THE SOUTH AFRICAN NATIONAL
ROADS AGENCY LTD

Registration No: 1998/009584/06

THE SOUTH AFRICAN NATIONAL ROADS AGENCY LIMITED

STANDARD SPECIFICATIONS FOR OPERATIONS AND MAINTENANCE OF CTROM PROJECTS: ELECTRICAL AND MECHANICAL EQUIPMENT

OCTOBER 2010

VOLUME 2 BOOK 3

ISSUED BY:

THE CHIEF EXECUTIVE OFFICER
SOUTH AFRICAN NATIONAL ROADS AGENCY LIMITED
P O BOX 415
PRETORIA
0001

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1. PREAMBLE TO ELECTRICAL WORKS

1.1 GENERAL INFORMATION

1.1.1 The general technical specification covers the manufacture, installation, testing, Commissioning and maintenance, as well as Equipment and material used for electrical installations. These requirements shall be read in conjunction with the Standards and Codes as specified below.

1.1.2 This general specification shall be applicable to the manufacture, supply, installation, testing, Commissioning and maintenance of any Plant or SANRAL's Equipment as required of the Contractor.

1.2 STANDARDS AND CODES

1.2.1 Where reference is made to any code of practice or standard specification the latest amendment or edition shall apply. The Contractor shall ensure that it is acquainted with the contents of such documents.

1.2.2 Installation Works shall be carried out in full compliance with the mentioned codes of practice and in accordance with good engineering practice.

1.2.3 All materials and Equipment shall be new and of high quality which complies with the relevant standard specification, SANRAL's Requirements and other standard specifications. The Contractor shall ensure compliance with these specifications and if requested by SANRAL, shall prove compliance at its own cost.

1.3 REGULATIONS & STANDARDS

1.3.1 The manufacture of Equipment and the complete installation shall be carried out and tested in accordance with the latest issues or amendments of the following regulations and standards, as applicable:

1.3.1.1 The Occupational Health and Safety Act, 1993 (OHS Act).

1.3.1.1.1 SANS Code of Practice 10142-1; for the Wiring or Premises.

1.3.1.2 The National Building Regulations, SANS 10400:1990.

1.3.1.3 The local Municipal By-laws and Regulations as well as the regulations of the local Supply Authority.

1.3.1.4 The Standard Regulations of any Government Department or public service company where applicable.

1.3.1.5 The local Fire Regulations.

1.3.1.6 The Mines and Works Regulations, Government Notice No R1609 of 28 September 1962.

1.3.1.7 The Regulations of the Department of Communications.

1.3.1.8 The Regulations of Telkom SA Limited.

1.3.1.9 International Electro technical Commission (IEC).

1.3.1.10 Deutsche Industrial Norm (DIN).

1.3.1.11 British Standard (BS).

1.4 ARRANGEMENTS WITH THE SUPPLY AUTHORITY

1.4.1 The costs of all arrangements with the supply authority with regard to inspections, tests and requirements to comply with regulations, and the actual costs of inspections, tests, provision of labour, test equipment, etc shall be for the Contractor's own account and the Contractor shall bear all costs in this regard.

1.4.2 The design and arrangements for permanent power supplies and connection fees shall be done and paid for by the Contractor.

1.5 INSTALLATION WORKS

1.5.1 It shall remain the Contractor's responsibility to carry out the Works in accordance with this document, to provide the logistics and infrastructure required for the Works, to provide adequate fulltime supervision at the Works, to programme and manage the Works, to ensure compliance with codes, standards and regulations, to provide registered and qualified Site staff at all times in accordance with the applicable Laws.

1.5.2 SANRAL shall inspect the installation from time to time during the progress of Works. Discrepancies shall be pointed out to the Contractor and these shall be remedied at the Contractor's expense. Under no circumstances shall these inspections relieve the Contractor of his obligations in terms of this Contract nor will these inspections be regarded as final approval of the Works or portions thereof.

1.5.3 Where SANRAL has appointed a full-time representative at the Works, this representative shall not be regarded as relief of the Contractor's obligations in terms of SANRAL's Requirements.

1.5.4 The Contractor shall notify SANRAL timeously when the installation reaches important stages of completion (e.g. before closing cable trenches, before casting concrete), so that SANRAL's representative may schedule his inspections in the best interest of all parties concerned. Failure to do so may result in SANRAL's instructing the Contractor to re-open trenches, at the Contractor's cost, so that inspections may be carried out at a later stage. SANRAL's inspection shall only be carried out after the Contractor has carried out his own preliminary inspections to ensure that the Works are completed in compliance with the documents. SANRAL's inspection shall therefore not be regarded as supervision, fault listing, quality assurance or Site management.

1.6 MATERIAL AND EQUIPMENT

1.6.1 All material shall be of high quality and suitable for the conditions on Site. These conditions shall include weather conditions as well as conditions under which materials are installed, stored and used. Should the materials not be suitable for use under temporary Site conditions, the Contractor shall at his own cost provide suitable protection until these unfavourable Site conditions cease to exist.

1.6.2 The Contractor shall, where requested to do so, submit samples of equipment and material to SANRAL for his approval prior to installation. Samples may be retained in SANRAL's possession until the termination or Contract Completion Date after which they will be returned.

1.6.3 Imported material or Equipment shall only be used in lieu of locally manufactured material or Equipment when imported Equipment or material is specified in this Contract or SANRAL issues written approval for the use of imported material or Equipment. Even in such a case, the Contractor shall inform SANRAL if locally manufactured Equipment or material that can successfully replace specified imported Equipment or material becomes available during the course of the installation.

1.7 CO-ORDINATION

1.7.1 The Contractor shall co-ordinate the installation of Equipment and fittings with the other Contractors and trades on Site before installation. Should agreement not be reached or if the Equipment or fittings cannot be installed in the obvious locations to conform to the design, SANRAL's ruling shall be obtained beforehand.

1.7.2 The cost of relocation of Equipment or fittings due to the lack of co-ordination shall be for the Contractor's own account and at the Contractor’s cost.

1.8 WORKSHOP DESIGNS AND DRAWINGS

1.8.1 The Contractor shall submit to SANRAL detailed or workshop drawings of all Equipment as per the Contract to be manufactured, assembled or installed for approval prior to the commencement of the manufacture or construction of such Works.

1.8.2 For the construction of new facilities the Contractor shall submit comprehensive details of standards and criteria which will be used in the detailed designs, preparation of workshop drawings, manufacture and testing of Equipment.

1.8.3 In the event of facility expansion the Contractor shall submit comprehensive details of standards and criteria for Equipment as listed in the Contract which will be used in the detailed designs, preparation of workshop drawings, manufacture and testing of Equipment within 3 months of such expansion having been approved by Employer.

1.9 DESIGN RESPONSIBILITIES

1.9.1 The design and detail design responsibility of the electrical and mechanical Equipment as listed in the Contract rests with the Contractor with regard to the interpretation of Employer's Requirements, the general layouts and arrangements and the functionality of the electrical and mechanical Equipment and also includes the design for installation and manufacturing and the compliance to specifications and requirements which are stipulated in this Contract.

1.10 SAFETY PRECAUTIONS AND REQUIREMENTS

1.10.1 The Contractor shall be responsible for the safety of its personnel and the Equipment at all times. All applicable Laws shall be strictly followed in this regard and all the necessary precautions and measures shall be taken to ensure the safety of personnel, the public and Equipment.

1.10.2 Where Works are to be carried out on or in the proximity of live electrical equipment, the Contractor shall make all the necessary arrangements with the relevant supply authority to isolate and earth such equipment. These arrangements shall be in writing and copies thereof shall be submitted to SANRAL. The Contractor shall adhere to any requirements or procedures the social supply authority may have in this regard. None of these arrangements however, shall alleviate the Contractor's responsibilities in terms of this Contract and all applicable Laws.

1.11 EMPLOYER'S DRAWINGS

1.11.1 The electrical drawings and schedules are of a schematic nature and unless specific dimensions to electrical Equipment are shown, these drawings shall not be scaled to determine physical dimensions or position and fit.

1.12 ELECTRICAL CERTIFICATE OF COMPLIANCE

1.12.1 The Electrical Certificate of Compliance (ECOC) is a valid certificate with a unique number obtained from the Chief Inspector, or a person appointed by the chief inspector, and issued by a registered person in respect of an electrical installation or part of an electrical installation; or a certificate of compliance issued under the Electrical installation Regulations, 1992.

1.13 ELECTRICAL CERTIFICATE OF COMPLIANCE (ECOC) – NEW INSTALLATIONS

1.13.1 The Contractor shall issue a valid ECOC for the facility electrical installation that is kept on Site in accordance with SANS Standard Code of Practice SANS 10142 – 1: low-voltage installations.

1.14 ELECTRICAL CERTIFICATE OF COMPLIANCE (ECOC) – EXISTING INSTALLATIONS

1.14.1 The Contractor will be issued with a valid ECOC for the electrical installation for each Site with a dedicated electrical connection to the supply authority at handover from SANRAL. The Contractor shall use this ECOC as a base and add to the ECOC new valid ECOCs for every modification or addition made to the electrical installation

1.14.2 The Contractor shall ensure that an accredited person ("person registered as an installation electrician in terms of regulation 9 and who has been approved by the Chief Inspector for the verification and certification of the construction, testing and inspection of any electrical installation …") has access to the entire electrical installation and has the opportunity to inspect and test the electrical installation.

1.14.3 The Contractor shall ensure that all the non-compliance items identified by the accredited person be replaced or repaired to comply with the SANS 10142-1 before the ECOC is issued.

1.14.4 The Contractor shall ensure that a ECOC is issued by an accredited person every time the electrical installation is upgraded, repaired or extended to confirm that the Works are in accordance to the SANS 10142-1 standard.

1.14.5 The Contractor shall obtain an updated ECOC for the facility's electrical installation from an accredited person three months before the handover of the installation to the Client or new Contractor. The ECOC shall not be older than three months at date of handover.

1.15 DOCUMENTS TO BE SUBMITTED WITH THE ELECTRICAL CERTIFICATE OF COMPLIANCE (ECOC)

1.15.1 The Contractor shall submit the following relevant documentation with each ECOC:

(a) Detail drawings (indicating SSOs, lighting, light switches, etc.) of the equipment (in area) tested.

(b) Photos of all tested equipment.

(c) Certificate of Compliance for lightning protection systems (LPSs) as per Annexure A of SANS 10313:2008 as amended.

(d) Earthing test report.

(e) Drawing indicating each test point and reading.

(f) Type test certificate of all DBs.

(g) Manuals of all the equipment.

(h) Signed standard specification data sheets to confirm compliance where applicable.

1.16 BASIC POWER ARRANGEMENT

1.16.1 The Contractor shall use the following table as a guideline to design the load of the electrical installation and specialized equipment. Any deviation from the allocation of supply as indicated below shall be submitted for approval by SANRAL or the Independent Engineer. The Contractor shall use energy-efficient equipment to keep the overall load as low as possible. The Contractor shall reduce or expand the list below and submit the final table with load estimates to SANRAL or the Independent Engineer for approval.

TABLE 1-1: ELECTRICAL AND MECHANICAL POWER ARRANGEMENT

Equipment	Normal Power supply	Emergency Power supply	UPS power supply
Air conditioners			
Manager's Office AC. Class A energy sufficient unit shall be used.	X		
Control Room AC. AC with auto restart and class A energy sufficient unit shall be used.		X	
Computer/server Room AC. AC with auto restart and class A energy sufficient unit shall be used with auto restart.		X	
Conference/Board Room AC. Class A energy sufficient unit shall be used.	X		
Admin Office AC. Class A energy sufficient unit shall be used.	X		
Engineer's Office AC. Class A energy sufficient unit shall be used.	X		
Staff Restroom AC. Class A energy sufficient unit shall be used.	X		
Cash-up Room AC. Class A energy sufficient unit shall be used.		X	
Supervisor's Office AC. Class A energy sufficient unit shall be used.	X		

Equipment	Normal Power supply	Emergency Power supply	UPS power supply
General offices AC. Class A energy sufficient unit shall be used.	X		
Technician's office. Class A energy sufficient unit shall be used.	X		
Ventilation and fresh air supply			
Toilet Extract Fan mounted in store room	X		
Building fresh air system	X		
Tunnel & booth fresh air system. Tunnel to have inlet and outlet for excess air.		X	
Extraction Fan - Staff Restroom	X		
Power			
Normal power Switch Socket Outlet (SSO) cover plate shall be white. SSO as required per office, room or area. All live wiring shall be Orange.	X		
Emergency power Switch Socket Outlet (SSO) cover plat shall be red. SSO as required per office, room or area. All live wiring shall be red.		X	
UPS power (dedicated) Switch Socket Outlet (SSO) cover plat shall be blue. SSO as required per office, room or area. All live wiring shall be purple.			X
Lighting			
Lighting installation Manager office		X	
Lighting installation UPS room			X
Lighting installation Switch room			X
Lighting installation control room		X	
Lighting installation computer room			X
Lighting installation tunnel			X
Lighting installation conference room		X	
Lighting installation admin office		X	
Lighting installation engineer office		X	

Equipment	Normal Power supply	Emergency Power supply	UPS power supply
Lighting installation staff rest room		X	
Lighting installation cash-up room		X	
Lighting installation archive room 1		X	
Lighting installation archive room 2		X	
Lighting installation cash transfer room		X	
Lighting installation corridor and stairs		X	
Lighting installation supervisor's office		X	
Lighting installation Toilets		X	
Lighting installation vault		X	
Lighting installation reception		X	
Lighting installation open court yard		X	
Lighting installation covered portion		X	
Street lighting installation		X	
Area lighting installation		X	
General building lighting outside		X	
General electrical			
Geysers	X		
Photo cell		X	
Garage door motor		X	
Security gate motors		X	
Weigh In Motion (WIM) facility		X	
Electronic equipment			
Telephone PABX			X
Radio/Telemetry Emergency Communication			X
ECS system controller			X
Data Communication (Hubs, X-25, modems, switch, etc.)			X
Voice Communication (Intercom system)			X

Equipment	Normal Power supply	Emergency Power supply	UPS power supply
SCADA system			X
24 V DC UPS			X
Access control system			X
Security system			X
Queue length system (QLS)			X
Data Concentration System (DCS)			X
Video grabbing System or VERS			X
OCR server			X
MIS/BOS server			X
MIS/BOS terminals			X
Desktop computers			X
Report printer			X
General non essential printers.		X	
Lane Electrical and Mechanical			
Ventilation for booths single		X	
Ventilation fan motor		X	
AC units for booths single	X		
Booth lighting		X	
Booth Switch Socket Outlet (SSO)	X		
Toll Collector Computer (TCC)			X
Traffic light (TL)			X
Over Head Lane Sign (OHLS)			X
Automatic Vehicle Classification system (AVC)			X
Exit boom			X
Extra wide boom			X
User Fair Display (UFD)			X
Electronic Toll Collection (ETC) equipment			X
Camera System (AVC accuracy and queue length)			X

Equipment	Normal Power supply	Emergency Power supply	UPS power supply
Camera System (OCR cameras)			X
OCR screen in lanes			X
Receipt printer (RP)			X
ORT Road Side System (RSS) Equipment			X
ORT Additional lighting during night			X
ORT Technical shelter RSS Equipment			X
Out-building Electrical and Mechanical			
Lighting internal		X	
Lighting outside		X	
Switch Socket Outlets (SSO)	X	X	
Photo cell		X	
Tunnel Electrical and Mechanical			
Ventilation for tunnel		X	
Sump pump for manholes		X	
Tunnel Lighting 50/50		X	X
Canopy lighting 50/50		X	X
Contactor for canopy lights 50/50		X	X
OCR computers in tunnel (if applicable)			X
Fog lights			X
Three phase SSO	X		
Tunnel SSO	X		
Booster pump room Electrical			
Lighting		X	
Power		X	
Booster pump		X	
Booster Pump motor 01		X	
Booster Pump motor 02		X	
Sewer pump station		X	

Equipment	Normal Power supply	Emergency Power supply	UPS power supply
Borehole pump Electrical			
Lighting		X	
Power		X	
Borehole pump		X	

1.17 LIFE EXPECTANCY OF ELECTRICAL, MECHANICAL AND ELECTRONIC EQUIPMENT

1.17.1 The Contractor shall use the life expectance as indicated in the table below to allow for the replacement of equipment.

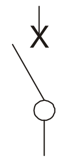
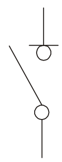
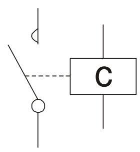
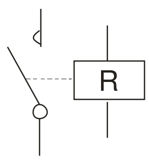
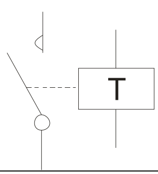
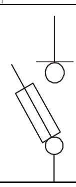
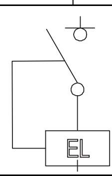
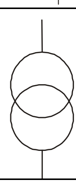
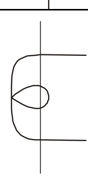
Equipment	Category	Life Expectancy
Air conditioner	Mechanical	15 Years
Ventilation System	Mechanical	30 Years
Geyser	Electrical/Plumbing	14 Years
Electrical hand dryers	Electrical	8 Years
Pumps	Electrical	10 Years
Luminaires	Electrical	20 Years
Road and area lighting installation excluding luminaries	Electrical	30 Years + (including costal areas)
Photo cell	Electrical	10 Years
Garage door motor	Electrical	10 Years
Security gate motor	Electrical	10 Years
UPS excluding batteries	Electrical	20 Years
UPS batteries	Electrical	5 – 10 Years
Diesel Generator	Electrical	100 000 hrs or 30 Years
Diesel fuel filter	Fuel	1000 hrs
Diesel fuel injectors	Fuel	15 000 hrs
Diesel fuel storage	Fuel	8 Years
PABX system	Electronic	10 Years
Access control	Electronic	10 Years
Security system	Electronic	10 Years
CCTV system	Electronic	4 Years
Data Server	Electronic	4 Years
Computers/terminals	Electronic	10 Years

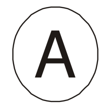
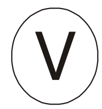
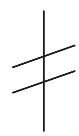
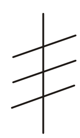
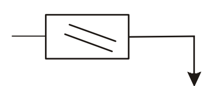
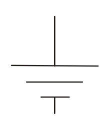
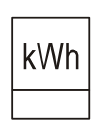
Equipment	Category	Life Expectancy
PLC/RTU systems	Electronic	20 Years

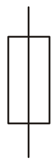
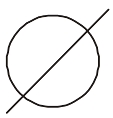
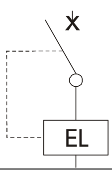
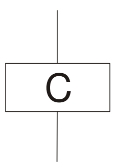
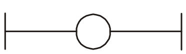
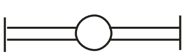
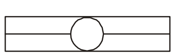
1.18 STANDARD ELECTRICAL SYMBOLS

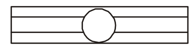
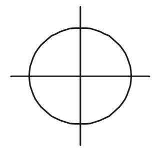
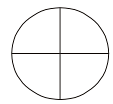
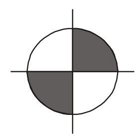
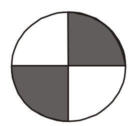
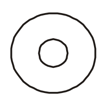
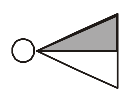
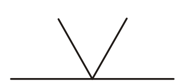
1.18.1 The Contractor shall use the following standard electrical symbols to indicate equipment, installation layouts and requirements, alternative symbols may be used if approved by SANRAL:

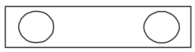
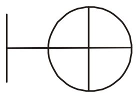
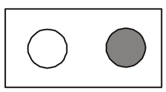
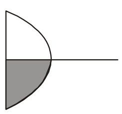
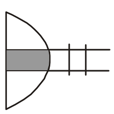
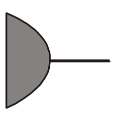
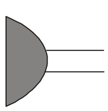
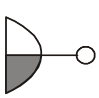
TABLE 1-2: ELECTRICAL SYMBOLS

