shall be run in twisted pair cables with continuous screening over each pair as well as an overall screen. The screen drain wires shall be terminated but isolated from earth at the equipment end and shall be terminated and connected to the common earth bar at the panel end.
- 15.2.6 In the case of UPS supplies the UPS shall have a suitable static bypass feature. The design of the UPS power distribution board shall also incorporate a normal/UPS power source selector switch to enable the UPS to be taken out of service for repairs if necessary. The design shall be such that once UPS power is restored the transfer to UPS power is automatic.
- 15.3 Process instrumentation

- hr/>
- 15.4 Preference shall be for 2 wire transmitter type of instrumentation.
- 15.4.1 All analogue instruments shall have output signals of 4 - 20 mA and shall be capable of supplying the signal into an impedance of 750 Ohms. The scaling of all metering equipment, digital indicators and parameters within the PLC system shall be submitted for approval by the Engineer. Generally the full scale value shall be twice the normal design operating level.
- 15.4.2 All instrumentation loops shall be provided with voltage surge protection if the cable length exceeds 30 m and/or the loop wiring leaves a control panel to the field. Protection shall normally be applied at both ends of the primary loop. Phoenix UF BK-2-PE surge protection units are approved. Instrumentation loops that are fitted with surge protection and are to be connected to the PLC input/output cards shall be fitted with signal isolation so as to maintain a minimum of 1 000 volts galvanic isolation between the PLC terminals, the primary field loop and the power supply. M-System Co Ltd Product Modules KDY and KWDY or FDY are approved.
- 15.5 Proximity switches
- 15.5.1 Proximity switches shall be inductive proximity switches, 24 V DC 3 wire type - Pepperl and Fuchs.
- 15.6 Vibration transducers
- 15.6.1 Shall be Bentley Nevada Model 89129-01-07 accelerometers and Model 1900/27-02 vibration monitors.
- 15.7 Magnetic Induction Flow Meters
- 15.7.1 Electro-magnetic induction flow meters shall be supplied and installed for continuous flow measurement complete with a configurator module. The Contractor shall propose the best diameter and pressure rating for the meters.
- 15.7.1.1 The meters shall be provided with at least the following:
- (a) Transmitted signals directly proportional to flow rate from a remotely located converter/transmitter unit with a maximum error of less than +/- 0,3% of the measured true value when installed.
 - (b) Voltage free pulsed signals for flow totalising in the PLC equipment. (Normally rate at 240 Volts 100 VA.)
 - (c) Signal damping adjustment at least 0 to 15 seconds.
 - (d) At least a 9 digit indicator of flow rate and of totalised flow on the transmitter and scaled in engineering units e g MP/D and MP.
- 15.7.2 ABB Kent Magmaster and Endress and Hauser Promag electro-magnetic flow meters are approved.
- 15.7.3 A hand held programmer/configurator that is removable and able to store multiple flow meter information is preferred to a fixed key pad within the converter unit.
- 15.8 Nuclide Density Meters
- 15.8.1 Nuclide density meters shall be supplied and installed for continuous safe measurement of the density of the process medium.
- 15.8.2 The meters shall be provided with at least the following:
- (a) Transmitted signals directly proportional to the density and dry mass flow rate of the process medium with a maximum error of less than +/- 2,0% and a repeatability error not exceeding +/- 0,8% of the measured value of density. These values to be confirmed on site.
 - (b) Voltage free pulsed signals for mass flow totalising in the PLC equipment. (Normally rate at 240 Volts 100 VA.)