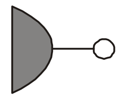
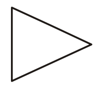
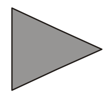
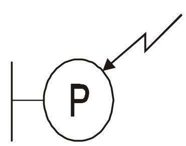
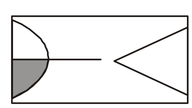
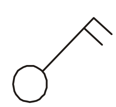
SYMBOL NO	SYMBOL	DESCRIPTION
SC1		CIRCUIT BREAKER
SC2		SWITCH DISCONNECTOR (ON LOAD)
SC3		CONTACTOR
SC4		RELAY
SC5		TIMER
SC6		FUSE SWITCH (ON LOAD)
SC7		EARTH-LEAKAGE CIRCUIT BREAKER
SC8		DISTRIBUTION TRANSFORMER
SC9		CURRENT TRANSFORMER

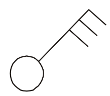
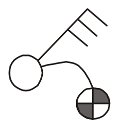
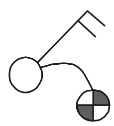
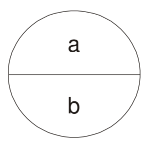
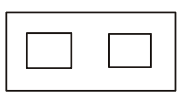
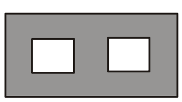
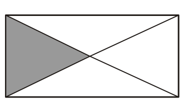
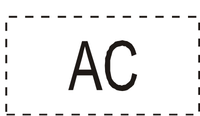
SYMBOL NO	SYMBOL	DESCRIPTION
SC10		AMPERE METER
SC11		VOLT METER
SC12		SELECTOR SWITCH
SC13		SINGLE PHASE/POLE
SC14		DOUBLE PHASE/POLE
SC15		TRIPLE PHASE/POLE
SC16		SURGE ARRESTOR
SC17		EARTH CONNECTION
SC18		KILOWATT HOUR METER

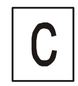
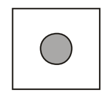
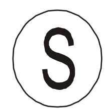
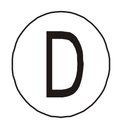
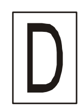
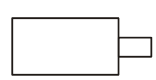
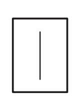
SYMBOL NO	SYMBOL	DESCRIPTION
SC20		MAXIMUM DEMAND METER
SC21		FUSE
SC22		DISCONNECTABLE TERMINAL
SC23		EARTH-LEAKAGE ISOLATOR
SC24		COIL
LIGHTING		
L1		SINGLE LAMP SURFACE FLUORESCENT LUMINAIRE
L2		DOUBLE LAMP SURFACE FLUORESCENT LUMINAIRE
L3		SINGLE LAMP RECESSED FLUORESCENT LUMINAIRE

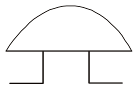
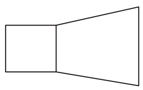
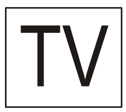
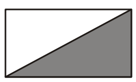
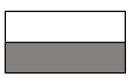
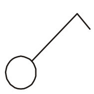
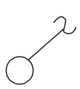
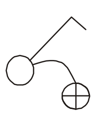
SYMBOL NO	SYMBOL	DESCRIPTION
L4		DOUBLE LAMP RECESSED FLORESCENT LUMINAIRE
L5		RECESSED LUMINAIRE
L6		SURFACE-MOUNTED LUMINAIRE
L7		RECESSED DOWN LIGHT
L8		SURFACE-MOUNTED DOWN LIGHT
L9		POLE-MOUNTED LUMINAIRE
L10		FLOOD LIGHT
L11		220V SUPPLY
L12		BRICK LIGHT

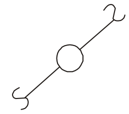
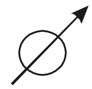
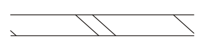
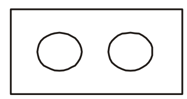
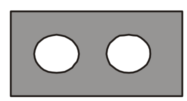
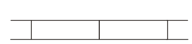
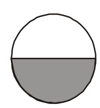
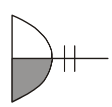
SYMBOL NO	SYMBOL	DESCRIPTION
L13		TUBE LIGHT
L14		WALL-MOUNTED LUMINAIRE
POWER		
L15		STOP/START PUSHBUTTON STATION
P7		16A, 550 AT 400 AFFL
P8		16A, DEDICATED 550 AT 400AFFL
P9		16A, 550 AT SPECIFIED HEIGHT
P10		16A, DEDICATED 550 AT SPECIFIED HEIGHT
P11		5A, 550 AT 400 AFFL

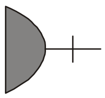
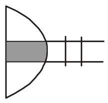
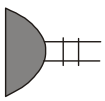
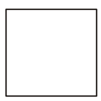
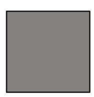
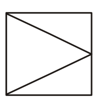
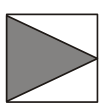
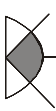
SYMBOL NO	SYMBOL	DESCRIPTION
P12		5A, 220 AT SPECIFIED HEIGHT
P13		TELEPHONE OUTLET AT 400 AFFL
P14		TELEPHONE OUTLET AT SPECIFIED HEIGHT
P15		HAND DRIER OUTLET COMPLETE WITH ISOLATOR IN CEILING VOID AND 50mm dia ROUND BOX AT
P16		THERMOSTAT AT 1200 AFFL
P17		SHAVER SOCKET OUTLET
P18		PHOTO CELL
P19		FLOOR PEDESTAL
P20		DOUBLE-POLE ISOLATOR

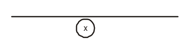
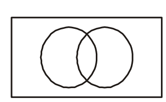
SYMBOL NO	SYMBOL	DESCRIPTION
P21		THREE-POLE ISOLATOR
P22		THREE-POLE ISOLATOR FOR FAN
P23		DOUBLE-POLE ISOLATOR FOR GEYSER
P24		CIRCUIT IDENTIFICATION: a - CURRENT b -
B25		15A SPECIALIZED SOCKET OUTLET IN CEILING (NORMAL SUPPLY)
B26		15A SPECIALIZED SOCKET OUTLET IN CEILING (EMERGENCY SUPPLY)
B27		INDICATION PANEL
B28		AIR CONDITIONER UNIT (BY OTHERS)
SECURITY SYMBOLS		

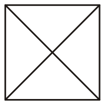
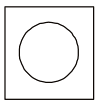
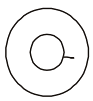
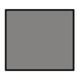
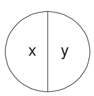
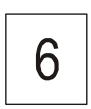
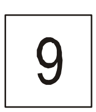
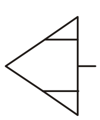
SYMBOL NO	SYMBOL	DESCRIPTION
SE1		CARD READER AT SPECIFIED HEIGHT
SE2		PUSHBUTTON RELEASE FOR DOOR LOCK
SE3		SMOKE DETECTOR
SE4		DOOR MONITOR
SE5		MOVEMENT DETECTOR
SE6		BREAK GLASS AT SPECIFIED HEIGHT
SE7		FIRE TELEPHONE
SE8		CCTV OUTLET AT SPECIFIED HEIGHT
SE9		INTERCOM AT SPECIFIED HEIGHTS

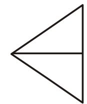
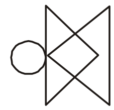
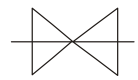
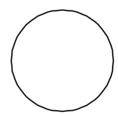
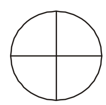
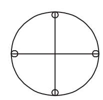
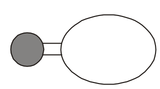
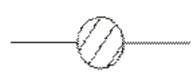
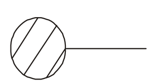
SYMBOL NO	SYMBOL	DESCRIPTION
SE10		BELL SIREN
SE11		SIREN
P67		TELEVISION OUTLET
B30		POWER DISTRIBUTION BOARD
B31		DATA DISTRIBUTION BOARD
B32		TELEPHONE DISTRIBUTION BOARD
B34		1-WAY, 1-LEVER LIGHT SWITCH
B35		2-WAY, 1-LEVER LIGHT SWITCH
B36		1-WAY LIGHT SWITCH WITH INDICATOR LAMP

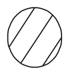
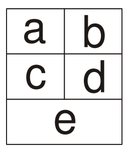
SYMBOL NO	SYMBOL	DESCRIPTION
B37		INTERMEDIATE SWITCH
B38		DIMMER SWITCH
B43		POWER SKIRTING
B44		5A UNSWITCHED SOCKET OUTLET IN CEILING (NORMAL SUPPLY)
B45		5A UNSWITCHED SOCKET OUTLET IN CEILING (EMERGENCY SUPPLY)
B46		CABLE TRAY (SIZE A5 SPECIFIED)
B47		WIRED OUTLET
B48		16A, 550 AT 400 AFFL (DOUBLE)
B49		TRUNKING (SIZE AS SPECIFIED)

SYMBOL NO	SYMBOL	DESCRIPTION
B50		16A, 550 AT SPECIFIED HEIGHT (DOUBLE)
B50		16A, DEDICATED 550 AT 400 AFFL (DOUBLE)
B51		16A, DEDICATED 550 AT SPECIFIED HEIGHT (DOUBLE)
B52		DATA OUTLET AT 400 AFFL
B53		DATA OUTLET AT SPECIFIED HEIGHT
B54		COMBINED DATA AND TEL OUTLET AT 400 AFFL (TUBED WITH 2 X 25mm dia CONDUITS)
B55		COMBINED DATA AND TEL OUTLET AT 400 AFFL (TUBED WITH 2 X 25mm dia CONDUITS)
B56		3 PHASE, 5 PIN 550 AT SPECIFIED HEIGHT
B57		FAN

SYMBOL NO	SYMBOL	DESCRIPTION
ELECTRICAL RETICULATION SYMBOLS		
RET1		HT CABLE
RET2		LT CABLE:; PRIMARY
RET3		LT CABLE: SECONDARY
RET4		STREET LIGHT CABLE
RET5		ELECTRICAL CABLE DUCT, x = AMOUNT OF DUCTS
RET6		COMMUNICATION DUCT (100mm dia), x = AMOUNT OF DUCTS
RET7		COMMUNICATION DUCT (50mm dia)
RET8		MINIATURE SUBSTATION

SYMBOL NO	SYMBOL	DESCRIPTION
RET9		DISTRIBUTION KIOSK
RET10		DRAW PIT (SIZE AS PER SPECIFICATION)
RET11		STREET LIGHT (POST TOP)
RET12		COMMUNICATION DRAW BOX (SIZE AS PER SPECIFICATION)
RET13		CABLE IDENTIFICATION x = CONDUCTOR SIZE y = AMOUNT OF CORES
RET14		CENTRAL METERING KIOSK (4 METERS)
RET15		CENTRAL METERING KIOSK (6 METERS)
RET16		CENTRAL METERING KIOSK (9 METERS)
RET17		POLE WITH STAY

SYMBOL NO	SYMBOL	DESCRIPTION
RET18		POLE WITH STRUT
RET19		POLE WITH SHORT STRUT
RET20		IN-LINE STAY BETWEEN TWO POLES
RET21		LT POLE
RET22		HT POLE
RET23		AREA LIGHT
RET24		STREET LIGHT (CANTILEVER ARM)
RET25		STREET LIGHT 2 x OVERHANG
RET26		STREET LIGHT 1 x OVERHANG

SYMBOL NO	SYMBOL	DESCRIPTION
RET27		DECORATIVE POST TOP
RET28		POLE IDENTIFICATION a = Mast/Pole No. b = Height and No. of Luminaires c = Lamp type d = Lamp voltage e = Mast position/ coordinates

2. SWITCHBOARDS AND MOTOR CONTROL CENTRES FOR VOLTAGES UP TO 1KV

2.1 GENERAL

2.1.1 Introduction

2.1.1.1 This subsection of the specification is applicable to and should be read in conjunction with the following detail requirements:

SUBSECTION 2.2:	CONSTRUCTION OF FLUSH-MOUNTED SWITCHBOARD
SUBSECTION 2.3:	CONSTRUCTION OF SURFACE-MOUNTED SWITCHBOARDS
SUBSECTION 2.4:	CONSTRUCTION OF FREE-STANDING SWITCHBOARDS
SUBSECTION 2.5:	CONSTRUCTION OF MOTOR CONTROL CENTRES
SUBSECTION 2.6:	CONSTRUCTION OF LOW-VOLTAGE DISTRIBUTION CUBICLES (KIOSKS)

2.1.1.2 It should be noted that the word switchboard shall imply motor control centre and vice versa with regard to this part of the specification.

2.1.2 Paint finish

2.1.2.1 The boards shall be finished in accordance with the STANDARD PAINT SPECIFICATION (SECTION 15 of this document). The colour of switchboards shall be electrical orange to SANS 0140, Part 2 on the outside and white on the inside.

2.1.3 Size

2.1.3.1 The switchboards shall be of ample size to accommodate all the specified switchgear and provide space for future switchgear. For every 6 (or part of 6) circuit breakers of a kind on a switchboard, space for an additional circuit breaker of similar size shall be allowed unless future space requirements are clearly specified. Blanking plates shall be provided in these unused positions.

2.1.4 External Dimensions

2.1.4.1 All specified external dimensions for switchboards shall be strictly adhered to. If the spacing requirements specified cannot be adhered to as a result of restricting external dimensions the Contractor or Manufacturers shall obtain the ruling of SANRAL or the Independent Engineer before manufacturing the switchboards. The Contractor shall be responsible for notifying the Manufacturer of the restricting external dimensions. The maximum height of free-standing switchboards shall be 2200 mm.

2.1.5 Moisture and Vermin

2.1.5.1 The switchboards shall be rendered moisture, dust and vermin proof.

2.1.6 Ventilation

2.1.6.1 Switchboards shall be ventilated, especially cubicles containing contactors, transformers or other heat dissipating equipment. Vermin-proof louvers shall be fitted.

2.1.7 Earthing of Metal Parts

2.1.7.1 All non-current-carrying metal parts of the switchboard including the framework, metal enclosures of equipment, iron cores of contactors and transformers, etc. shall be solidly earthed to the earth busbar. All hinged panels and doors in which equipment is mounted shall have a 4 mm flexible braided copper connection bolted to the frame and the panel/door. Screw connections on finished surfaces shall be made with tooth washers.

2.1.8 Welding

2.1.8.1 Sheet metal joints shall be non-continuously butt-welded. Care shall be taken to prevent distortion due to localized heating. Welds shall be ground smooth and the joint wiped with plumber's metal in order to provide a smooth finish.

2.1.9 Mounting of Equipment

2.1.9.1 Access

2.1.9.2 All equipment, busbars and wiring shall be completely accessible when the front and/or back panels are removed.

2.1.9.3 Where front access only is specified, all equipment shall be completely accessible through the front panels.

2.1.10 Space Requirements

2.1.10.1 In designing the switchboards the following requirements shall be strictly adhered to:

(a) A minimum of 75 mm between any piece of equipment and the frame or internal partitioning. This minimum space is required above, below and on the sides of the equipment. In the case of a row of single-pole circuit breakers, the spacing on one side of the row may be reduced to 25 mm.

(b) A minimum of` 75 mm between horizontal rows of equipment. The maximum outside 4 dimensions of equipment shall be considered.

(c) Miniature circuit breakers up to a fault rating of 10 kA, control timers and relays may be installed adjacent to each other.

(d) A minimum of 40 mm between circuit breakers and isolators with a maximum fault rating of 15 kA. For higher ratings, the minimum spacing is 75 mm.

(e) Sufficient space shall be provided for wiring and cable terminations allowing for the appropriate bending radius.

(f) Space for future equipment shall be allowed as specified.

2.1.11 Mounting of Chassis

2.1.11.1 The chassis of flush-mounted and smaller surface-mounted boards shall be mounted on the tray, leaving sufficient space for wiring between rows of equipment and on the sides. For all free-standing switchboards and surface-mounted switchboards where the main switch rating exceeds 100 A (triple pole), space for wiring shall be provided between the chassis and tray. This space shall also be adequate to pass the supply cable behind the chassis to connect to the main switch without making use of sharp bends.

2.1.12 Grouping of Equipment

(a) Equipment shall generally be grouped in the following logical fashion:

i. Main switch - to be installed separately where the rating exceeds 100 A (single pole) or 60 A (triple pole). The minimum spacing of 75 mm all round shall apply.

ii. Sub main switches i.e. Earth leakage units, fuses, fuse switches, circuit breakers and isolators shall be so arranged so that it is clear from the layout which sub-circuits are supplied from such equipment.

iii. Contactors, time switches and relays shall be contained in the same, or special adjoining, compartment as the supplies controlled by such equipment.

iv. Instrumentation, indication and protection relays shall be arranged so that it is evident from the layout on which circuits the equipment is monitoring.

v. Where a portion of a board is supplied from an emergency or special power source, the associated equipment including changeover equipment shall be grouped in an electrically and mechanically separate compartment. The front panel of such compartments shall be painted in a different colour, normally red.

vi. A switchboard shall thus normally contain the following groupings:

vii. Main switch;

viii. Sub main switches and corresponding outgoing circuits;

ix. Outgoing fused or other circuits; and

x. Special power source equipment.

2.1.13 General Mounting Requirements

2.1.13.1 Equipment shall be mounted by bolts, washers and nuts or by bolts screwed directly into the mounting plate for equipment up to 1 kg. Under no circumstances shall equipment be fixed with self-tapping screws.

2.1.14 Mounting of Circuit Breakers and Isolators

2.1.14.1 All moulded-case circuit breakers and isolators shall be flush mounted with only the toggles protruding. Miniature frame equipment may be installed in clip-in trays mounted on the chassis. Large frame equipment shall be bolted to the frame or chassis.

2.1.15 Mounting of Contactors, Transducers, Relays and Control Circuit Timers

2.1.15.1 Shall be mounted onto rails fixed to the chassis or shall be fixed directly onto the chassis.

2.1.16 Instrumentation and Control Equipment

2.1.16.1 All metering equipment shall be mounted flush in the hinged front panel or door.

2.1.16.2 Metering and indication equipment shall be clearly visible from the front. Where it is not practical to mount the equipment on the hinged panel or door due to the size of the equipment, cut outs closed with glass or Perspex shall be provided and the equipment shall be mounted directly behind these viewing windows.

2.1.16.3 The terminals on the back of equipment mounted on hinged doors/panels shall be covered or shrouded by removable covers of insulating material, fixed to the door, to prevent accidental contact.

2.1.17 Adjustable Control Equipment

2.1.17.1 Shall be mounted flush into the panel/door so that Equipment is accessible for adjustments.

(a) Equipment not designed for flush mounting shall be mounted behind the door/panel with a hinged access flap in the front panel to obtain access to control adjustments.

(b) Timers used in process control circuits shall not be subject to the above unless specifically specified for panel/door mounting. Timers controlling power circuit i.e. lights etc. shall be accessible without opening the panel/door.

2.1.18 Fuses and Fuse Holders

2.1.18.1 Power fuses shall be mounted semi-recessed through the front panel to facilitate replacement without opening the panel.

2.1.18.2 Control fuses shall be mounted behind the panel.

2.1.18.3 Voltmeters and kWh meters shall be protected by busbar-mounted fuses (20 A) and panel-mounted fuses (5 A).

2.1.19 Rack-out Circuit Breakers

2.1.19.1 Rack-out type air or vacuum circuit breakers shall be mounted in the bottom section of the board, flush behind the panel with only the handle protruding. The panel/door shall be designed that it will have to be opened to rack the breaker out. The frame of the breaker shall be bonded to the earth bar by means of a solid copper bar.

2.1.20 Fused Switches

2.1.20.1 The framework shall be so designed that fused switches may be mounted flush and bolted directly to the frame. The frame of the switches shall be bonded to the earth bar with a solid copper bar.

2.1.21 Shrouding of Terminals

2.1.21.1 The live terminals of all main switches, main circuit breakers and main isolators shall be shrouded with an insulating material to prevent accidental contact if the panel or door is opened.

2.1.22 Provision for Cable Connections

2.1.22.1 Busbar stubs shall be provided for the termination of all cables larger than 35 mm², all parallel cables that are to be terminated to the board and in cases where the terminals of the equipment are not of sufficient size to accept the conductor.