- p>15.8.3 Nuclide density meters as supplied by Endress and Hauser, Krohne SA and Ramsey Technology are type approved.
- 15.8.4 Coriolis Mass Flow and Density Meters.
- 15.8.5 Liquid and dry mass flow and density meters employing the Coriolis principle shall be supplied and installed for continuous safe measurement of the mass flow and density of the process medium.
- 15.8.5.1 The meters shall be provided with at least the following:
- (a) Transmitted signals directly proportional to the dry mass flow rate of the process medium with a maximum error of less than +/- 0,5% and a repeatability error not exceeding 0,15% of the measured true value of mass flow. These values to be confirmed on site.
 - (b) Voltage free pulsed signals for mass flow totalising in the PLC equipment. (Normally rate at 240 Volts 100 VA.)
 - (c) Additional transmitted signal for fluid density of the process medium with a maximum error of less than +/- 2,0% of the true reading.
- 15.8.6 ABB Kent Measurements and Endress and Hauser Coriolis mass flow meters are type approved.
- 15.9 Ultrasonic Level Sensors
- 15.9.1 Ultrasonic level sensors shall be supplied and installed for continuous level measurement complete with converter/transmitter module.
- 15.9.1.1 The meters shall be provided with at least the following:
- (a) Transmitted signal to be directly proportional to the level of the process medium or if the application is to measure flow rate across a weir or flume the transmitted signal shall be directly proportional to the actual flow rate. The maximum error of the transmitted signal shall be less than +/- 1,0% of the true value and a repeatability error not exceeding 0,3%. These values to be confirmed on site.
 - (b) The remote sensor head to be IP 67 and the material suitable for the application.
 - (c) The converter to be provided with at least 2 independent alarm relays (e g high and low). The contacts shall have a minimum rating of 240volts 150 VA 50Hz and 120 Volts 50 Watts DC.
 - (d) A display of at least 4 digits excluding the decimal point and the engineering units shall be provided on the remote from the sensor head.
- 15.9.1.2 Ultrasonic meters supplied by Endress and Hauser, Miltronics and Vega are type approved.
- 15.10 Sludge Blanket Level Sensors
- 15.10.1 For use in thickeners and clarifiers an interface level detector shall be supplied and installed for continuous operation and display of the level and profile of the coagulated material in the tank. The Contractor shall propose the best location, range and accessories for the application.
- 15.10.1.1 The meter shall be provided with at least the following:
- (a) Transmitted signal to be directly proportional to the level of the most significant profile interface.
 - (b) A LCD display of all the interfaces within the range and a separate display showing the depth of the most significant interface.

- (c) Digital interface and software to provide input signals to Modbus PLC equipment so that the complete profile as well as the normal transmitted signal can be scanned by the PLC system.
- 15.10.1.2 Royce Instrument Corporation are approved suppliers of sludge interface detectors.
- 15.11 Streaming Current Detector
- 15.11.1 For use as an accurate coagulant dosage meter and an on-line monitor, the Contractor shall supply and fit a streaming current detector that provides an output signal for both deficient and excess dosing of anionic colloids.
- 15.11.1.1 The meter shall be provided with at least the following:
- (a) The transmitted 4 - 20 mA signal shall be adjustable so that the “zero” or correct dosage point can be easily set.
- (b) Automatic audible and alarm contacts to be activated in the event of failure of the monitor.
- Zetachem Type CDC 2000 coagulant dosage controller is type approved.
- 15.12 Turbidity Meter
- 15.12.1 The Contractor shall supply and install for continuous use ratio turbidity meters such that the water sample is always a true representation of the process fluid.
- 15.12.2 The Contractor shall propose the best location and range selection for the specific application.
- 15.12.2.1 The meter shall be provided with at least the following:
- (a) The transmitted signal shall be directly proportional to the range of the meter.
- (b) The instrument shall be calibrated in NTUs.
- (c) The signal converter shall be fitted with a digital display of the measured value and at least 1 fully adjustable alarm output relay.
- 15.12.3 Hach type ratio 2000 and surface scatter models are approved.
- 15.13 Instrumentation enclosures
- 15.13.1 All instrumentation shall be specified to have IP 65 enclosures. If an instrument cannot meet this requirement it shall be installed in an additional enclosure that will meet the IP 65 requirement.
- 15.13.2 All instrumentation mounted in the field shall be provided with splash covers manufactured from sheet metal of minimum thickness 1,5 mm and shall be galvanised or painted in accordance with the paint specification described in Section 12.6.
16. TESTING OF ELECTRICAL EQUIPMENT AND INSTALLATIONS
- 16.1.1 All electrical equipment shall be formally tested on site before it is energised and a comprehensive set of test certificates shall be included in the hand-over package to the Operations Division. This section provides details of the minimum testing that shall be carried out on low voltage installations.
- 16.1.2 Transformers
- | | | |
|----------------|---|--|
| Test equipment | : | 5 000 Volt meggar
Multimeter |
| Tests | : | Meggar primary winding to earth
Meggar secondary winding to earth
Meggar primary to secondary winding
Ratio test for all tappings |