2.1.22.2 Cable tails shall be limited to a length of 600 mm and in cases where equipment intended for termination is further away from the gland plates, terminals or busbars will be provided within 600 mm of the gland plate for the termination of such cables.

2.1.22.3 Care shall be taken to ensure that at least 200 mm is provided between the gland plate and the termination point for cables between 35 mm² and 70 mm² and at least 300 mm for larger cables.

2.1.23 Busbar in Switchboards

2.1.23.1 Type

Busbars shall be fabricated of solid drawn high conductivity copper with a rectangular cross section in accordance with SANS 784 as amended and BS 159: 1992 where applicable. Aluminium bars are not acceptable.

2.1.23.2 Ratings

The maximum allowable temperature of busbars (including joints) carrying full load current in an ambient temperature as specified shall not exceed 80°C. Table II can be used as a guide in determining busbar ratings where the distance between the phase busbars including joints and bolts is at least 50 mm and at least 150 mm from the sheet metal enclosure. It is however essential that the switchboard Manufacturer shall make due allowance for the “proximity and skin” effects, the effect of ferrous enclosures, ventilation, etc. for the arrangement used in his switchboard design. Manufacturers shall, where requested, prove that the busbar rating and enclosure design comply with the temperature rise as specified above. Neutral busbars in 3-phase, 4-wire supplies shall have a cross section of at least

60% of the cross section of the phase busbars. Busbars shall be capable of carrying the full rated current along their entire length. Tapering of busbars will not be permitted.

In addition to the current rating, busbars shall comply with the fault level rating of BS 159 where:

A = 7,2I3 I (t) °·'

A = minimum cross section in mm²

I = prospective fault current in KA

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

(minimum allowable value for t = O,2 s.).

Where a busbar consists of two or more busbars per phase (laminations), the laminations shall be separated by a minimum distance of the thickness of one lamination. The laminations shall be clamped together with copper spacers at intervals not exceeding 450 mm in order to equalise the current distribution in the laminations. The busbar ratings shown in Table II shall be multiplied by the multiplication factors in Table I to determine the total current rating per phase:

TABLE 2-1: DERATING FACTORS FOR LAMINATED BUSBARS

WIDTH (VERTICAL) DIMENSION (mm)	NUMBER OF PARALLEL BUSBARS PER PHASE		
	2	3	4
Less than 50	1,74	2,30	2,90
Less than 75	1,70	2,20	2,45
Less than 100	1,66	2,09	2,30
Less than 150	1,62	1,97	2,15
More than 150	1,57	1,84	2,00

TABLE 2-2: CURRENT RATING OF SINGLE COPPER BUSBARS (A)

Width (mm)	Thickness (mm)							
	3.15	4.0	5.0	6.3	8.0	10	2.5	16
2.5	146							
16	178	205						
20	215	246	280					
25	250	296	335	383				
31.5	316	360	406	458	552			
40	388	441	492	556	635	715		

Width (mm)	**Thickness (mm)**							
	3.15	**4.0**	**5.0**	**6.3**	**8.0**	**10**	**2.5**	**16**
50	471	534	592	668	775	842		
63	570	642	719	805	902	1005	120	
80	700	786	877	979	1090	207	1338	
100		950	1050	1170	1301	1440	1582	
25			262	1396	1555	1706	1885	2090
160				1703	1887	2074	2270	2560
200					2307	2550	2795	3100
250						3010	3210	3630
315							4000	4300

2.1.23.3 Mounting

All busbars shall be installed horizontally or vertically with the longer side of the section in the vertical plane. Main busbars shall be supported by 'DELARON" or "THIOLITE" resin bound synthetic wood panels or a similar dielectric material. The surfaces of these supports shall be treated to prevent surface tracking. The support shall be bolted securely to the framework and busbars shall fit tightly in the supports. Alternatively, busbars may be supported on resin insulators. Porcelain and glass insulators are not acceptable. The supports shall be designed to prevent collapse due to mechanical stress under short circuit conditions. The maximum allowable spacing of busbar supports for fault levels of 15 kA and more is 500 mm. All busbars other than main busbars shall be mounted on suitable insulators or directly on circuit breaker terminals, where practical. Busbars shall be mounted at least 100 mm away from the nearest equipment. Busbars shall be properly insulated and sufficiently supported to withstand the maximum fault current at the point where they pass through panels or partitions of switchboards. This shall preferably be achieved by means of resin bound synthetic wood or similar material with cut outs, which fit tightly around the busbars. The insulating panel shall be firmly bolted to the frame. Busbars or 'droppers' that pass through internal partitions in the switchboard shall be similarly insulated and supported.

2.1.23.4 Marking

Busbars shall be provided with phase colour identification marking i.e. red, yellow, blue and black taking the form of coloured bands at intervals along the busbar so that the phase colour can be determined when any access panel to the busbar is opened. The bands shall be at least 50 mm wide and shall consist of heat-shrinkable PVC or paint. PVC tape is not acceptable.

2.1.23.5 Covering

Only dropper bars to equipment shall be insulated with heat-shrinkable PVC or suitable PVC power tape, coloured according to phase colours.

2.1.23.6 Shutters

Hinged shutters shall be provided to cover busbars where rack-out air circuit breakers are installed. These shutters shall be manufactured of a suitable insulating material. The shutters shall operate automatically with the rack-out movement of the circuit breaker. The wording LINE and LOAD shall appear on the inside of the shutters to indicate the corresponding contact points for switchgear.

2.1.23.7 Busbar Joints

Busbar joints shall be accomplished by overlaps for a distance equal to twice the width of the bar and shall be fastened by the use of high tensile cadmium plated bolts, nuts and spring washers.

On the main bars, at least four 10 mm diameter bolts shall be used at each Joint surface. On bars smaller than 40 mm wide only two 6 mm diameter bolts will be acceptable. Contact surfaces shall be tinned or silver plated. Acid-based flux shall not be used.

2.1.23.8 Earth Busbar

An earth busbar shall be installed in a convenient position along the entire length of the switchboard, bolted directly to the framework. The cross-sectional area of earth busbars shall be calculated according to the formula in I.E.C. 439 with a minimum cross section of 6,3 mm x 25 mm. In addition, the longer side of the earth busbar shall be at least twice the diameter of the largest bolt that will be fitted to the busbar. Earth terminal strips with screws will only be accepted for flush mounted and small surface mounted boards. Earth terminal strips where allowed, shall have two bolts per connection point.

2.1.24 Wiring

2.1.24.1 Type

Connections in the switchboard shall consist of 600/1000V grade (minimum) heavy duty coloured PVC-insulated stranded annealed copper conductors. All circuits with a rating of 200 A and more and all connections to cables larger than 70 mm^2 shall consist of insulated busbars ("droppers') only.

No conductor shall be less than 2,5 mm cross-sectional area nor be less than 7 strands in lay-up.

2.1.24.2 Rating

The current rating of all conductors used for the internal wiring of switchboard shall be equal to the capacity of the circuit breaker or fuse which protects the circuit and shall be determined according to the following table which is applicable for an ambient temperature of 40°C. For higher ambient temperatures the derating factors of SANS 10142-1, Table 10 shall be applied.

TABLE 2-3: CONDUCTOR CURRENT RATING

NOMINAL CROSS SECTION (mm²)	CONDUCTOR CURRENT RATING (A)				
	Number of conductors bunched together				
	1	2-3	4-5	6-9	10 & more
2.5	17	16	14	2	10
4	22	20	18	16	13
6	29	26	23	20	17
10	40	36	32	28	24
16	55	49	44	38	33
25	74	67	59	52	44
35	93	84	74	65	56
50	119	107	95	83	71
70	148	133	119	104	89

2.1.24.3 Bunching

Bunched conductors shall be neatly formed to present a uniform appearance without twisting or crossing of conductors. Conductors leaving harnesses shall be so arranged that they are adjacent to the chassis. Power and auxiliary wiring shall not be bunched in groups of more than 3 and 20 conductors respectively. Spacing between bunches shall be equal to at least the diameter of the larger bunch.

Under no circumstances may PVC tape be used for the bunching of conductors, only purpose-made straps or spiral binding is acceptable.

2.1.24.4 Wiring Channels

Where wiring channels are used, they shall be installed horizontally and vertically. Under no circumstances may power and control circuit conductors be installed in the same wiring channel. Channels shall not be more than 60% full.

2.1.24.5 Protection

Grommets shall be installed in each hole in the metalwork through which conductors pass.

All wiring shall be installed away from terminals, clamps or other current carrying parts. Wiring shall be kept away from exposed metal edges or shall be protected where they cross metal edges.

2.1.24.6 Joints

Conductors may be joined at equipment terminals or numbered terminal strips only. Ferruled and taped or other joints are not acceptable.

2.1.24.7 Neutral Connections

Where neutral connections are looped between the terminals of instruments, it is essential that the two conductor ends be inserted into a common lug and are crimped together in order that the neutral connection is not broken when the conductors are removed from one of the instruments.

2.1.24.8 Lugs

Conductors terminating on meters, fuse holders, other equipment with stud terminals and all control wiring shall be tilted with crimped lugs.

2.1.24.9 Marking

Both ends of all control conductors shall be numbered by means of white interlocking ”HELAGRIP" or "OVALGRIP” markers as distributed by BOWTHORPE-HELLERMAN DEUTSCH (PTY) LTD. Adhesive strips or split ferrules are not acceptable.

2.1.24.10 Colours

Power circuit conductors shall he coloured according to phase colours or black in the case of conductors, which carry alternative phase, e.g. reversing circuits. Control wiring shall be coloured as follows:

(a) In phase colours for phase connection on current and voltage transformers or connections in power circuits.

(b) Black in the case of a.c. and a.c./d.c. circuits.

(c) Grey for d.c. circuits only.

(d) Green for earth connections.

2.1.24.11 Door Connections

Conductors to hinged panels and doors shall be secured on both the door and the frame and shall be looped between the two points. The loop shall be arranged to produce a twisting motion when the door is opened or closed.

2.1.24.12 Segregation

All wiring between different panels within the same switchboard shall be installed in wiring channels.

2.1.24.13 Bends

Where conductors change direction, smooth bends shall be formed with a radius of at least 5 times the outside diameter of the conductor or harness.

2.1.24.14 Position

For ease of access, wiring should be confined to the front portions of switchboards as far as possible. This requirement is important for wiring between circuit breakers with a rating of less than 60 A and the associated main circuit breaker as well as the wiring from circuit breakers to lighting and socket outlet circuits.

2.1.24.15 Load-End Connections

The supply-end connections to equipment, as a rule, shall be at the top and the load-end connections at the bottom. Where the load and supply ends of the main circuit breaker or isolator of a switchboard are not indicated the load may be connected to the top end only if the wording LINE and LOAD is correctly indicated on the equipment.

2.1.24.16 Wiring to Circuit Breakers

Loop connections may only be installed for a maximum of two outgoing circuits. Where there are more than two outgoing circuits, busbars shall be used and equipment connected individually to busbars. Where M.C.Bs are mounted in continuous rows and supplied by busbars connected to each M.C.B., each busbar shall be supplied by a separate conductor. This conductor shall be connected to the busbar by means of a separate lug and not via an M.C.B. terminal.

2.1.25 Labelling

2.1.25.1 Material

Engraved sandwich board e.g. Traffolyte, Darxic or equivalent.

For outdoor applications labels shall be brass engraved with black letters and clear lacquered after the labels have been lightly sanded.

2.1.25.2 Colour

Black letters on white background except in the case of cautionary labels where the letters shall be white on a red background.

2.1.25.3 Letter Format

All lettering shall be in upper-case letters except where standard abbreviations are used, e.g. kWh, etc.

2.1.25.4 Language

All labels shall be bilingual (English and Afrikaans) unless specifically specified to the contrary in the Detailed Specification.

2.1.25.5 Fixing

The label shall be fixed in one of the following ways to ensure that the label is squarely fixed and does not warp:

(a) Nickel-plated self-tapping screws;

(b) Brass bolts and nuts;

(c) Crewed rivets; and

(d) Extruded aluminium sections, with tight-fitting labels, fixed by one of the above methods.

(e) Adhesive fixing alone will not be accepted.

2.1.25.6 Minimum Labelling Required

The minimum labelling required for switchboards and equipment shall be as follows:

Board Label:	Designating the board with lettering of at least 25 mm high, e.g. SWITCHBOARD DPI.-2
Section Label:	Designating various sections of one switchboard with lettering of at least 10 mm high e.g. 50 V D.C. SECTION BUSBAR SECTION
Equipment Labels:	Designating the functions of equipment with 6 mm high lettering e.g. MAIN SWITCH SUPPLY TO SWITCHBOARD MXP-06 VOLT METER SELECTOR SWITCH ON - OFF - TRIP
Fuses:	All fuses including instrument fuses shall have labels indicating the function and fuse rating, in 6 mm high lettering, e.g. TRIP CIRCUIT - 6 A
Circuit Labels:	Indicating the plant reference with 10 mm high letters e.g. SLUDGE PUMP NO. 1

Components:	All components including instruments, indicating lights, switches, pushbuttons, relays, timers, contactors etc. shall be identified with labels. The function of the equipment shall be clearly identified with 5 mm high lettering. Numbers allocated to relays, timers etc. shall correspond with the numbers used on the circuit diagrams.
Legend Cards:	In the cue of grouped single pole circuit breakers or where equipment is positioned too close to each other, such equipment may be identified with a code. The code shall be identified on a legend card, which shall be installed on the inside of the door or in any other position where it can conveniently be observed. Legend cards shall be protected behind a clear protective material.
Metering:	Current transformer ratios and multiplication factors shall be indicated on labels (5 mm lettering) next to corresponding instruments.

2.1.25.7 Approval of Labels

All labels shall be approved by SANRAL or the Independent Engineer prior to engraving. This does not relieve the Contractor from correcting errors if found afterwards.

2.1.26 Inspection and Tests

2.1.26.1 Notice

Seven days notice of pending inspections or tests shall be given in writing to SANRAL or the Independent Engineer.

2.1.26.2 Inspections

SANRAL or the Independent Engineer will inspect the boards after the steelwork has completed and painted prior to the fitting of equipment and again upon completion in all respects.

2.1.26.3 Tests

The following tests shall be carried out in the presence of SANRAL or the Independent Engineer:

(i) Pressure test - 2 kV, 50 Hz for one minute;

(ii) Primary current injection tests to prove the functioning of all protective devices, metering and current transformers; and

(iii) Functional tests of all equipment, controls and interlocking.

2.1.26.4 Test Certificate

Test certificates of current transformers, capacitor banks etc. and complete test reports of tests carried out at the works shall be submitted to SANRAL or the Independent Engineer.

2.1.26.5 Equipment

The Contractor shall supply all test equipment, test facilities, dummy loads, etc. at his cost.

2.1.26.6 Planning

The test equipment shall be immediately available during tests.

The tests shall be so planned that they can be carried out sequentially without delays between tests. All the tests shall be carried out in full, prior to SANRAL or the Independent Engineer being requested to witness the tests, to ensure that defects are corrected before SANRAL or the Independent Engineer is called on to witness the tests.

2.1.27 Drawings and Manuals

2.1.27.1 Drawings of Approval

A set of three prints of the shop drawings for the switchboards shall be submitted to SANRAL or the Independent Engineer for approval before the boards are manufactured. The following information shall be presented:

(a) A complete wiring diagram of the equipment on the boards.

(b) A complete layout of the arrangement of the switchboards indicating all equipment dimensions and the construction of the boards. The positions, method of fixing and dimensions of busbars shall be shown.

(c) All labelling information.

(d) The make, catalogue number and capacity of all equipment such as isolators, circuit breakers, fuses, contactors, etc.

(e) All terminal and wire numbers.

(f) A schedule of all equipment intended for use on the switchboard i.e. relays, timers, indicating lamps etc.

2.1.27.2 Approval

The approval of drawings shall not relieve the Contractor of his responsibility to the Owner to supply the switchboards according to the requirements of this Specification or to the requirements of the Detailed Technical Specification. Drawings submitted to the Contractor by a manufacturer may not be passed on to SANRAL or the Independent Engineer without the Contractors stamp of approval.

2.1.27.3 “As built” Drawings

A complete set of transparent drawings with all the above information updated to include all modifications and/or revisions shall be handed to SANRAL or the Independent Engineer upon completion of the switchboards.

2.1.27.4 Manuals

The Contractor shall prepare at his cost three copies of operating and maintenance manuals of all the components used in the switchboard including descriptive brochures and pamphlets of the equipment. Three copies of a complete materials list indicating catalogue and ordering information of all components, shall also be provided.

2.1.28 Installation

2.1.28.1 Positions

The Contractor shall ascertain the exact position of switchboards and shall arrange timeously for the installation of cable ducts, openings in the structure, flush draw trays behind switchboards and supports over cable trenches and other openings.

2.1.28.2 Bases

Where floor standing type switchboards are indicated in areas where no floors exist or outdoors the Contractor shall be responsible for the provision of suitable concrete bases.

2.1.28.3 Protection

During construction, the switchboards shall be protected against damage and penetration of moisture, dust or vermin. The boards shall be handed over in a clean, undamaged state.

2.1.28.4 Mounting Heights

Flush and surface-mounted switchboards shall he mounted so that the upper edge of the board is 2000 mm above final floor level.

2.1.28.5 Storage

Switchboards which cannot be installed and put into service immediately, shall be stored so as to maintain the equipment in a clean and dry condition and shall be placed on a level surface.

2.1.28.6 Vermin Proofing

The switchboard shall be rendered vermin proof after the installation of all cables and other terminations.

2.1.28.7 Cable Supports

In the case of top-entry boards, suitable supports shall be provided to clamp the cables to relieve the weight on the glands.

2.1.28.8 Free-Standing Board

The switchboard shall be bolted down into position prior to terminating. Wedges shall be provided to ensure that the board is level and all gaps between the base frame and floor shall be grouted with a cement grout mixture. At least two fixings per cubicle shall be provided.

2.1.28.9 Surface Boards

The switchboard shall be fixed to the wall with four or more expansion type anchor bolts.

2.1.28.10 Termination of Cables

All conductors shall have crimped lugs and shall be bolted onto busbars with high tensile bolts, nuts and spring washers.

Parallel incoming or outgoing cables shall be terminated onto busbars without crossing of the conductors. All cables shall be labelled above the gland plate to indicate the purpose or destination of the cable. These designations shall be indicated on the wiring diagrams.

2.1.28.11 Termination of Conduits

Conduits shall terminate in the trays of flush and surface-mounted boards. In the case of free-standing switchboards, conduits shall terminate in the gland plate or in top non-removable panels.

2.1.28.12 Tests

Prior to energising the following tests shall be done and witnessed by SANRAL or the Independent Engineer:

Pressure test (2 kV, 50 Hz for one minute) between phases and earth and between neutral and earth. Care shall be taken to ensure that all control fuses are removed prior to the pressure test, as the control circuits should not be subjected to the test. Lightning arrestors should also be disconnected.

All control circuits shall be checked to ascertain their correct functioning.

The operation of all fuse switches, circuit breakers and isolators shall be checked to ensure that the equipment opens and closes properly and continuity is obtained.

Over and above the pressure test, 500 V Megger tests shall be done between phases and neutral.

2.2 CONSTRUCTION OF FLUSH-MOUNTED SWITCHBOARDS

2.2.1 Bonding Tray

2.2.1.1 Bonding trays for flush mounted switchboards shall be of rigidly constructed galvanized steel, braced and reinforced. The steel used shall be 1,4 mm thick for boards up to 600 mm wide and 700 mm high and 1,6 mm thick for bigger boards. Formed gussets shall be provided at the corners. All tray joints shall he properly welded or securely bolted. A brass or cadmium plated steel earth connection stud and nut shall be provided. The depths of the switchboard shall not exceed 100 mm for single brick walls and 150 mm for double brick walls. If the type of equipment specified requires a greater depth, the board shall be semi-flush.

2.2.2 Expanded Metal

2.2.2.1 Where switchboards are to be built into single brick walls expanded metal shall be spot welded to the rear of the bonding trays. The expanded metal shall protrude at least 75 mm on each tray side to prevent plaster from cracking.

2.2.3 Knock-outs

2.2.3.1 Ample knock-outs shall be provided in the top and bottom ends of each switchboard tray to allow for the installation of conduits for the specified and future circuits. Knock-outs shall be allowed for equal quantities of 20 mm dia and 25 mm dia conduits. Provision shall however be made for termination of at least 2 x 25 mm dia conduits at the top and 2 x 25 mm dia conduits at the bottom of each tray over and above the knock-outs provided for 20 mm dia conduits.

2.2.4 Architrave Frame

2.2.4.1 The switchboard shall have an architrave frame manufactured of 1,6 mm thick sheet steel with bevelled edges. The architrave frame shall be fixed to the tray in such a fashion to allow for depth adjustment and irregularities of the wall.

2.2.5 Extension Frames

2.2.5.1 Semi-flush-mounted switchboards shall be equipped with extension frames. Generally, the frame depths shall be 50 mm but may be altered to suit each application.

2.2.6 Chassis

2.2.6.1 The chassis for mounting of switchgear and equipment shall be of rigid construction and shall be fixed securely to the architrave frame or bonding tray by means of bolts screwed into tapped holes or bolts and nuts. Self-tapping screws are not acceptable. The chassis position shall be adjustable in the horizontal plane.

2.2.7 Panel (Faceplate)

2.2.7.1 A suitable stiffened panel manufactured of 1,6 mm thick sheet steel shall be installed in the architrave frame for flush mounting of switchgear. The panels shall have machine-punched slots for housing the specified and future switchgear, instruments, fuse holders, isolating switches, indicator lamps, etc. No equipment may be mounted on the panel (faceplate) unless it is permanently hinged to the switchboard frame.

2.2.8 Fixing of Panels

2.2.8.1 The panel for each switchboard shall be secured to the architrave frame by means of 6 mm studs and chromium plated hexagonal domed nuts, hank nuts, or square key fasteners. Alternatively, the panel may be secured to the architrave frame by means of two pins at the bottom and a latch or lock at the top of the panel. Self-tapping screws will not be allowed. Where it is required that equipment be mounted on the panel, the panel shall be securely hinged to the switchboard frame.

2.2.9 Panel Handles

2.2.9.1 Two chromium plated handles shall be provided on each front cover. The handles shall be horizontally mounted at the top and bottom of each panel. Handles can be omitted if square key fasteners are used.

2.2.10 Hinged Panels

2.2.10.1 Where hinged panels are specified, the hinges shall be fixed to the architrave frame and the panel shall be secured by means of square key fasteners. The panel shall be removable when it is in the open position.

2.2.11 Doors

2.2.11.1 All switchboards shall be equipped with doors unless otherwise specified in the Detailed Specification. The doors shall be suitably braced to ensure stiffness and when in the closed position shall be flush with the architrave frame. The doors shall be of 1,6 mm sheet steel. The door width shall not exceed 600 mm.

2.2.12 Door Handles and Catches

2.2.12.1 All switchboard doors shall be equipped with handles and catches. Locks shall only be provided when specified in the Detailed Specification. In all cases where lockable doors are required and in all cases where the switchboard doors are higher or wider than 450 mm, handles consisting of a pushbutton-and-catch combination shall be installed. Switchboard doors smaller than 450 mm in height and width may be equipped with spring-loaded flush-mounted ring type latches, Square key operated catches are not acceptable unless specifically specified in the Detailed Specification.

2.2.13 Neutral Bar

2.2.13.1 Neutral bar(s) of the solid square brass type with saddle type terminals shall be provided with sufficient terminations for each circuit in close proximity of the live termination for the circuits. The neutral bar shall be connected to the main neutral bar.

2.2.14 Earth Bars

2.2.14.1 Solid square earth bars with double screw connections shall be provided with sufficient space for the individual connection of all earth conductors.

2.3 CONSTRUCTION OF SURFACE-MOUNTED SWITCHBOARDS

2.3.1 Switchboard Tray

2.3.1.1 Surface-mounted switchboards shall be equipped with a 1,6 mm sheet steel, reinforced tray. The tray shall be fixed to walls or other surfaces from the inside of the tray. A brass or cadmium plated steel earth connection stud and nut shall be provided.

2.3.2 Construction

2.3.2.1 All joints shall be welded or securely bolted. The tray shall be square and neatly finished without protrusions. The front tray sides shall be rounded with an edge of at least 20 mm to accommodate flush doors.

2.3.3 Dimensions

2.3.3.1 The depth of the switchboard shall be determined by the equipment specified.

2.3.4 Chassis

2.3.4.1 The requirements for chassis, panels and doors shall be as specified for flush-mounted switchboards. The doors shall be hinged and shall fit flush in the frame in the closed position. Knock-outs shall not be provided unless specifically called for.

2.4 CONSTRUCTION OF FREE-STANDING SWITCHBOARDS (MAIN AND SUB-MAIN SWITCHBOARDS)

2.4.1 Framework

2.4.1.1 Free-standing switchboards shall be manufactured from solid angle iron, channel iron or 2 mm minimum folded metal framework and a solid U-channel base frame, sufficiently braced to support all equipment and span floor trenches and access holes. Enclosures may also consist of prefabricated components bolted together to form complete tiers in which case all such components shall be fabricated by means of jigs and shall be interchangeable. Switchboards shall be of cubicle design with 2 mm side panels forming divisions between cubicles. The maximum allowable cubicle width is 1,5 m. The design of the frame shall provide for the mounting of main circuit breakers, busbars and other equipment. Switchboards wider than 200 mm shall be fitted with lifting lugs fitted to stiffened and braced top panels to facilitate loading and transportation of the board.

2.4.1.2 Beaded rubber packing shall be installed in the joints between adjoining cubicles.

2.4.2 Side Panels

2.4.2.1 The side and rear panels shall be removable and shall be manufactured from 2 mm minimum sheet steel. The panels shall have upturned edges which are recessed in the frame or which fit over lips on the switchboard frame. The panels shall be secured to the frame by means of square key fasteners. Where switchboards are installed in vertical building ducts or against walls, the rear and side panels may consist of a single folded sheet which is either bolted or welded to the frame or forms part of the folded metal frame.

2.4.3 Front Panels

2.4.3.1 The front panels of floor standing switchboards shall be hinged except where flush-mounted equipment prevents this. Enclosed switchgear with front panels e.g. combination fuse switch units, may be flush mounted in the board in lieu of separate hinged panels. The panels shall be arranged in multi-tiered fashion to allow for the logical grouping of equipment.

2.4.3.2 The hinged front panels shall have a dished appearance with upturns, which fit over a lip on the switchboard frame. Alternatively, the hinged panels shall have folded edges and shall be fitted flush or slightly recessed in the switchboard frame. Corners shall be welded and smoothed.

2.4.3.3 The panels shall be of 2 mm minimum sheet steel with machine-punched slots to allow for the flush mounting of all instrumentation and switchgear toggles and operating handles. A minimum clearance of 50 mm shall be maintained between the rear (taking into account terminals or other projections) of equipment mounted on the panels and the frame, chassis and live components of the switchboard. Separate panels shall preferably be provided for the mounting of instrumentation and for covering flush-mounted switchgear.

2.4.3.4 Hinged panels shall be suitably braced and stiffened to carry the weight of flush-mounted equipment and to prevent warping.

2.4.3.5 Long pedestal type hinges with two fixing bolts per hinge shall be used to support hinged panels. Panels with a height of more than 900 mm shall be fixed with at least three hinges.

2.4.3.6 The panels shall be secured by means of square key fasteners.

2.4.3.7 Blanking plates shall be fitted over slots intended for future equipment. These plates shall be fixed in such a fashion that fixing holes do not need to be drilled through the front panel.

2.4.3.8 Panels shall be fitted with gaskets of resilient non-perishable material, which will not be distorted by the open/close action of the panel.

2.4.3.9 Unhinged, removable front panels with 2 retaining rings, and square key fastener or similar arrangement may only be used where the prior approval of SANRAL or the Independent Engineer has been obtained. The panels shall comply with the relevant items above.

2.4.3.10 Panels used for the mounting of equipment shall always be hinged.

2.4.4 Chassis

2.4.4.1 Suitably braced chassis for the mounting of switchgear and equipment shall be firmly secured to the frame of the switchboard. The chassis shall be designed so that the switchgear can be installed in accordance with the specified mounting requirements. Circuit breakers and isolating switches, which are not of the moulded-case type and the busbar insulators may be secured directly to the framework.

2.4.5 Doors

2.4.5.1 Doors shall only by provided when specified in the Detailed Technical Specification. Doors shall be arranged in multi-tiered fashion.

2.4.5.2 Doors shall have a dished appearance with 20 mm upturns which fits on the switchboard frame or which fit flush in the switchboard frame. Corners shall be welded and smoothed.

2.4.5.3 Doors shall be of 2 mm minimum sheet steel.

2.4.5.4 Doors shall be suitably braced and stiffened to prevent distortion.

2.4.5.5 Long pedestal type hinges with two fixing bolts per hinge shall be used to support doors. At least three hinges shall be provided on doors higher than 900 mm.

2.4.5.6 Doors shall be fitted with handles consisting of a pushbutton-and-handle combination with spring-loaded latch or a rotary handle-and-catch combination. Flush mounted ring type handles or square key operated latches are not acceptable. Unless specifically specified in the detail specification the same key shall fit all doors on the switchboard.

2.4.5.7 Doors shall be fitted with gaskets of resilient non-perishable materials, which will not distort owing to the action of the door.

2.4.6 Dismantling and Transportation

2.4.6.1 The Contractor shall verify the position of all switchboards on site. For ease of transportation and to facilitate access to the allocated accommodation, the switchboard may be dismantled into cubicles. The cubicles of the board shall be of suitable size to pass through doorways, passages etc. Each cubicle shall be rigidly manufactured to ensure that damage to the switchgear will not occur during transportation and handling. Where required, switchboards shall have temporary wood or steel bracing to protect switchgear and facilitate handling. When positioned, the cubicles shall be bolted together.

2.4.7 Busbars

2.4.7.1 Solid copper busbars shall be provided in the switchboard in accordance with SUBSECTION 1.10. In switchboards with a fault current in excess of 20 kA, the busbars shall be contained in a chamber completely segregated from the rest of the board except those cubicles constituting incoming feeder or busbar sectionalizing cubicles, which may form part of the busbar chamber.

2.4.8 Earth Busbars

2.4.8.1 An earth busbar shall be provided for the full length of the board in a suitable position in the switchboard in accordance with the requirements of subsection 1.10.

2.4.9 Cable Gland Plate

2.4.9.1 A cable gland plate shall be installed a minimum of 300 mm above the bottom of the switchboard to house the cable glands. The gland plate shall be suitable for the type of gland or end boxes to be used. Cable glands for top-exit cables may be secured to a top panel of the switchboard. The top-entry gland plates shall be removable and shall not form part of access panels.

2.4.9.2 The gland plates shall be of the multiple, independently removable type.

2.4.9.3 Gland plates for single-core cables shall be of non-magnetic material (e.g. aluminium) of adequate mechanical strength with a minimum thickness of 9 mm.

2.4.10 Termination of Conduit

2.4.10.1 Conduit shall be terminated on the gland plate or top non-removable panel.

2.4.11 Securing

2.4.11.1 Securing lugs shall be provided on each cubicle for fixing the switchboard to the floor.

2.5 CONSTRUCTION OF MOTOR CONTROL CENTRES

2.5.1 Type

2.5.1.1 The switchboards shall be of the floor standing type and shall be totally enclosed, fixed pattern, multi-tiered boards built in sections, allowing for the logical grouping of equipment behind individual hinged panels. The switchboards shall be suitable for mountings against a wall and shall provide for front access to all equipment and terminations. Side, top and rear panels shall also be removable.

2.5.2 Framework

2.5.2.1 The switchboards shall consist of a solid angle iron, channel iron or 2 mm minimum folded metal framework and solid U-channel-base frame, sufficiently braced to support all equipment and to span floor trenches and access holes.

2.5.2.2 Enclosures may also consist of prefabricated components bolted together to form complete tiers in which case all such components shall be fabricated by means of jigs and shall be interchangeable.

2.5.3 Removable Panels

2.5.3.1 Top, side and rear removable panels of 2 mm minimum steel shall be fixed with square key fasteners.

2.5.4 Front Panels

2.5.4.1 Access to all sections of the switchboard shall be via hinged front panels consisting of 2 mm minimum sheet steel with square key operated non-ferrous fasteners designed to draw the panel closed. Panels fixed by nuts and bolts or captive screws are not acceptable. Unhinged panels with retaining pins and latches are not acceptable. Hinged panels shall be dished and shall be equipped with gaskets of resilient non-perishable material that will not distort owing to the action of the door. The panels shall be suitably braced to prevent warping. Long pedestal type hinges with two bolts per hinge shall be used on all hinged panels. At least three hinges shall be provided on panels higher than 900 mm.

2.5.5 Layout

2.5.5.1 A busbar chamber shall be provided on top of the switchboard for the full length of the board and shall be completely segregated from the rest of the board.

2.5.5.2 Between every two vertical sections containing tiers of motor control cubicles, a vertical terminal or marshalling cubicle shall be provided. These cubicles shall be used for the mounting of terminals for outgoing power and control connections as well as terminals for interconnections between motor controls.

2.5.5.3 The dropper busbars to the motor controls shall be installed in the rear section of these cubicles and covered with a front removable non-conductive sheet marked with danger labels. The isolating sheet shall be removable without removing terminals or connections. A cable gland plate shall be provided in the bottom of this cubicle for the termination of all outgoing power and control cables.

2.5.5.4 With the prior consent of SANRAL or the Independent Engineer and in cases where the space available for the switchboard does not allow for a vertical termination compartment, a terminal/marshalling cubicle shall be provided on the top and bottom of the board. Power and control wiring in this instance shall be installed in wiring channels mounted vertically through the motor control tiers.

2.5.5.5 The switchgear, control and protection equipment, instrumentation and other auxiliary equipment for each outgoing circuit shall be grouped individually in the switchboards, subdivided into physically separate compartments for each circuit.

2.5.5.6 The equipment shall be arranged in a multi-tiered fashion with hinged cover panels with the same horizontal dimensions but varying vertical dimensions to accommodate different circuit ratings.

2.5.5.7 Each circuit shall be provided with a positive means of isolation, operated by a clutch type handle interlocked with the hinged panel to open in the "OFF" position only.

2.5.5.8 Instrumentation, pushbuttons and indicating lights shall be flush mounted on the hinged panels.

2.5.5.9 An earth bar shall be provided for the full length of the switchboard bolted directly to the framework.

2.5.5.10 Outgoing circuits other than control circuits i.e. lights, sockets or non controlled power supplies shall be grouped in one or more tiers of the switchboard separated from the control sections and shall comply to the requirements of Free-standing Switchboards

2.5.6 Special Requirements

2.5.6.1 Reset pushbuttons for protection equipment shall be fitted with extension shafts to operate chassis-mounted equipment.

2.5.6.2 An ammeter to indicate current in one phase shall be provided in the case of motor circuits.

2.5.6.3 Test pushbutton(s) shall be provided on each separate control compartment for all indicator lights.

2.5.6.4 All outgoing terminations shall be made onto terminals as follows:

2.5.6.5 Control wiring shall be terminated to clamp type feed-through pattern terminal blocks mounted on rails.

2.5.6.6 Power wiring shall terminate on stud type terminals for cables bigger than 35 mm² and by means of clamp type terminals for cables up to 35 mm².

2.5.6.7 Terminal blocks shall not carry more than two conductors on the panel side and no more than one conductor on the outgoing side. Terminals shall be provided for all spare unused cores in each cable.

2.5.7 Spares

2.5.7.1 At least one for each four fuses with a minimum of three fuses of each rating of fuses installed in the switchboard shall be mounted in brackets inside the board.

2.5.7.2 At least three of each type and rating of indicating lamps shall be provided in each switchboard.

2.5.7.3 None of the equipment supplied as spares may be used during Commissioning and the maintenance period.

2.6 CONSTRUCTION OF LOW VOLTAGE DISTRIBUTION CUBICLES (KIOSKS)

2.6.1 General

2.6.1.1 Where-ever the word kiosk is used in this section of the specification it shall imply switchboard and distribution cubicle.

2.6.2 Weatherproofing and Ventilation

2.6.2.1 In addition to moisture, dust and vermin proofing, kiosks shall be rendered weatherproof for outdoor installations.

2.6.2.2 To prevent ingress of moisture onto live equipment, the door entry surrounds shall be channel shaped, at least 2 mm deep, to accommodate door edges.

2.6.2.3 Roofs shall be constructed with overhangs and shall be provided with drip edges.

2.6.2.4 Two ventilation grilles or slots, approximately 150 x 25 mm, vermin and insect proofed by means of 1,5 mm brass mesh or perforated stainless steel plate spot welded on the inside, shall be provided on the top and bottom of side panels.

2.6.2.5 The construction of the grilles shall be such to prevent the ingress of rainwater.

2.6.2.6 All electrical equipment inside the kiosk shall be treated with a non-conductive water repellent spray to reduce the effects of condensation.

2.6.3 Construction

2.6.3.1 General

The construction of the canopies shall be of the material specified in the Detailed Technical Specification and shall comply with the following requirements:

2.6.3.2 Fibreglass Canopies

Where specified and for all kiosks to be installed within 50 km of the coast and in corrosive industrial atmospheres the canopy and doors shall be manufactured of fibreglass in accordance with the following minimum requirements:

(a) The laminate shall be constructed to SANS 141.

(b) An outer isophthalic resin gel coat with a minimum thickness of 0,4 mm and ultraviolet absorption properties to prevent degradation of the surface from exposure to the sun shall be provided.

(c) The gel coat shall be backed by multiple layers of chopped strand mat glass rendering not less that 1,2 kg/m². The strength shall be increased to 1,65 kg/m² on kiosks with panelling larger than 500 x 500 mm.

(d) The fibreglass shall be thoroughly impregnated with polyester resin. The resin should preferably be clear.

(e) The resin to fibreglass ratio shall not be less than 2,5: l and not more than 3,0: 1.

(f) Air entrapped between the glass matt layers shall be thoroughly worked out. The laminate must be free of air bubbles and voids.

(g) All edges shall be reinforced with an additional 700 g/m² of fibreglass.

(h) All large surfaces, wider than 300 mm, shall he reinforced or panelled to improve stiffness and rigidity.

(i) A resin coat shall be applied to the inside of the kiosk to cover the fibre pattern.

(j) Brass or stainless steel backing plates shall be laminated into the fibreglass at hinge points, locking mechanism catch support areas, door restraint fixing points and all other points which will be subjected to mechanical stresses.

(k) Doors shall be adequately braced, reinforced, ribbed or double laminated with an air gap between the two layers of laminate to ensure rigidity.

(l) The fibreglass canopy shall be fixed to the internal equipment support frame with bolts accessible through the door only.

(m) The outside surface of the kiosk shall have a glossy, smooth finish to ensure good weathering. To obtain this the manufacturer shall ensure that the mould is smooth, free of voids, hairline cracks, pores or other defects.

(n) Compound rubbing or sandpapering of the outside surface will not be permitted.

(o) Pigments shall be added to the outer gel coat to obtain a matching colour to SANS 1091 "Light Stone" C37 or “Beige” C34.

(p) Fibreglass kiosks shall not be painted.

2.6.3.3 Sheet steel canopies

Where specified the canopy and doors shall be manufactured of steel to the following requirements:

(a) A metal framework shall be manufactured from solid angle iron, channel iron or 2,5 mm minimum folded sheet steel.

(b) Joints shall be non-continuously butt-welded. Welds shall be ground smooth and the joint wiped with plumber’s metal in order to provide a smooth finish.

(c) Side panels, doors and the roof shall be manufactured from 2 mm minimum sheet steel. The panels shall have upturned edges which are recessed in the frame or which fit over lips on the frame. The side panels may be either bolted or welded to the frame or form part of the folded metal frame.

(d) The roof of the cubicle shall be removable and shall be titled by means of bolts, which shall be accessible from inside the cubicle only.

(e) All panels and doors shall be suitably braced and stiffened to ensure rigidity and to prevent warping.