			Buchholz operation including alarm and trip contacts Top oil temperature - including alarm and trip contacts
	Visual inspection	:	Earthing to specification Leaks Radiator isolating valves open
16.1.3	Low voltage switchgear		
	Test equipment	:	2 500 Volt meggar Low resistance meter (“Ductor”) Multimeter
	Tests	:	Meggar busbars (ph-ph to earth)
			Earth busbar continuity Main busbar continuity and joint resistance Device ratings and settings Functional tests of all circuits Earthing continuity to main earth bars
	Visual inspection	:	Damage during installation Busbar bolts torqued No loose nuts and bolts in busbar compartments Earthing to specification
16.2	Cable installation (low voltage)		
	Test equipment	:	1 000 and 2 500 volt meggar Multimeter
	Tests	:	Meggar all cables core to core and core to earth Measure loop resistance
	Visual inspection	:	Damaged insulation Core and cable numbering Terminals correctly tightened Functional testing of all circuits
16.3	Lighting installations		
	Test equipment	:	Light meter
	Tests	:	Lighting levels of SABS 0114 Control and operation of photocells Functional testing of circuits
	Visual inspection	:	Lighting circuits to drawing No faulty lamps
17.	TEST CERTIFICATIONS		
17.1	The standard Rand Water test certificates shall be completed and signed off by the Engineer carrying out tests or in the case of a Contractor certificates shall be signed by the Contractor and witnessed by Rand Water’s Engineer.		

APPENDIX A1 - APPROVED MCCBs, CONTACTOR AND OVERLOADS

Permitted combinations for which Group 2 coordination certification is available.

- (a) Merlin Gerin moulded case circuit breakers
Telemecanique contactors and overload relays
- (b) CBI moulded case circuit breakers (C Series)
Siemens contactors and overload relays

Motor kW	Merlin Gerin/Telemecanique		CBI/Siemens	
	Circuit breaker	Contactor	Circuit breaker	Contactor
Up to 11 kW	Telemecanique Integral 32		Telemecanique Integral 32	
15	Telemecanique Integral 32		Telemecanique Integral 32	
185	Telemecanique Integral 63		Telemecanique Integral 63	
22	Telemecanique Integral 63		Telemecanique Integral 63	
30	C101L-MA-100	LCI-D80	HFAN 100 A	3TF4822-OA
37	C101H-MA-100	LCI-F115	HFAN 100 A	3TF4822-OA
45	C101H-MA-100	LCI-F115	HFAN 100 A	3TF5022-OA
55	C101H-MA-150	LCI-F150	HFAN 150 A	3TF5022-OA
75	C250H-MA-250	LCI-F185	HKD 250 A	3TF5222-OA
90	C250H-MA-250	LCI-F265	HKD 250 A	3TF5422-OA
110	C250H-MA-250	LCI-F265	HKD 250 A	3TF5422-OA

For 132 kV and above vacuum contactors shall be used as follows:

	Circuit breaker		Contactor
	Merlin Gerin	CBI	Mitsubishi
132 kW	C401H-MA-320	HKD-300 A	SH-V400
160 kW	C401H-MA-400	HKD-400 A	SH-V400
185 kW	C630H-MA-500	HLD-500 A	SH-V600
220 and 250 kW	C630H-MA-630	HLD-600 A	SH-V600
300 kW and above and above		Refer to Chief Electrical Engineer	

APPENDIX A2 - CABLE RATINGS - COPPER CONDUCTORS

Cable ratings - "In Air"