(f) The steel canopy and framework, panels and doors shall he painted in accordance with the STANDARD PAINT SPECIFICATION.

(g) The colour shall be "Light Stone" C37 of SANS 1091. A tin of matching touch-up paint (not smaller than 500 ml) shall he provided with each consignment.

2.6.3.4 Cast iron canopies

Where specified the kiosk panels and doors shall be manufactured from cast iron to the following requirements:

(a) A metal framework shall be manufactured from solid angle iron or channel iron.

(b) Cast iron panels shall be bolted to the framework and shall be replaceable with standard cast iron panels.

(c) The panels shall be bolted to the frame from the inside of the cubicle. Bolts or nuts on the outside of the cubicle are not acceptable.

(d) The roof of the cubicle shall be one casting and shall be bolted in position from inside the cubicle.

(e) The minimum thickness of the cast iron panels and doors shall be 6 mm.

(f) All cast iron panels and doors shall be fettled prior to painting.

(g) Metal components of the framework, panels and doors shall be painted in accordance with SECTION 15 of PART 4.

(h) The colour shall be 'Light Stone" C37 of SANS 1091. A tin of matching touch-up paint (not smaller than 500 ml) shall be provided with each consignment.

2.6.4 Doors

2.6.4.1 Doors shall be fitted to the front and to the rear of each cubicle. The doors shall provide free access to equipment which has to be operated and shall provide a full view of all meters. Cubicles wider than 700 mm shall be provided with double doors.

2.6.4.2 Doors shall swivel through 135°.

2.6.4.3 Brass hinges shall be used to hang the doors. The hinges shall be bolted to the canopy with brass bolts and nuts. Bolt heads or nuts shall not protrude beyond the outer surface of the kiosk. Nylon, aluminium or piano hinges are not acceptable.

2.6.4.4 Doors shall be fitted with lever locks equal or equivalent to the "BARKER & NELSON" type with a 135° movement. The locking mechanism shall have a catch on the rear, which catches behind the frame or door entry surround. The locking mechanism as well as the catch support area shall be backed with brass or galvanized steel plates. The locking mechanism shall be padlock able. The Contractor shall supply one set of padlocks for each kiosk. All the padlocks shall use the same key. Four keys shall be supplied with each consignment.

2.6.4.5 The locking mechanism shall be made of brass or stainless steel.

2.6.4.6 Door restraints shall he provided. Cloth or canvas straps are not acceptable. The fixing points of the restraint at both the door and canopy shall be reinforced.

2.6.4.7 At least three hinges shall be supplied on steel doors higher than 1,2 m.

2.6.4.8 Doors shall be fitted with neoprene or equivalent seals.

2.6.4.9 Metal doors shall be earth bonded to the frame by means of a copper braided strap, tooth washers, bolts and nuts.

2.6.5 Concrete Bases and Base Frames

2.6.5.1 The base frames shall be constructed of angle iron, at least 50 mm x 4 mm thick and shall be of a welded construction, hot dip galvanized and coated with epoxy resin tar.

2.6.5.2 The height of the support frame shall be at least 900 mm to provide a rigid support for the kiosk on the concrete base that will be cast into the bottom of the cable trench.

2.6.5.3 The base frame shall protrude to a maximum height of 200 mm above ground level. Provision shall be made for the protection and concealing of the cables entering the kiosk.

2.6.5.4 The base frame shall be secured by at least four M16 bolts to the support frame of the kiosk and four M16 anchor bolts and nuts to the concrete base. The bolts, nuts and washers shall be galvanized and supplied with the kiosk.

2.6.5.5 All galvanizing shall be to SANS 121:2000/ISO 1461:1999.

2.6.5.6 The kiosk manufacturer shall supply a detailed drawing of the base frame and the concrete base required.

2.6.6 Equipment Support Frame

2.6.6.1 A free-standing, angle iron or similar type rigid support framework shall be provided.

2.6.6.2 The frame shall be bolted down on the base using four Ml6 high tensile steel bolts. The holding-down bolts shall be accessible from the inside of the cubicle only. The frame for sheet steel or cast iron canopies may be bolted to the canopy framework.

2.6.6.3 A galvanized steel cable gland plate shall be bolted to the bottom of the frame across the full width of the cubicle to cover the cable entry opening in the base.

2.6.6.4 The gland plate shall be suitably punched to accept the number and size of cables specified.

2.6.6.5 All steelwork shall be hot dip galvanized in accordance with SANS 121:2000/ISO 1461:1999.

2.6.6.6 A panel of "Delaron' or “Thiolite” resin synthetic wood or similar dielectric material shall be provided for the mounting of all equipment and busbars. Impregnated hardboard and other treated or untreated wood products are not acceptable.

2.6.6.7 Alternatively, all equipment and busbars shall be flush mounted within a purpose-made sheet-metal frame enclosed by a machine-punched removable front panel through which the operating handles of the equipment protrude. Care shall be exercised that the rear studs of circuit breakers are properly insulated from the steel chassis. Miniature circuit breakers may be installed in clip-in trays mounted on the frame.

2.6.7 Busbars

2.6.7.1 Solid copper busbars shall he provided in the switchboard in accordance with Subsection 1 of this Specification.

2.6.8 Notices & Labels

2.6.8.1 In addition to the labelling specified in Subsection 1 of this Specification, at least one skull and crossbones notice with the words "GEVAAR/DANGER/INGOZI" shall be mounted on the front of the kiosk.

2.6.8.2 The danger notice shall be of vitreous enamelled steel or cast aluminium plate with embossed lettering on a red background.

2.6.8.3 A notice with the wording L, shall be fixed to the inside of the doors of the kiosk. This notice shall be of the same material as the danger sign.

2.6.8.4 The above notices shall be riveted to the steel or cast iron doors so that they cannot easily be removed. Brass rivets shall be used. The notices shall be laminated into the fibreglass where fibreglass canopies are specified.

2.6.9 Installation

2.6.9.1 The Contractor shall ascertain the exact position of the kiosks and shall arrange timeously for the installation of the concrete plinths so that the kiosks may be installed directly onto the plinths.

2.6.9.2 During installation and other construction activities on site, the kiosks shall be protected against damage and penetration of moisture, dust or vermin. The kiosks shall be handed over in a clean and undamaged state.

2.6.9.3 Kiosks which cannot be installed and put into service immediately shall be stored so as to maintain the equipment in a clean and dry condition and shall be placed on a level surface.

2.6.9.4 The kiosks shall be rendered vermin proof after the cable installations have been completed.

2.6.9.5 All cable conductors shall have crimped lugs, which shall be bolted onto the busbars or studs with high tensile cadmium plated bolts, nuts and washers.

2.6.9.6 All cables shall be labelled at or above the gland plate to indicate the purpose or destination of the cable. These designations shall be indicated on the wiring diagrams.

2.6.9.7 The Contractor shall cast or arrange for the casting of concrete plinths on site. The plinths shall be made in accordance with the kiosk manufacturer's design and specification, which has been approved by SANRAL or the Independent Engineer. The cost of the concrete plinths shall be included in the tender price.

2.6.9.8 The tops of the plinths shall be at least 150 mm above the final surrounding ground level.

2.6.9.9 The plinths shall be wood float finished before the kiosks are mounted and shall slope from the channel steel foundation to permit the run off of rain water. A 3 mm thick gasket of approved 'MALTHOID" shall be inserted between the kiosk and the concrete surface. The gasket shall be as wide as the channel iron foundation.

2.6.9.10 Cable entries shall be provided in the plinths to accommodate all the incoming and outgoing cables. The cable entries shall be sealed to prevent ingress of rodents. The sealing shall be such that it can be readily removed in the event of future cable work and may consist of a filling of sand covered with approximately 10 mm thick 10:1 sand and cement and finished flush with the tops of the concrete plinths.

2.6.9.11 The Contractor shall ensure that the kiosks are mounted horizontally and parallel to the roadway.

2.6.9.12 The doors of the kiosks shall generally face the roadway. Where the kiosk is not installed relative to a road, the ruling of SANRAL or the Independent Engineer shall be obtained of the exact position and facing direction before installation of the plinths commence.

2.6.10 Commissioning

Prior to energising, the following tests shall be carried out in the presence of SANRAL or the Independent Engineer:

2.6.10.1 A 500 V Megger test shall be done between phases and between phases and neutral.

2.6.10.2 All control circuits shall be checked to ascertain their correct functioning.

2.6.10.3 The operation of all fuse switches, isolators, circuit breakers, etc. shall be checked to ensure that the equipment opens and closes properly and continuity is obtained.

2.6.10.4 All connections to busbars and equipment shall be physically checked for tightness.

2.7 SWITCHBOARDS AND MOTOR CONTROL CENTRE DATA AND COMPLIANCE SHEET

TABLE 2-4: SWITCHBOARDS AND MOTOR CONTROL CENTRE DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
2.7.1	SANS 10142 - 1	The wiring of premises Part 1: Low-voltage installations				
2.7.2	SANS 10140-1:2008 (SABS 0140-1)	Identification colour marking Part 1: General				
2.7.3	SANS 10140-2:2008 (SABS 0140-2)	Identification colour marking Part 2: Identification of hazards and equipment in work situations				
2.7.4	SANS 121:2000	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods				
2.7.5	BS 159:1992	Specification for high-voltage busbars and busbar connections				
2.7.6	SANS 141	Glass-reinforced polyester (GRP) laminates				
STANDARD SPECIFICATION CLAUSE						
	CLAUSE					
2.7.7	2.1	General				
2.7.8	2.1.2	Painting				
2.7.9	2.1.3	Size				
2.7.10	2.1.4	Moisture and vermin				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
2.7.11	2.1.5	External Dimensions				
2.7.12	2.1.6	Ventilation				
2.7.13	2.1.7	Earthing of metal parts				
2.7.14	2.1.8	Welding				
2.7.15	2.1.9	Mounting of equipment				
2.7.16	2.1.10	Busbar in switchboards				
2.7.17	2.1.11	Wiring				
2.7.18	2.1.12	Labelling				
2.7.19	2.1.13	Inspection and testing				
2.7.20	2.1.14	Drawings and manuals				
2.7.21	2.1.15	Installation				
2.7.22	2.2	Construction of flush mounted switchboards				
2.7.23	2.3	Construction of surface mounted switchboards				
2.7.24	2.4	Construction of free-standing switchboards				
2.7.25	2.5	Construction of motor control centres				

3. EQUIPMENT TO BE USED IN SWITCHBOARDS

3.1 WITHDRAWABLE METAL-CLAD AIR CIRCUIT BREAKERS

3.1.1 Withdrawable air circuit breakers shall be suitable for use in power distribution systems up to 1 kV, 50 Hz.

3.1.2 The air circuit breaker (ACB) shall comply with BS EN 60947-2:1992 and IEC 157.

3.1.3 The air circuit breaker shall be metal clad and shall be withdrawable. The ACBs shall be self-contained units of the dead front type, with the necessary mechanical interlocks to prevent:

3.1.3.1 Access to 'LIVE' terminals when the circuit breaker is withdrawn.

3.1.3.2 The withdrawal or insertion of the unit when the circuit breaker is in the closed position.

3.1.3.3 Closing of the circuit breaker following an automatic trip condition without re-setting the mechanism.

3.1.4 The air circuit breaker shall be of the quick-make and quick-break type with a stored-energy spring assisted operating mechanism provided with:

3.1.4.1 A trip free mechanical hand operated closing mechanism;

3.1.4.2 A manually operated mechanical trip mechanism suitably protected to prevent inadvertent tripping;

3.1.4.3 A positively driven mechanical device to provide ON/OFF/TRIP indication. This indication shall be clearly visible with the circuit breaker in position.

3.1.5 All non-current-carrying metal parts of ACBs shall be solidly inter-connected and connected to an earth contact on the track that shall engage with a mating contact or copper plate on the cradle that is connected to the earth busbar of the switchboard. The arrangement shall be such that the ACB frame is earthed in the test position and before the circuit breaker contacts engage the live fixed contacts.

3.1.6 The fixed cradle shall be of high mechanical strength.

3.1.7 The ACB shall have RACKED-OUT, TEST and ENGAGED positions which shall be clearly marked.

3.1.8 The ACB shall bear a clearly legible rating plate indicating the current rating, breaking capacity and voltage rating.

3.1.9 The complete ACB and its electrical and mechanical constituents and accessories shall be from a standard product range of a single original supplier.

3.1.10 Extension type operating handles shall be fixed to the ACB on completion of the installation.

3.1.11 The ACBs shall be designed to allow the incoming terminals to be at the top or bottom without affecting the operation of the unit.

3.1.12 ACBs shall be derated if necessary to compensate for the following environmental factors:

3.1.12.1 Maximum ambient air temperature in excess of 40℃ or the daily average ambient air temperature in excess of 30℃. This is especially important with regard to the type of enclosure in which the ACB is to be installed.

3.1.12.2 Height above sea level.

3.1.12.3 Operational duty cycle and estimated loading.

3.1.13 Adjustable thermal overload releases shall be provided to suit the required current range. In addition, instantaneous magnetic short circuit trips that are adjustable shall be fitted. This delay adjustment shall be bypassed with an instantaneous making current release when the ACB is closed, to prevent the delay timer from operating when the ACB is closed on a fault.

3.1.14 ACBs shall have electrically separate auxiliary contacts as specified in SANRAL's Requirements. Where none is specified, two N/O and two N/C auxiliary contacts shall be provided.

3.1.15 Shunt trips and electrical stored energy circuit breakers shall be interlocked to prevent repeated operation of the trips or winding mechanisms when the circuit breaker is in the tripped or closed position.

3.1.16 Provision must exist for the addition, if required, of a supply side under-voltage release.

3.1.17 A description and illustration of the ACB as well as trip curves, operating manuals and rupturing test certificates shall be provided.

3.2 MOULDED-CASE CIRCUIT BREAKERS

3.2.1 Single or multi-pole moulded-case circuit breakers shall be suitable for use in power distribution systems, for panel mounting and for ratings up to 1 000 A, 600 V, 50 Hz. The circuit breakers shall comply with SANS 156, as amended.

3.2.2 The overload and short circuit trips in the circuit breakers may be of the following types to suit the application:

3.2.2.1 Combined thermal/magnetic trips with interchangeable trip units, the magnetic trip setting being adjustable.

3.2.2.2 Combined thermal/magnetic trips with fixed and sealed trip units, the magnetic trip setting being adjustable.

3.2.2.3 Combined thermal/magnetic trips with fixed and non-adjustable units.

3.2.2.4 Hydraulic/magnetic trips with fixed non-adjustable trip units.

3.2.2.5 Solid state controlled trips with interchangeable fixed rating plugs for overload tripping and adjustable magnetic trip settings incorporating a short time delay.

3.2.2.6 Solid state controlled trips with interchangeable adjustable rating plugs for overload tripping and adjustable magnetic trip settings incorporating a short time delay.

3.2.2.7 The continuous current rating, trip rating and rupturing capacity shall be as specified herein or in SANRAL's Requirements.

3.2.3 All moulded-case circuit breakers in a particular installation shall be supplied by a single manufacturer.

3.2.4 The incoming terminals of single-pole miniature circuit breakers shall be suitable for connection to a common busbar. Ganged toggles for miniature circuit breakers supplying similar, related circuits will be acceptable provided that the trip mechanisms are internally linked.

3.2.5 The operating handles of circuit breakers shall give a positive indication of the ON/TRIP/OFF status.

3.2.6 Only circuit breakers which have been approved by the SABS and which carry the SABS mark will be accepted. Where circuit breakers that have been specified in SANRAL's Requirements do not comply herewith (due to for example the rating or fault capacity), SANRAL's approval shall be obtained beforehand.

3.3 COMBINATION SWITCH-FUSE UNITS

3.3.1 Combination switch-fuse units shall be triple pole devices fitted with neutral links.

3.3.2 Light duty (up to 200 A, 250 V) switches shall comply with BS 2510 as amended. Heavy duty (up to 1 200 A, 660 V) switches shall comply with BS 3185 as amended. The maximum rating of 1 200 A does not apply to motor isolating switches, for which the maximum rating is 800 A.

3.3.3 The switches shall be of the on-load type capable of carrying full load continuously, tested to IEC 408 for making and breaking capacities.

3.3.4 Switch-fuse units shall be of the double air-break, quick-make, quick-break type with an arc chamber. The mechanism shall be driven by springs on both sides or approved equivalent mechanism. The unit shall consist of a fixed contact assembly, heavy-duty mechanism, moving contact carriage and a retractable operating handle mounted on a rigid frame. The contacts shall be of high quality material, e.g. silver plated.

3.3.5 The switch-fuse shall have a hand-operated lever with clearly indicated “ON” and “OFF” positions. The nominal rating, voltage and allowable fuse ratings shall be clearly and indelibly marked on the cover.

3.3.6 The cartridge fuses used in the units shall conform to BS 88 or the equivalent DIN and VDE standards. The category of duty shall be suitable for the voltage level and the fault level at the point where the fuses are installed. Time/current characteristics shall be matched to the equipment supplied or protected by the switch.

3.3.7 When the switch is in the “OFF” position, the fuses shall be fully isolated at both the load and supply ends. Interlocks shall be provided to prevent the cover from being opened when the switch is “ON” and to prevent the switch from being operated when the cover is open.

3.3.8 Fuse gear carrying the HRC fuses on the cover, the cover also forming the operating level, is regarded as a fuse isolator and is not acceptable.

3.4 TRIPLE-POLE ON-LOAD ISOLATOR

3.4.1 Switches shall be suitable for panel mounting and for use in power distribution systems up to 600 V, 50 Hz. Switches for motor isolation shall be included.

3.4.2 The switches shall be of the triple-pole, hand-operated type conforming to BS 861 Part 1, (up to 200 A, 600 V) and Part 2, (up to 200 A, 600 V). Breaking capacities shall conform to BS 755, Part 1.

3.4.3 The switches shall be suitably rated for the continuous carrying, making and breaking of rated current as well as through-fault current capacity as required.

3.4.4 To distinguish the switches from circuit breakers the operating handles shall have a distinctive colour and/or the switch shall be clearly and indelibly labelled “ISOLATOR”.

3.5 EARTH LEAKAGE RELAYS (30 MA)

3.5.1 Earth leakage relays shall be of the single-turn primary core balance type designed for long and reliable operation.

3.5.2 The units shall have a sensitivity of 30mA unless otherwise specified and shall maintain their sensitivity and operating response time within the range of ambient temperatures, voltage fluctuations and load currents normally encountered in service. The relays shall fully comply with the requirements of SANS 767 - Part 1 – 4 as amended, and shall as far as possible be supplied as integral units with their associated moulded-case circuit breakers or load-break isolators and shall bear the SABS mark.

3.5.3 Circuit breakers with trip coils used integrally with earth leakage units (two-pole for single-phase units and three-pole for three-phase units) shall conform to SANS 156.

3.5.4 On-load switches used integrally with earth leakage units (two-pole for single-phase units and three-pole for three-phase units) shall comply with BS EN 60947-3:1992.

3.5.5 The fault current rating of the unit shall be 5 kA when tested in accordance with SANS 156.

3.5.6 The relays shall withstand without damage or change phase-to-phase, phase-to-neutral and phase-to-earth fault currents, which are required to be handled by the associated circuit breakers or load-break switches, and shall not be affected by lightning surges.

3.5.7 The design of the earth leakage unit shall be such that spurious tripping due to switching transients does not occur.

3.5.8 The units shall be designed for clip tray mounting and the depth and height of the units shall be the same as the 5kA moulded-case circuit breakers supplied. The units shall be completely sealed against the ingress of dust and moisture.

3.5.9 All earth leakage relays shall be provided with a test button to enable the operation of the relay to be checked at will.

3.6 CONTACTORS

3.6.1 Contactors shall be of the open or totally enclosed, triple- or double-pole, electro-mechanically operated air-break type suitable for 400 V or 230 V supplies. Open type contactors shall comply with SANS 1092 where applicable.

3.6.2 Contactors shall be of modern design with the following characteristics:

3.6.2.1 Enclosed coil easily replaceable,

3.6.2.2 A permanent air gap in the magnetic circuit to prevent sticky operation,

3.6.2.3 Provision for quick and simple inspection of contacts, and

3.6.2.4 Clearly marked main and auxiliary terminals.

3.6.2.5 All parts shall be accessible from the front.

3.6.2.6 Contactors which are not located in switchboards shall be housed in enclosures which comply with IP 54 of IEC 144.

3.6.2.7 In all cases the current rating of the contactor shall be as specified for the circuit with a switching duty in accordance with the IEC Publication 158-1, utilisation category AC3 for motor starting.

3.6.2.8 The mechanical duty of the contactor shall comply with the specified requirements for class IV of clause 5.6 of BS 775.

3.6.2.9 The magnetic system of the contactor shall be carefully designed and all laminations tightly clamped to ensure that when the armature is closed and full voltage at normal frequency is applied to the coil, the contactor will not emit more noise than the hum associated with any properly constructed laminated core with tightly clamped laminations. Noisy contactors shall not be accepted.

3.6.2.10 Non-current-carrying metallic parts shall be solidly interconnected and a common screwed earth terminal shall be provided. The contactor shall be earthed to the switchboard earth bar.

3.6.2.11 Latched contactors shall be provided with a trip coil and a closing coil. The contactor shall remain closed after de-energising the closing coil and shall only trip on energising the trip coil.

3.6.2.12 Contactor operating coils shall have a voltage rating as required by the control circuitry and shall have the limits of operation and temperature rise as specified in clause 7.5 and Table IV of the IEC Publication 158-1. Latched contactors shall be capable of being tripped at 50 % of the rated coil voltage.

3.6.2.13 Contactors for normal/standby changeover circuits shall be electrically and mechanically interlocked. Contactors shall also be electrically interlocked in star-delta starters.

3.6.2.14 Contactors with provision to add auxiliary contacts and convert auxiliary contacts on Site are preferred. Contactors with permanently fixed auxiliary contacts shall have at least 1 x N/O and 1 x N/C spare auxiliary contacts in addition to the contacts specified for control purposes and in addition to contacts required for self-holding operations or economy resistances.

3.6.2.15 Where the number of auxiliary contacts required is greater than the number of contacts that can be accommodated on the contactor, an auxiliary relay or additional contactor shall be provided to supply the additional contacts.

3.6.2.16 It shall be possible to replace main contacts without disconnecting wiring.

3.6.2.17 Auxiliary contacts for contactors used on 400/230 V systems shall be AC1 rated and capable of making, carrying continuously and breaking 6 A at 230 V AC, unity power factor.

3.6.2.18 Auxiliary contact functions required e.g. “lazy” contacts, late-make, late-break, and make-before-break, etc. shall be inherent in the contact design. Under no circumstances may these functions be improvised by bending or loading the contacts. These functions shall be available in all contactors.

3.6.2.19 Spare auxiliary contacts shall be wired to numbered terminal strips in the switchboards and shall appear on the switchboard drawings.

3.6.2.20 All contactors shall be from a standard range of one single manufacturer, unless otherwise specified herein or in SANRAL’s Requirements.

3.7 ROTARY CAM SWITCHES

3.7.1 The switches shall be equivalent to KLOCKNER MOELLER type "T" rotary cam switches and shall conform to BS EN 60947-5-1:2004 A1:2009, IEC 337 and VDE 0113, where applicable.

3.7.2 The switches shall be of the cam-actuated type with two breaks per pole, the required number of poles and number of control functions provided by the assembly of switching units on a common spindle.

3.7.3 The spindle shall be operated by a control handle suitable for the method of installation of the switch. The control handle shall be located by a keyway on the spindle.

3.7.4 The switches shall be provided with a suitable faceplate, indicating the angle of throw and the switch positions. The latching mechanism shall ensure positive positioning in accurate relation to the positions indicated on the faceplate.

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

3.7.6 For normal applications, the making capacity of the switch shall be at least three times the normal current rating. For AC4 duties (inching, reversing, plugging), the rated current of the switch shall be at least equal to the stalled rotor current of the motor.

3.7.7 Special contacts, e.g. late-making, early-breaking shall be inherent in the design and shall not be improvised by loading or bending contacts.

3.8 CARTRIDGE FUSES AND FUSE HOLDERS (LOW VOLTAGE UP TO 600 V)

3.8.1 The following fuse and fuse holder types are acceptable for use in distribution and power systems:

3.8.1.1 A cartridge type fuse-link, fitting into a fuse carrier, together with a fuse base with fixed terminals. The fuse can be removed by taking out the fuse carrier and then removing the fuse from the carrier.

3.8.1.2 A cartridge type fuse-link, which fits into a fuse base with fixed terminals. In this case, a fuse puller is required to disengage the fuse from the base. These fuses are only acceptable on equipment imported with these fuses as a standard item. One puller shall be supplied for each board or box in which these fuses are used.

3.8.1.3 Rewireable fuses are not acceptable and shall not be used.

3.8.1.4 Fuses shall contain visual inspection eyes for fault location.

3.8.1.5 Fuses shall be equipped with moulded plastic covers, or rigid isolating barriers shall be installed between the fuses. Sufficient spacing to prevent accidental contact when inserting or withdrawing fuses shall be maintained. The covers or barriers shall be manufactured for the specific fuses to be used.

3.8.1.6 Striker pin fuses shall be equipped with an alarm contact so that the contact closes and remains closed when the striker pin operates.

3.8.1.7 Fuses and holders shall not contain any parts that can wear unduly or distort.

3.8.1.8 All fuses used for distribution systems shall conform to the following standards:

(a) Fuses: BS 88-2:2007, Parts 1 and 2 and SANS 60269-1 to 4.

(b) Holders: SANS 60269-1 to 4:2007 as revised.

3.8.2 Fuses of the types described above and conforming to the relevant DIN (49510, 49511, 49515, 49522, 49360, 49367) and VDE (0635, 0660) standards are also acceptable.

3.8.3 Fuse ratings shall be accurate to within ± 5 % of the published value for unused fuses and shall not vary significantly after long periods of service.

3.8.4 Fuses shall be derated for ambient temperatures above 25°C in accordance with the supplier's recommendation. If no such recommendation exists, a derating factor of 1 % per °C above 25°C shall be applied.

3.8.5 Fuses shall be derated for elevations of more than 1000 m above sea level in accordance with the supplier's recommendation. If no such recommendation exists, a derating factor of 1 % per 300 m above 1000 m above sea level shall be applied.

3.8.6 Time/current characteristics shall be chosen to suit the application.

3.8.6.1 Cable protection: The fusing factor shall not exceed 1,5.

3.8.6.2 Motor circuits: Time-lag characteristic so that the starting currents will not cause deterioration of the fuse.

3.8.6.3 Capacitor circuits: Fuses shall be chosen to withstand a higher normal full-load current (1,5 times rated capacitor current) to allow for harmonics and shall not deteriorate due to the high transients at switch-on.

3.8.6.4 Distribution systems: The total operation I^2t let through the secondary (minor) fuses shall be less than that of primary (major) fuses in any specific branch.

3.8.7 It shall be ensured that the rupturing capacity of a fuse chosen for a specific application shall be adequate, both as far as short circuit current and applied voltage are concerned.

3.9 TIME SWITCHES

3.9.1 Time switches shall be of the single-pole type, suitable for 230 V systems, with contacts rated for the duty to be performed with a minimum rating of 10 A. Contacts shall be of high quality material, e.g. silver plated or solid silver.

3.9.2 Digital timers of the HAGER range or similar with a reserve in excess of that specified for synchronous timers may be used.

3.9.3 The clock shall be driven by a self-starting synchronous motor, keeping accurate mains time. All clocks shall be controlled by an electrically wound escapement providing the main spring with a minimum of 24 hours reserve in case of a power failure. The main spring shall be kept fully wound without the use of slipping clutch devices that may wear and get out of adjustment.

3.9.4 The motor shall be protected by an easily accessible single-pole fuse.

3.9.5 A manual bypass switch shall be provided to permit the circuit to be switched “ON” or “OFF” manually without affecting the operation of the time switch.

3.9.6 The switch shall have a 24-hour dial, with day and night indication that can be set with a minimum accuracy of 15 minutes unless otherwise specified herein or in SANRAL’s Requirements. The dial shall be fitted with a number of adjustable hands corresponding to the number of ON/OFF switching in a 24-hour period.

3.9.7 The switch shall be housed in a dust tight moulded plastic or metal case, or an approved equivalent consisting of a plastic clip-on front cover and a moulded plastic or metal vase. Switches to be used for surface mounting on walls shall be provided with a suitably positioned 20 mm conduit knock-out.

3.10 SEQUENCE TIME SWITCHES

3.10.1 Sequence time switches suitable for starting a group of machines in a pre-determined sequence, shall be provided where specified. The switches shall provide the number of steps indicated and minimum time intervals of 15 seconds between starts, unless otherwise specified herein or in SANRAL’s Requirements.

3.10.2 Sequence time switches shall have normally open contacts unless otherwise specified herein or in SANRAL’s Requirements. The contacts shall be of silver-to-silver or other approved type with a minimum rating of 20 A.

3.10.3 Sequence time switches shall be of the reversible type, i.e. switching Equipment on the required sequence when rotating forward and switching Equipment off in the reverse sequence when rotating backwards.

3.10.4 The switches shall be constructed so that the driving motor of the unit shall switch off when forward rotation is complete, while the controlled machines run on uninterrupted. When the machinery is to be switched off, the drive motor on the unit shall rotate backwards and switch the machinery off in the reverse sequence. An ON/OFF switch shall control the sequence time switch from a remote position, where “ON” denotes the starting sequence and “OFF” denotes the stopping sequence. Switch positions shall be indelibly labelled.

3.10.5 The switches shall return automatically to the start position when a power failure occurs.

3.10.6 The switches shall be suitable for operation at the system voltage.

3.10.7 Process timers shall be driven by a synchronous motor controlled by an electromagnetic clutch. The timer shall be designed so that it can remain energised indefinitely. Pneumatic timers may not be used.

3.10.8 Digital adjustable sequence timers from the HAGER range or similar may be used.

3.10.9 Instantaneous switching shall be facilitated by the electromagnetic clutch, and delayed switching by a compressed spring retained by a latch.

3.10.10 On de-energising, the clutch shall disengage and all switches shall return to the nominal position.

3.10.11 It shall be possible to operate the timer at zero delay setting.

3.10.12 All timers shall be provided with both running and setting pointers.

3.11 PUSHBUTTONS AND PUSHBUTTON ASSEMBLIES

3.11.1 Pushbuttons and pushbutton arrangements may be used in switchboards and control boards or in self-contained units for control functions.

3.11.2 Pushbuttons and pushbutton assemblies shall be supplied from a single reputable supplier's product range.

3.11.3 The various types of pushbuttons employed shall be specifically selected for the required duty and mounting characteristics, e.g. flush mounted, enclosed, self-contained, illuminated.

3.11.4 All pushbuttons on a specific switchboard shall be of the same physical dimension (round or square) and shall be fully interchangeable as far as possible. Pushbuttons must preferably be interchangeable with indicator lamps, key switches.

3.11.5 Pushbuttons shall be designed for long life, low contact bounce and constant resistance. Mechanisms may be of the mechanical type with spring control and a clutch or catch frame or of the solid state type operating on the principle of a non-contacting, inductive proximity switch.

3.11.6 All pushbuttons shall be provided with replaceable lenses with a variety of symbols for insertion and for removable and interchangeable legend plates. Legend plates shall be clear and versatile.

3.11.7 Pushbutton terminals shall be suitable for the application with regard to spacing, conductor capacity, etc. Screw type, soldered or connector type terminals shall be chosen to suit the specific application with regard to good contact, ease of removal or alteration and rigidity.

3.11.8 Terminals shall be suitable for conductor sizes to be used. Pushbutton assemblies mounted on doors of control boards shall be enclosed to prevent inadvertent contact with the terminals.

3.11.9 Pushbuttons shall be suitable for the environmental conditions to be encountered, e.g. moisture, excessive temperatures, mechanical shock, vibration, etc.

3.11.10 Contact duty shall be chosen to suit the application. Wiping contacts shall be used for low voltages and currents. Contacts shall be constructed of high quality material such as silver-dipped or gold laminated contacts.

3.11.11 Illuminated pushbuttons may employ LED clusters, neon, or incandescent lamps. Lamp voltages shall suit system control voltages. Lamps shall be under run by at least 10% when used for continuous duty, e.g. using 20 V supply on 28 V rated lamps.

3.11.12 Pushbuttons may be grouped together in purpose-made stations, suitable for the environment in which they are to be installed.

3.11.13 Keylock pushbuttons shall be supplied with duplicate keys. The removal action of the key shall suit the application.

3.11.14 Pushbuttons shall comply with the applicable requirements of BS 3955, Part 1 and BS 4794.

3.12 INDICATOR LIGHTS

3.12.1 Indicator lights shall be of the LED cluster type or approved equivalent. The indicator rating shall suit the supply or control voltage and units shall be rated for continuous duty.

3.12.2 Each indicator unit shall be surge protected and external resistors shall be fitted to avoid excessive current.

3.12.3 Indicator units shall consist of four high-brightness LEDs mounted in a reflector with suitably rated and accessible terminals and a screw-on retaining ring. The LEDs shall be brightness matched and the LED cluster and lens elements shall be easily replaceable from the front without removal of the unit from the panel or the use of special tools.

3.12.4 Where incandescent (filament) type indicator lights are specified herein or in SANRAL's Requirements, the lamp voltages shall suit the supply or control voltage and the lamps shall be derated for continuous duty by using economy resistors or using input voltages of at least 20 % lower than the rated lamp voltages. The lights shall conform to BS 1050 where applicable.

3.12.5 Incandescent type indicator lamps shall consist of interchangeable lenses, lamp bases, suitably rated and accessible terminals and screw-on rating rings.

3.12.6 All indicator units or lights for a specific application or switchboard shall be from the range of one manufacturer and shall preferably be of the same size and rating and shall use the same LED cluster or lamp type.

3.12.7 Surface-mounted indicator lights shall be housed in purpose-made boxes with suitable cover plates.

3.12.8 All indicator lights and units shall be equipped with standard removable legend plates.

3.13 INDICATING INSTRUMENTS

3.13.1 General Requirements

3.13.1.1 Instruments shall be suitable for flush mounting in switchboards and instrument panels and shall be suitably rated for the supply voltage and frequency to be applied, which shall be 400/230 V, 50 Hz unless otherwise specified herein or in SANRAL's Requirements.

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

3.13.1.3 All instruments shall conform to BS EN 60051-1:1999 and/or IEC 51.

3.13.1.4 Instruments shall be screened against magnetic interference and shall have anti-static, impact-resistant glass or "macrolon" faces.

3.13.1.5 Preference will be given to locally manufactured instruments.

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

3.13.1.7 All instruments shall be splashproof and dustproof with an SABS approved IP rating unless otherwise specified herein or in SANRAL's Requirements for hazardous locations.

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

3.13.1.9 For normal environmental and supply conditions, instruments shall be suitable for use inside the limits specified in Tables III and VI of IEC 51.

3.13.1.10 All instruments shall be capable of withstanding overloads of continuous or short duration in accordance with section 8.3 of IEC 51.

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

3.13.2 Voltmeters and Voltmeter Selector Switches

3.13.2.1 Unless otherwise specified herein or in SANRAL's Requirements, voltmeters shall be scaled from 0-500V in the case of LV applications.

3.13.2.2 Voltmeters shall be of the moving iron type with class 1.5 accuracy as specified in IEC 51.

3.13.2.3 Zero adjustment screws shall be provided.

3.13.2.4 Unless otherwise specified herein or in SANRAL's Requirements, a single voltmeter and selector switch shall be provided. Each voltmeter switch shall have an "OFF" and six metering positions to indicate readings of phase to phase and neutral to each of the three phases.

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

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

3.13.3 Ammeters

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

3.13.3.2 Direct reading ammeters up to a maximum rating of 60 A may be used. Current transformer operated ammeters shall be 5 A full scale, calibrated to read actual primary circuit currents. The current transformer ratio shall be indicated on the faceplate.

3.13.3.3 A zero adjustment screw shall be provided.

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

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

3.13.3.6 The bimetal element shall be designed to compensate for variations in the ambient temperature between -20 and +70°C.

3.13.3.7 Full load or rated current shall be clearly indicated, preferably with a red line. Unless otherwise specified herein or in SANRAL's Requirements, a 100 % condensed over scale shall be provided for instantaneous reading instruments and no over scale for combined maximum demand ammeters.

3.13.3.8 The intrinsic error, expressed in terms of the fiducial value in accordance with IEC 51 shall be class 1.5 for the instantaneous readings and class 2.5 for the mean maxima.

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

3.13.4 Kilowatt-hour meters

3.13.4.1 Unless otherwise specified herein or in SANRAL's Requirements, kilowatt-hour meters shall be suitable for operation on 400/230 V, 50 Hz systems.

3.13.4.2 Meter elements shall be of the inductor disc type and designed to carry the rated current continuously.

3.13.4.3 Kilowatt-hour meters shall conform to BS 37.

3.13.4.4 The registering mechanism shall be of the cyclometer type, providing a six-digit readout with the sixth digit indicating one tenth of a unit.

3.13.4.5 Unless otherwise specified herein or in SANRAL's Requirements, the meters shall conform to accuracy class 1 as specified in IEC 51.

3.13.4.6 Kilowatt-hour meters shall be graded and calibrated for the specific application to avoid the application of multiplication factors where possible.

3.13.4.7 The kilowatt-hour meter shall preferably be provided with a magnetic type of bearing for the disc spindle.

3.13.4.8 For application of direct reading of kWh, up to and including 60A for single phase or three-phase applications, a mini DIN rail mounted kWh meter as CBI ECOLEC EC110 or similar may be used.

3.13.5 Frequency meters

3.13.5.1 Frequency meters may be of the vibrating reed type or the direct indicating type consisting of a moving coil milli-ammeter and a current/frequency transducer.

3.13.5.2 Unless otherwise specified herein or in SANRAL's Requirements, the indicating range shall be 45 Hz - 55 Hz.

3.13.5.3 The accuracy class shall be class 0,5 in accordance with IEC 51 unless otherwise specified herein or in SANRAL's Requirements.

3.13.5.4 Where required an adjustable speed alarm contact shall be provided, adjustable over the complete scale length.

3.13.6 Running hour meters

3.13.6.1 Running hour meters shall be of the electrically operated cyclometer type, suitable for flush mounting.

3.13.6.2 Numerals shall be clearly defused white on a black background.

3.13.6.3 The range of hour meters shall be five digits, the fifth digit indicating one tenth of an hour, i.e. from 0 to 9999,9 hours.

3.13.6.4 The accuracy class shall be class 1 in accordance with IEC 51 unless otherwise specified herein or in SANRAL's Requirements.

3.14 CONTROL RELAYS

3.14.1 The coil, contacts and operating mechanism of all relays shall be contained in a transparent, dust proof enclosure of plastic or other suitable synthetic material.

3.14.2 Relays shall be supplied with plug-in bases of bakelite or other insulation material. Bases shall be fixed to the switchboard frame in a fashion to facilitate removal or insertion of the relay and enclosure.

3.14.3 Relay bases shall be fitted with wire-spring type retaining clips to ensure positive relay contact even when the switchboard is subjected to severe vibrations.

3.14.4 Relay contact ratings shall be sufficient for the duty taking into account:

3.14.4.1 Voltage, current, inductance and capacitance of the circuit;

3.14.4.2 Conditions including ambient temperature and humidity, ambient gases; and

3.14.4.3 Switching frequency.

3.14.5 Relays shall provide the type of switching function specified. Late-make or late-break functions shall be inherent in the design and shall under no circumstances be improvised by bending or loading the contacts.

3.14.6 Conductor connections to the relay base shall be soldered.

3.14.6.1 Preferably shall be able to interface with PLC systems for future use by a SCADA system if required.

3.15 CURRENT TRANSFORMERS

3.15.1 Current transformers shall comply with the requirements of the latest edition of BS 3938. Where the current value of the primary side is more than 50 A (irrespective of ratio), the current transformer shall be of the ring type with an opening to suit the dimensions of the conductor or busbar. Where the current value of the primary side is 50 A or less (irrespective of ratio), wound primary current transformers shall be used.