Ambient temperature 35 degrees Celsius
Installation On a cable rack as defined in SABS 0142 - Table 5 method 4

Cable ratings - "In Ground"

Ground temperature 25 degrees Celsius
Soil thermal resistivity 1,2EC m/W
Cable depth of laying 0,5 to 0,7 m

3 or 4 core cable size (mm ²)	600/1 000 PVC, PVC, SWA, PVC		11 kV PILCSWA		11 kV XLPE	
	Air	Ground	Air	Ground	Air	Ground
2,5	21	35				
4	28	40				
6	37	50				
10	51	67				
16	68	87				
25	86	120				
35	107	140				
50	129	167				
70	166	200	166	175	215	230
95	201	243	205	205	265	275
120	233	278	234	236	315	305
150	265	310	270	270	355	345
185	307	354	306	306	395	390
240	363	390	355	350	470	460
Single core cables - Trefoil configuration with screen earthed at one end only						
300	506				700	550
500	675				930	700
630	771				1 050	770

APPENDIX A3 - CABLE DERATING FACTORS

LOW VOLTAGE CABLES

Temperature derating									
Temperature (EC)	10	15	20	25	30	35	40	45	50
Derating	1,26	1,23	1,18	1,12	1,06	1	0,93	0,85	0,77

Grouping - Loaded cables touching (Note: Control cables have no derating)					
Number of cables	2	3	4	6	9
Derating (vertical)	0,85	0,8	0,75	0,7	0,7
Derating (horizontal)	0,84	0,8	0,78	0,75	0,73

Buried cables - Grouping					
Number	Axial spacing				
	Touching	150 mm	300 mm	350 mm	600 mm
2	0,80	0,85	0,89	0,90	0,92
3	0,69	0,75	0,80	0,84	0,86
4	0,63	0,70	0,77	0,80	0,83
5	0,59	0,65	0,72	0,77	0,80
6	0,56	0,62	0,70	0,75	0,79

Buried cables - Depth of laying	
Depth	Derating
500 mm - 700 mm	1,00
701 mm - 900 mm	0,99
901 mm - 1 100 mm	0,98

Soil resistivity							
Resistivity (EC m/W)	0,7	1,0	1,2	1,5	2,0	2,5	3,0
Derating	1,24	1,08	1,00	0,92	0,81	0,75	0,68

Soil temperature - buried conductors							
Soil temperature	10	15	20	25	30	35	40
Derating	1,16	1,11	1,06	1,00	0,95	0,85	0,82

APPENDIX A4 - CABLE SELECTION CHART - MOTOR CIRCUITS (400 V SYSTEMS)

Motor	Cable run length (metre)						
kW	50	75	100	125	150	175	200
Up to 4	2,5	2,5	2,5	2,5	4	4	4
5,5	4	4	4	6	6	6	6
7,5	4	4	6	6	6	10	10
11	6	6	6	10	10	16	16
15	10	10	10	10	16	16	16
18,5	16	16	16	16	16	25	25
22	25	25	25	25	25	25	25
30	25	25	25	25	25	35	35
37	35	35	35	35	35	50	50
45	50	50	50	50	50	50	70
55	70	70	70	70	70	70	70
75	95	95	95	95	95	95	95
90	120	120	120	120	120	120	120
110	150	150	150	150	150	150	150
132	185	185	185	185	185	185	185
160	240	240	240	240	240	240	240
185	2 x 95 2 x 95						
200	2 x 120 2 x 120						
220	2 x 120 2 x 120						
250	2 x 150 2 x 150						
275	2 x 185 2 x 185						
300	2 x 185 2 x 185						

Where 185 mm and 240 mm cable is specified consideration should be given to rather using 2 smaller cables, for example 2 x 95 mm and 2 x 120 mm respectively.

The above is a guide and is applicable for bunched cables on a rack with a number of loaded circuits. The mechanical absorbed power should also be taken into account as it may be possible to reduce cable sizes. Reduction of cable sizes should however be considered very carefully as generally the mechanical power requirement will only increase with time.