3.15.2 Current transformer ratios, where not specified herein or in SANRAL's Requirements, shall match the rating of the circuit and the scaling factor and saturation points required on instruments or by circuit protection equipment.

3.15.3 Unless otherwise specified herein or in SANRAL's Requirements, current transformers shall have the following accuracies and burden capacities:

	Class	VA
Metering	0,5	15
Motor protection	1OP15	15
Differential protection	X	15
I.D.M.T. relays	1OP15	15
Instantaneous relays	1OP15	15

3.15.4 Each current transformer shall be provided with a robust mounting bracket and proper terminal studs on the circumference of the coil for connections.

3.15.5 A nameplate shall be fixed to the coil circumference in such a position that it can easily be read from outside the switchboard after removal of the access panels. The nameplate shall clearly indicate class, rating, ratio and function.

3.15.6 Current transformers shall be mounted on rigid supports in such a fashion that the connections to the switchgear and connections to the coil terminals can be installed without difficulty.

3.15.7 Current transformers shall be capable of withstanding the maximum fault current that can occur at that point in the system for the time taken by the circuit protection devices to clear the fault.

3.15.8 Current transformers shall be capable of withstanding an insulation test of 3 kV and an interturn insulation test in accordance with par. 2.4.4 of BS 7626:1993.

3.16 TERMINALS

3.16.1 Terminals for wiring circuits of less than 30 A ratings shall be of the non-combustible, screw-clamp type, individually insulated and suitable for mounting on DIN railing. The terminals shall be rated for the required current rating and the specified fault level. The terminals shall also be suitable for attachment of auxiliary devices such as bridging bars, links, fuses, indicators, isolators and isolation devices.

3.16.2 Each terminal shall be uniquely identified by numbers or letters to coincide with the wiring numbering system specified herein or in SANRAL's Requirements.

3.17 EQUIPMENT TO BE USED IN SWITCHBOARDS DATA AND COMPLIANCE SHEET

TABLE 3-1: EQUIPMENT TO BE USED IN SWITCHBOARDS DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
3.17.1	BS EN 60947-2:1992	Specification for low-voltage switchgear and control gear. Circuit breakers				
3.17.2	SANS 767-1:1982 (SABS 767-1)	Earth leakage protection units Part 1: Fixed earth leakage protection circuit breakers				
3.17.3	SANS 767-2:1983 (SABS 767-2	Earth leakage protection units Part 2: Single-phase, portable units				
3.17.4	SANS 156	Moulded-case circuit breakers				
3.17.5	IEC 60947-1 (2007-06) Ed. 5.0	Low-voltage switchgear and control gear - Part 1: General rules Maintenance Result Date: 2010				
3.17.6	BS 7626:1993	Specification for current transformers				
3.17.7	BS EN 60051-1:1999	Direct acting indicating analogue electrical measuring instruments and their accessories. Definitions and general requirements common to all parts				
3.17.8	BS 775-2:1974 BS	Specification for contactors. A.C. contactors for voltages				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
	775:Part 2:1974	above 1 kV and up to and including 12 kV				
3.17.9	BS EN 60947-5-1:2004 A1:2009	Specification for low-voltage switchgear and control gear. Control circuit devices and switching elements. Electromechanical control circuit devices				
3.17.10	IEC 60947-5-1 (2003-11) Ed. 3.0	Low-voltage switchgear and control gear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices				
3.17.11	EN 60204/VDE 0113	Safety of machinery – Electrical equipment of machines, part 1: Specification for general requirements				
3.17.12	BS EN 60947-3:1992	Specification for low-voltage switchgear and control gear. Switches, disconnectors, switch-disconnectors and fuse-combination units				
3.17.13	BS 88-2:2007	Low-voltage fuses. Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application). Examples of standardized systems of fuses A to I				
3.17.14	SANS 60269-1:2007/IEC 60269-1:2006 (SABS IEC 60269-1)	Low-voltage fuses Part 1: General requirements				
3.17.15	SANS 60269-	Low-voltage fuses Part 2:				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
	2:2007/IEC 60269-2:2006 (SABS IEC 60269-2)	Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) - Examples of standardized systems of fuses A to I				
3.17.16	SANS 60269-3:2007/IEC 60269-3:2006 (SABS IEC 60269-3)	Low-voltage fuses Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) - Examples of standardized systems of fuses A to F				
3.17.17	SANS 60269-4:2009/IEC 60269-4:2009 (SABS IEC 60269-4)	Low-voltage fuses Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices				
3.17.18	BS EN 60730-2-10:1995, BS EN 60730-2-11:1994, BS E	Specification for electrical controls for household and similar general purposes				
3.17.19	BS 1050:1984	Specification for indicator lamps for use in telecommunication apparatus and for allied purposes				
3.17.20	BS EN 60051-1:1999	Direct acting indicating analogue electrical measuring instruments and their accessories. Definitions and general requirements common to all parts				
3.17.21	DB 89-2:1990	Direct acting indicating analogue electrical measuring instruments and				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		their accessories. Specification for special requirements for ammeters and voltmeters				
3.17.22	DB 89-3:1990	Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for wattmeters and varmeters				
3.17.23	DB 89-4:1990	Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for frequency meters				
3.17.24	DB 89-5:1990	Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for phase meters, power factor meters and synchroscopes				
3.17.25	DB 89-6:1990	Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for ohmmeters (impedance meters) and conductance meters				
3.17.26	DB 89-7:1990	Direct acting indicating analogue electrical measuring instruments and their accessories.				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		Specification for special requirements for multi-function instruments				
3.17.27	DB 89-8:1990	Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for accessories				
3.17.28	DB 89-8:1990	Direct acting indicating analogue electrical measuring instruments and their accessories. Recommended test methods				
3.17.29	IEC 60051-1 (1997-12) Ed. 5.0	Direct acting indicating analogue electrical measuring instruments and their accessories - Part 1: Definitions and general requirements common to all parts				
3.17.30	BS 7626:1993	Specification for current transformers				
3.17.31	SANS 177:2004/ISO 1519:2002 (SABS ISO 1519)	Paints and varnishes - Bend test (cylindrical mandrel)				
SWITCHBOARD						
	CLAUSE					
3.17.32	3.1	Withdrawable metal clad air circuit breakers				
3.17.33	3.2	Moulded-case Circuit breakers				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
3.17.34	3.3	Combination Switch-fuse Units				
3.17.35	3.4	Triple-pole On-load Isolator				
3.17.36	3.5	Earth Leakage Relays (30 mA)				
3.17.37	3.6	Contactors				
3.17.38	3.7	Rotary Cam Switches				
3.17.39	3.8	Cartridge Fuses and Fuse Holders (Low Voltage up to 600 V)				
3.17.40	3.9	Time Switches				
3.17.41	3.10	Pushbuttons and Pushbutton Assemblies				
3.17.42	3.11	Indicator Lights				
3.17.43	3.12	Indicating Instruments				
3.17.44	3.12.1	General Requirements				
3.17.45	3.12.2	Voltmeters and Voltmeter Selector Switches				
3.17.46	3.12.3	Ammeters				
3.17.47	3.12.4	Kilowatt-hour meters				
3.17.48	3.12.5	Frequency meters				
3.17.49	3.12.6	Running hour meters				
3.17.50	3.13	Control Relays				
3.17.51	3.14	Sequence Time Switches				
3.17.52	3.14	Current Transformers				
3.17.53	3.16	Terminals				

4. EXTRA LOW AND LOW VOLTAGE, FIBRE OPTIC AND DATA CABLES

4.1 GENERAL

4.1.1 This section covers the installation of cables, for the distribution of electrical power, in soil, buildings and structures for system voltages up to 11 kV at 50 Hz.

4.1.2 This section also covers the installation only of fibre optic and extra low-voltage (<- 50V) including data cables where applicable.

4.1.3 All cables shall be new and unused and unless cables are made to order, only cables from fresh stock shall be supplied.

4.1.4 All cables shall be manufactured according to SANS 1507-1 & 2.

4.1.5 Cables shall be manufactured and supplied in one length to the required lengths unless these lengths exceed a standard drum length, in which case a ruling shall be obtained from SANRAL.

4.1.6 Unless otherwise specified herein or in SANRAL's Requirements or approved, cables with copper conductors shall be used throughout.

4.1.7 Copper conductors shall be of high conductivity annealed or hard-drawn stranded copper and the cores may be shaped or circular but the cross-sectional area of each conductor shall not be less than that specified herein or in SANRAL's Requirements.

4.1.8 In cases where the use of aluminium conductors has been approved by SANRAL, plain wire or solid sectorial aluminium conductors and shaped or circular aluminium cores with the specified cross-sectional area shall be used. SANRAL shall in all cases approve the termination method before it is implemented.

4.1.9 Unless otherwise specified herein or in SANRAL's Requirements or approved, all unarmoured cable shall be installed in metal trunking, ducts or conduit.

4.1.10 At no point shall any cabling (processing, power, communication and sensor, etc.) be accessible to non-maintenance staff.

4.2 COMPETENCE OF PERSONNEL

4.2.1 It is a definite requirement that the Contractor shall only employ personnel fully conversant with the cable manufacturer's recommendations to lay, join and terminate cables.

4.2.2 Cables and cable accessories shall be installed in accordance with the manufacturer's installation instructions.

4.3 CABLE TERMINATIONS

4.3.1 General

4.3.1.1 Connection of cables to switchgear shall always be effected in such a way that the various phases, seen from the front of the switchgear shall be in the following positions where practically possible:

(a) Conductor no 1: left (red)

(b) Conductor no 2: centre (white or yellow)

(c) Conductor no 3: right (blue)

4.3.1.2 Exposed armouring shall be covered with bitumen base paint.

4.3.1.3 All cable ends shall be supplied with the necessary earth connection.

4.3.1.4 A P4000 channel or other approved means of support shall be provided to remove mechanical stress from the glands.

4.3.1.5 Cable cores shall be marked with heat-shrinkable ducts where necessary to identify the phases. Refer to clause 5.2.1 (d) of SANS 10142-1.

4.3.1.6 The current-carrying capacity and breakdown voltage of the cable end shall be the same as for the complete cable.

4.3.1.7 Cables shall be terminated in accordance with the recommendations laid down by the manufacturers of the cables and glands employed.

4.3.2 Cable terminations with heat-shrinkable materials

4.3.2.1 The complete kit shall be packed in a container that is marked for the type of cable insulation and construction as well as the voltage range for which the materials are suitable.

4.3.2.2 An illustrated set of instructions for the installation of the materials shall accompany every kit.

4.3.2.3 The terminations shall make minimal, if any, use of insulating or stress relieving tapes. The use of electrical stress control and insulating tubing that is heat-shrunk on to the terminations is preferred above other methods.

4.3.2.4 The kits shall include suitable boots for the covering of the terminal studs on the equipment. The ends shall be terminated strictly in accordance with the termination manufacturer's specification and shall withstand the same test voltage as the rest of the cable.

4.3.2.5 The materials shall comply with VDE 0278-629-1:2002-06 and the supplier shall be called upon to confirm this aspect before acceptance of the materials or installation.

4.3.2.6 The heat-shrinkable and other materials used for the terminations shall be of a high quality and shall retain their electrical and mechanical properties without deterioration.

4.3.2.7 Terminations shall be made of a material that gives lasting protection against ultra-violet radiation.

4.3.2.8 The cores of all cables terminated outdoors and the cores of 3,3 kV and higher voltage cables terminated indoors shall be completely covered with a shrunk-on protective layer against surface tracking, ultra-violet radiation and weathering.

4.3.2.9 Outdoor terminations shall be designed to prevent flashover under wet or contaminated conditions and to ensure additional mechanical strength. This shall be achieved with shrunk-on insulating spacers and rain sheds.

4.3.2.10 Heat-shrinkable termination kits of the "RAYCHEM" type shall be used for all high voltage (above 1 kV) terminations and shall be applied strictly in accordance with the manufacturer's recommendations.

4.4 CONNECTION OF CABLE CONDUCTORS

4.4.1 When cutting away insulation from cable conductors to fit into lugs, care shall be taken that no strands are left exposed. Under no circumstances may any of the conductor strands be cut away to fit into lugs.

4.4.2 Cables that are connected to clamp type terminals where the clamping screws are not in direct contact with the conductors need not be lugged, but the correct size terminals shall be used.

4.4.3 Ferrules shall be used where cable conductors are connected directly to equipment with screws against the conductor strands.

4.4.4 Suitable lugs shall be used and shall preferably be solidly sweated to cable conductor ends. Lugs may be crimped using mechanical, hydraulic or pneumatic tools specifically designed for this purpose, on condition that evidence is submitted that the system used complies with the performance requirements of BS 4579, Part 1, “Compression joints in copper”.

4.4.5 Lugs crimped to cable with a cross-sectional area of more than 16 mm² shall entail the use of either pneumatic or hydraulic crimping tools. Under no circumstances may a lug be crimped by means of a hammer and/or punch.

4.4.6 Lugs crimped to aluminium shall be subjected to thorough inspection with relation to the material and quality of crimping by SANRAL.

4.4.7 Contact surfaces shall be thoroughly cleaned and smoothed and fixing bolts shall match the whole size of the lug and shall be manufactured of cadmium plated high tensile steel.

4.5 CABLE JOINTS

4.5.1 General

4.5.1.1 Joints in cable runs will not be allowed unless authorized by SANRAL.

4.5.1.2 Jointing shall only be carried out by personnel competent in jointing the types of cable used and shall be carried out strictly in accordance with the manufacturer's instructions.

4.5.1.3 The Contractor shall notify SANRAL timeously of the day on which jointing is to be carried out in order that an inspection may be arranged, if so required. Any cable joint not inspected by SANRAL because of insufficient notice being given shall be opened for inspection and redone at the discretion of SANRAL at the cost of the Contractor.

4.5.1.4 During outdoor jointing operations, the joint bays shall be adequately covered by tents of waterproof material suitably supported. When necessary, a trench shall be excavated around the bay to prevent the ingress of moisture. The sides of the hole shall be draped with small tarpaulin or plastic sheeting to prevent loose earth from falling in during jointing operations.

4.5.1.5 Joints shall be fully waterproof and airtight and shall be free of voids and air pockets.

4.5.1.6 The joint shall not impair the anti-electrolysis characteristics of the cable.

4.5.1.7 The crossing of cores in joints shall not be permitted under any circumstances.

4.5.1.8 The electrical continuity of all the conductors, screens and armouring shall not be impaired by the joints and the earth continuity shall be accomplished within the joints, i.e. no external earth continuity conductor that will be subject to corrosion is acceptable. The joints shall be completely covered by a watertight sheath to prevent corrosion.

4.5.1.9 In the case of joints in cables with an outer PVC anti-electrolysis sheath, the joints shall be subject to the same electrical insulation test as the outer sheath of the cable.

4.5.1.10 Low voltage cable joints shall be of the epoxy resin type.

4.5.1.11 High voltage cable joints shall be of the heat shrinkable type.

4.5.2 Cable Joints with Heat Shrinkable Materials

4.5.2.1 The complete joint kit shall be packed in a container that is marked for the type of cable insulation and construction as well as the voltage range for which the materials are suitable.

4.5.2.2 An illustrated set of instructions for the installation of the materials shall accompany every kit.

4.5.2.3 The joints shall make minimal, if any, use of insulating or stress relieving tapes. The use of electrical stress control and insulating tubing that is heat-shrunk onto the joint is preferred to other methods.

4.5.2.4 The materials shall comply with VDE 0278-629-1:2002-06 and the supplier shall be called upon to confirm this aspect before acceptance of the materials or installation.

4.5.2.5 The heat-shrinkable and other materials used for joints shall be of a high quality and shall retain their electrical and mechanical properties without deterioration.

4.5.2.6 Heat-shrinkable joints kits of the RAYCHEM type shall be used for all high voltage (above 1 kV) joints.

4.5.2.7 Where cable joints are required to be made in the course of a cable run, a joint hole shall be excavated of sufficient size to enable the cable jointer to work efficiently and unimpeded.

4.6 CABLE AND CABLE ROUTE IDENTIFICATION

4.6.1 Cables shall be identified at all terminations (both ends). The identification of HT cables installed in cable ladders, ducts or to structures shall be to SANS 10142-2.

4.6.2 All cables shall be marked with the "OVALGRIP" markers with the international colour code secured to the cable with "INSULOK" cable ties as distributed by "BOWTHORPE-HELLERMANN-DEUTSCH (PTY) LTD" or exact equivalent approved by SANRAL.

4.6.3 The use of PVC tape with punched characters or punched metallic bands or tabs is not acceptable.

4.6.4 The identification number of cables shall be shown on the "as built' drawings of the installation.

4.6.5 Cable route markers shall consist of RF Tags, similar to 3M's, installed underground with the cables.

4.6.6 The RF tag shall contain the following information:

4.6.6.1 Unique sequential tag ID;

4.6.6.2 Type of cable in trench (MV or LV); and

4.6.6.3 Number of cables in trench.

4.6.7 Cable markers shall be installed at the beginning and end of a cable run (e.g. where a cable enters a substation or building), at all changes of direction, above all Joints, above cable pipe entries and exits and at intervals not exceeding 50 m along the cable route and at each cable joint.

4.6.8 The position of cable routes and dimensions to fix structures like bridges, km distances markers etc. shall be indicated on the "as built" drawings.

4.7 TRENCHING EXCAVATIONS

4.7.1 General

4.7.1.1 The Contractor shall be responsible for all trenching excavations unless otherwise specified herein or in SANRAL's Requirements.

4.7.1.2 The Contractor shall, before trenching commences, familiarize himself with the routes and Site conditions. The procedure and order of doing the Works shall be planned in conjunction with the general construction programme for other services and the construction activities, if applicable.

4.7.1.3 The Contractor shall verify the existence and the positions of any known buried services such as electrical and communication cables, sewer, water and storm water pipes and fuel lines in the vicinity of the cable route and shall ensure that they are not damaged during trenching operations. Care shall also be exercised at all times to prevent damage to uncharted services. For this purpose, the Contractor shall approach SANRAL, the local municipal authority and any other authority that may be involved in writing.

4.7.1.4 The Contractor will be held responsible for damage to any existing services brought to his attention by the relevant authorities and shall be responsible for the cost of repairs.

4.7.1.5 The Contractor shall take all the necessary precautions and provide the necessary warning signs and/or lights to ensure that the public and/or employees on Site are not endangered.

4.7.1.6 The Contractor shall ensure that the excavators will not endanger existing structures, roads, railways, other Site constructions or other property.

4.7.2 Routes

4.7.2.1 Trenches shall connect the points shown on the drawings in a straight line. Any deviations due to obstructions or existing services shall be approved by SANRAL beforehand.

4.7.2.2 SANRAL reserves the right to alter any cable route or portion thereof in advance of cable laying. Payment in respect of any additional or wasted Works involved shall be at the documented rates.

4.7.2.3 The removal of obstructions along the cable routes shall be subject to the approval of SANRAL.

4.7.3 SATS and Provincial Administration or National Road Crossings

4.7.3.1 The Contractor shall not trench beneath any railway tracks without the SATS administration's supervision. The Contractor shall request SANRAL timeously to arrange for the necessary supervision. The cost of such supervision will be paid for by SANRAL.

4.7.3.2 SANRAL will arrange for the necessary wayleave and permission to cross SATS property and railway tracks, or provincial or national road reserves and Telkom approval of proposed cable routes.

4.7.3.3 The Contractor shall carry out the crossing installation in strict accordance with the SATS and provincial administration's requirements and stipulations. Where these requirements are in contradiction with this specification, SANRAL's ruling shall be sought.

4.7.3.4 The Contractor shall ensure that he will conform to the various administrations' requirements regarding crossing of national roads, especially with regard to the safeguarding of the public. SANRAL shall also be indemnified from all liability in this regard.

4.7.3.5 The Contractor shall liaise with the various administrations well in advance regarding the intended dates, times and expected duration of the crossing operations and obtain their approval of the programme and method of operation before commencing with the Works.

4.7.4 Trenching

4.7.4.1 Trenching shall be programmed in advance and the approved programme shall not be departed from save with the consent of SANRAL.

4.7.4.2 Trenches shall be as straight as possible and shall be excavated to the dimensions indicated in this specification.

4.7.4.3 The bottom of the trench shall be of smooth contour and shall have no sharp dips or rises that may cause tensile forces in the cable during backfilling.

4.7.4.4 The excavated material shall be placed adjacent to each trench in such a manner as to prevent nuisance, interference or damage to adjacent drains, gateways, trenches, water furrows, other Works, properties or traffic. Where this is not possible, the excavated materials shall be removed from Site and returned for backfilling on completion of cable laying.

4.7.4.5 Surplus material shall be removed from Site and disposed of at the cost of the Contractor.

4.7.4.6 Trenches across roads, access ways or footpaths shall not be left open. If cables cannot be laid immediately, the Contractor shall install temporary "bridges" or cover plates of sufficient strength to accommodate the traffic concerned.

4.7.4.7 In the event of damage to other services or structures during trenching operations, the Contractor shall immediately notify SANRAL and institute repairs.

4.7.4.8 Prior to cable laying, the trench shall be inspected thoroughly and all objects likely to cause damage to the cables either during or after laying shall be removed.

4.7.4.9 Where ground conditions are likely to reduce maximum current carrying capacities of cables or where the cables are likely to be subjected to chemical or other damage or electrolytic action, SANRAL shall be notified before the cables are installed. SANRAL will advise on the course of action to be taken.

4.7.4.10 Extreme care shall be taken not to disturb surveyor's pegs. These pegs shall not be covered with excavated material. If the surveyor's pegs are disturbed, they shall be replaced by a person qualified to do so.

4.7.5 Dimensions of Trenches

4.7.5.1 Cable trenches for one or two cables shall be not more than 450 mm wide. This dimension shall be valid for the total trench depth.

4.7.5.2 The width shall be increased where more cables are installed to allow for the spacings as specified herein or in SANRAL's Requirements.

4.7.5.3 Where trenches change direction or where cable slack is to be accommodated, the Contractor shall ensure that the requirements of the relevant SABS specification regarding the bending radii of cables are met when determining trench widths.

4.7.5.4 Trench depths shall be determined in accordance with cable laying depths and bedding thickness.

4.7.5.5 Payment will be made on a volumetric excavation rate calculated on the basis of the given maximum dimensions or the actual dimensions, whichever is the lesser.

4.7.6 Mechanical Excavators

4.7.6.1 Power driven mechanical excavators may be used for trenching operations provided that they are not used in close proximity to other plant, services or other installations likely to be damaged by the use of such machinery.

4.7.6.2 The use of power driven mechanical excavators shall be subject to the approval of SANRAL. Should the excavator produce trenches that exceed the required dimensions, payment based on volumetric excavation rates will be calculated on the required dimensions only.

4.7.7 Shoring and Water logging

4.7.7.1 The Contractor shall provide shoring for use in locations where there is a danger of the sides of the trench collapsing due to water logging or other ground conditions. Refer to Reg. D16 of the Factories, Machinery and Building Work Act.

4.7.7.2 The strength of shoring must be adequate for Site conditions prevailing and the shoring must be braced across the trench.

4.7.7.3 The Contractor shall provide all pumps and equipment required to remove accumulated water from trenches. Water or any other liquid removed shall be disposed of without any nuisance or hazard.

4.7.8 Joint Holes

4.7.8.1 Where cable joints are required to be made in the course of a cable run, a joint hole shall be excavated of sufficient size to enable the cable jointer to work efficiently and unimpeded.

4.7.9 Cable Ducts

4.7.9.1 Where cables cross under roads, railway tracks, other service areas, etc. and where cables enter buildings, the cables shall be installed in Kabelflex corrugated pipes or similar approved by SANRAL. Pitch fibre and PVC pipes are not acceptable because of the adhesion that occurs after a period between the pipe and the sheathing or outer serving of the cables.

4.7.9.2 Pipes shall be jointed in accordance with the manufacturer's instructions.

4.7.9.3 Ducts shall cross roads and railway tracks at right angles.

4.7.9.4 Ducts shall have a minimum diameter of 150 mm and shall extend at least 2,0 m on either side of the centre line of a railway track or of the outermost track where there is more than one track and in the case of road at least 1,0 m beyond the road edge or kerb on either side of the road.

4.7.9.5 All ducts shall be graded 1:400 for water drainage.

4.7.9.6 Cable ducts shall be installed to the spacings and depths as specified herein or in SANRAL's Requirements.

4.7.9.7 Where pipes have to be built into structures by the Contractor or his subcontractor, the Contractor shall supply the pipes and ensure that they are installed correctly.

4.7.9.8 The ends of all ducts shall be sealed with chicken wire and builder's foam after the installation of cables. All ducts intended for future use shall likewise be sealed.

4.7.10 Bedding

4.7.10.1 The bottom of the trench shall be filled across the full width with a 100 mm bedding layer of suitable soil sifted through a 6 mm mesh and levelled off.

4.7.10.2 Only sandy clay or loam soil with a satisfactory thermal resistivity (not exceeding 1,5 °Cm/W) may be used for this purpose. Sea or river sand, ash, chalk, peat, clinkers or clayey soil shall not be used. The use of crusher sand is acceptable.

4.7.10.3 Where no suitable soil is available on Site, the Contractor shall import fill from elsewhere and make all the necessary arrangements to do so.

4.7.10.4 After cable laying, a further layer of bedding shall be provided to extend to 100 mm above the cables.

4.7.10.5 The bedding under joints shall be fully consolidated to prevent subsequent settling.

4.7.11 Backfilling

4.7.11.1 The Contractor shall not commence with the backfilling of trenches without prior notification to SANRAL so that the cable installation may be inspected. Should the Contractor fail to give timeous notification, the trenches shall be re-opened at the Contractor's cost. Such an inspection shall not be unreasonably delayed.

4.7.11.2 Medium voltage cables (1 kV to 11 KV) shall be protected as follows:

(a) Concrete tiles or orange "ESCOM"-type plastic tiles shall be installed immediately above the bedding in a continuous run. Only unbroken concrete tiles shall be used.

(b) A 100 mm wide plastic marking tape shall be installed 400 mm above the protective tiles or slabs. The tape shall be yellow, with red skull and crossbones and the words "ELECTRIC CABLE" printed on not more than 1 m spacing.

4.7.11.3 Low voltage cables (up to 1 kV) shall be protected by means of a 100 mm wide plastic marking tape installed 300 mm above the cable. The tape shall be red-and-white and the words "ELECTRIC CABLE" shall be printed on 500 mm spacing. A further plastic marking tape shall be installed at a depth of 200mm below the finished ground level.

4.7.11.4 Backfilling shall be done with soil suitable to ensure settling without voids. No large stones or rocks shall be present in the backfill material. Soil used for backfilling shall pass through an 80 mm mesh to ensure that the maximum diameter of stones present in the backfill material is 75 mm.

4.7.11.5 The Contractor shall allow import of suitable backfill material if required.

4.7.11.6 The backfill shall be compacted by hand in layers of 150 mm and sufficient allowance shall be made for final settlement. The Contractor shall maintain the refilled trench for the duration of the Operation Service Period. Surplus material shall be removed from Site and suitably disposed of.

4.7.11.7 On completion, the surface shall be made good to match the surrounding area. In the case of roadways or paved areas the excavations shall be consolidated to the original stability and the surface finish reinstated.

4.7.12 Installation Depths

4.7.12.1 Cables shall be installed at the following minimum depths below final ground level:

(a) Up to 1 kV: 600 mm

(b) Up to 11 kV: 900 mm

4.7.12.2 All cable depth measurements shall be made to the top of the cable when laid directly in ground or to the top of the duct where these are provided.

4.7.12.3 The above-mentioned depths shall apply to the top layer where cables are installed in layers.

4.7.12.4 The Contractor may only deviate from the above depths provided prior authority in writing has been obtained from SANRAL. In this event, the cables shall be protected with a suitable concrete covering.

4.7.12.5 The depth of cable pipes or ducts beneath railway lines or roads shall be no less than 1,1 m below the formation level.

4.7.13 Cable Spacing

4.7.13.1 Cables installed in the same trench shall be laid parallel to each other with the following minimum spacings between cables. (LV: up to 1 kV; MV: 1 kV to 11 kV):

(a) LV/LV: 2 cable diameters

(b) LV/MV: 600 mm minimum

(c) MV/MV: 300 mm minimum

4.7.13.2 Where MV and LV cables have to be installed in the same trench, the MV cable shall be laid on the one side of the trench at a depth of 900 mm and then covered with 300 mm of soil. The LV cable shall then be laid on the opposite side of the trench, i.e. not above the MV cable, and the trench can then be completely backfilled as specified.

4.7.13.3 Cables for telephones, communication systems and other low voltage systems (less than 50 V) shall be separated from power cables by at least 1 m. All control or pilot cables shall be laid at least 300 mm from power cables.

4.7.13.4 Where three single-core cables are laid directly in the ground forming one three-phase circuit, they shall be laid in triangular formation, the apex of the triangle being uppermost. In order to maintain a triangular formation, the three cables shall be bound together at 500 mm intervals by means of substantial plastic binders in accordance with SABS Code of Practice for “The Selection, Handling and Installation of Power Cables".

4.7.13.5 Cables shall not be buried on top of each other unless otherwise specified herein or in SANRAL’s Requirements. The minimum spacing between layers shall be 200 mm.

4.7.14 Cable Laying

4.7.14.1 Except where ducts, tunnels or pipes are provided, cables shall be laid directly in the ground.

4.7.14.2 The cable shall be removed from the drum in such a manner that the cable is not subjected to twisting or tension exceeding that stipulated by the cable manufacturer.

4.7.14.3 Cable rollers shall be used as far as possible to run out cables. Rollers shall be spaced so that the length of cable in the trench will be totally suspended during the laying operation and sufficiently close to prevent undue sagging and the cable from touching the ground. Rollers shall also be placed in the trench in such a manner that they will not readily capsize.

4.7.14.4 Cable rollers shall have no sharp projecting parts likely to damage the cables.

4.7.14.5 Where cables have to be drawn around corners, well lubricated skid plates shall be used. The skid plates shall be securely fixed between rollers and shall constantly be examined during cable laying operations.

4.7.14.6 Where cables have to be drawn through pipes or ducts, a suitable cable sock shall be used and particular care shall be exercised to avoid abrasion, elongation or distortion of any kind. In the case of oil-filled cables, a cable sock may never be used. Special eyes giving access to the interior of the cable must be utilised.

4.7.14.7 The maximum allowable tension when pulling a cable is 70 N/mm^2 of conductor area.

4.7.14.8 SANRAL shall be informed timeously of all intended cable laying operations to allow an inspection of the Works by SANRAL or the Independent Engineer.

4.8 INSTALLATION OF CABLES IN PURPOSE-BUILT TRENCHES (CABLE DUCTS)

4.8.1 General

4.8.1.1 This paragraph covers the installation of cables in building trenches and service ducts. The trenches and ducts inside buildings will be constructed and installed by others.

4.8.2 Installation

4.8.2.1 Cables shall be installed in one of the following ways:

(a) On horizontal cable trays;

(b) On horizontal metal supports with suitable clamps;

(c) On vertical cable trays or metal supports fixed to the side of the trench. Cables shall be clamped in position.

4.8.2.2 Cables shall not be bunched and laid on the floor of purpose-built trenches.

4.8.3 Covers

4.8.3.1 The covering of concrete trenches shall, as a rule, fall outside the scope of the electrical installation. The Contractor however, shall be responsible for the cutting or drilling and smoothing of holes for cables through chequer plates, concrete or other coverings as required.

4.8.3.2 Cables shall enter and exit the trench through ducts protruding 300 mm beyond the covering. The ducts shall be permanently secured in position and the open space between the cable and ducts shall be sealed with a non-hardening watertight compound.

4.8.4 Filled Trenches

4.8.4.1 Where specified herein or in SANRAL's Requirements, floor trenches shall be filled with sand.

4.8.4.2 If a sand filling is specified, the cables shall be fixed to non-corroding supports.

4.8.4.3 Sand-filled trenches other than in substations shall be covered in one of the following ways:

(a) Reinforced concrete covers;

(b) Sand and cement screed;

(c) Removable chequer plates.

4.8.4.4 Reinforced concrete covers shall be used where vehicular traffic may be encountered over trenches. Unless otherwise specified herein or in SANRAL's Requirements, allowance for a mass of 2 tons shall be made.

4.9 INSTALLATION OF CABLES ON TRAYS, LADDERS AND STRUCTURES

4.9.1 Installation

4.9.1.1 Cables may be installed in one of the following ways:

(a) On horizontal cable trays or ladders with purpose-made clamps;

(b) Against vertical cable trays or ladders with purpose-made clamps;

(c) Against horizontal or vertical metal supports or brackets with suitable clamps;

(d) With clamps which are fixed to the structure.

4.9.2 Clamps

4.9.2.1 On horizontal or vertical cable trays, cables shall be secured by means of "INSULOK" or "PULLTITE" or similar approved cable ties with maximum spacing as specified in Table 1 below.

4.9.2.2 On horizontal or vertical cable ladders, cables shall be secured by means of purpose-made hot-dip-galvanised “K”-clamps. This however, does not apply to single core cables.

4.9.2.3 Where cables are secured to channels cast in concrete, purpose-made hot-dip-galvanised “K"-clamps shall also be used. This however, does not apply to single core cables.

4.9.2.4 Suitable clamps (cleats), which will secure cables without damage, shall be used. Clamps shall consist of adjustable metal wings that clamp to a metal support, or consist of two halves that are bolted together. Wooden blocks shall only be used in exceptional circumstances with the approval of SANRAL. The correct clamp size to fit the cable shall be used. Cables of different sizes may only be fixed by a common clamp when the clamp is specially made to accommodate the various cables.

4.9.3 Spacing of Supports

4.9.3.1 General

The most generally known method of supporting cables is the restrained installation where the distance between supports is small enough to prevent any noticeable sag in the cable. Unless otherwise specified herein or in SANRAL's Requirements, this method shall apply to all cable installations.

4.9.3.2 Spacing of Supports of Restrained Cables

The maximum spacing between cleats (clamps) to which cables are fixed in horizontal and vertical cable routes shall be determined from Table 1 below. Additional cleats shall be installed at each bend or offset in the cable run. The maximum distance between supports or cleats for multi-core control cables shall be 20 times the outside diameter of the cable with a maximum spacing of 500 mm for unarmoured cables and 30 times the outside diameter of the cable with a maximum spacing of 1 m for armoured cables. A minimum of 20 mm ventilation clearance shall be maintained between cables and the wall to which they are cleated. Spacing of supports for cables for high-voltage lighting shall be in accordance with Table 8 of SANS 10142-1.

TABLE 4-1: MAXIMUM SPACING OF SUPPORTS (CLEATS) (MM) FOR RESTRAINED CABLE

Cross-sectional area of Cable conductors (mm²)	Wire Armoured Cables		Other than Wire Armoured Cables and Unarmoured Cables	
	Horizontal Cable Routes	Vertical Cable Routes	Horizontal Cable Routes	Vertical Cable Routes
1,5	500	750	300	400
2,5	500	750	300	400
4,0	600	750	300	400
6,0	600	750	300	400
10,0	750	900	400	500
16,0	750	1 000	400	500
25,0	900	1 000	400	500
35,0	900	1 000	400	500
Above 35,0	900	1 000	400	500

4.9.4 Grouping and Spacing of Cables

4.9.4.1 Cables with a cross-sectional area of more than 16 mm² shall as a rule be spaced two outside cable diameters apart, for which no grouping correction factor need be applied.

4.9.4.2 Where parallel cable runs are installed at different levels (e.g. on parallel cable trays) and where the spacing of the layers is not specified, a minimum spacing of 300 mm shall be maintained.

4.9.4.3 High-voltage cables shall be separated from other cables and services throughout the installation and shall as far as possible be installed in separate floor trenches, pipes or metal channels. Where this is not feasible, a minimum spacing of 500 mm shall be maintained.

4.9.4.4 Cables for telephone, communication and alarm systems and all other low-voltage systems (less than 50 V), shall be separated from power cables. In building ducts, a physical barrier shall be provided between power cables and cables for other services. Where armoured cables are used for such other services, they shall be at least 1 m away from power cables or shall be installed on separate cable trays. In the case where unarmoured cables are used for these other services, they shall be installed in separate metal channels or conduits.

4.10 INSTALLATION OF CABLES IN REINFORCED CONCRETE ENCLOSED TRENCHES (HIGH RISK AREAS)

4.10.1 General

4.10.1.1 This paragraph covers the installation of cables in reinforced concrete enclosed trenches for protection against cable theft. The reinforced concrete enclosed trenches with or without cable ducts may be constructed by the Contractor or by others.

4.10.2 Installation

4.10.2.1 Cables shall be installed in one of the following ways:

(a) Inside a duct;

(b) If approved by SANRAL or the Independent Engineer, directly covered with reinforced concrete (Portland or similar approved cement only);

(c) With or without manholes;

4.10.3 Cables shall be de-rated to allow for the additional heat load that will be generated due to the reinforced concrete covering;

4.10.4 A Cable Guard as supplied by Abardare Cables or similar approved device can be used to secure the cable in the duct.

4.10.5 Reinforced concrete trenches

4.10.5.1 The reinforced concrete trenches shall, as a rule, fall outside the scope of the electrical installation.

4.10.5.2 The reinforced concrete trenches shall be constructed by the civil contractor as per the details provided in the drawing below:

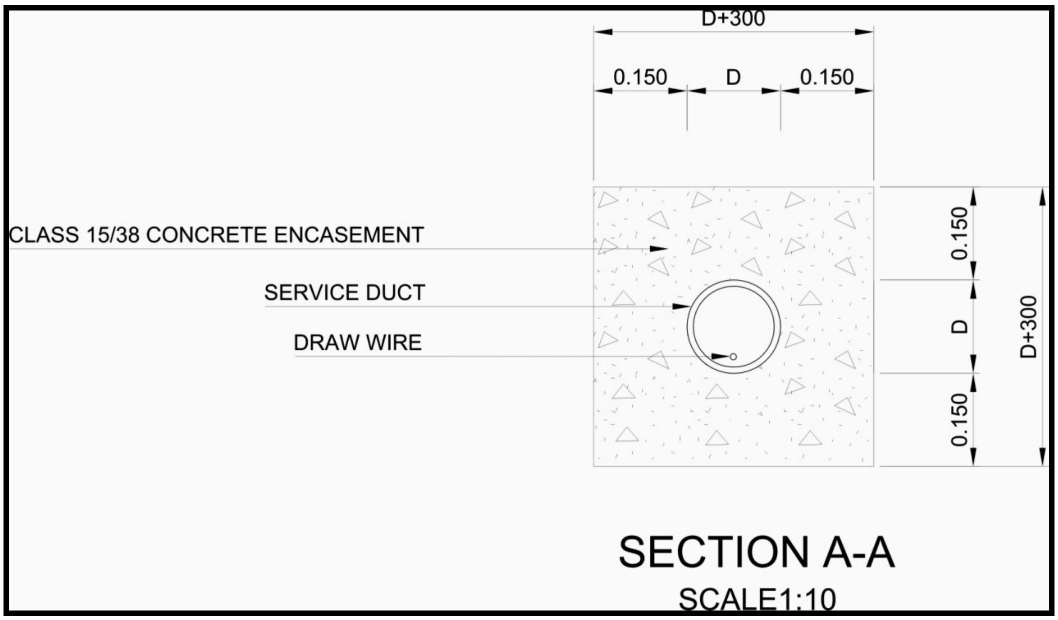


FIGURE 4-1: SERVICE DUCT IN CONCRETE ENCLOSED TRENCH

4.10.6 Service manholes

4.10.6.1 The service manholes shall be constructed as per the drawings below. Changes to the manhole construction shall be approved by SANRAL or his representative.

4.10.6.2 Manholes shall be spaced not more than 200m on a straight length of cable route, and al all change of direction in the cable route, where concrete encased cable sleeves are used. All manholes shall be RF tagged.

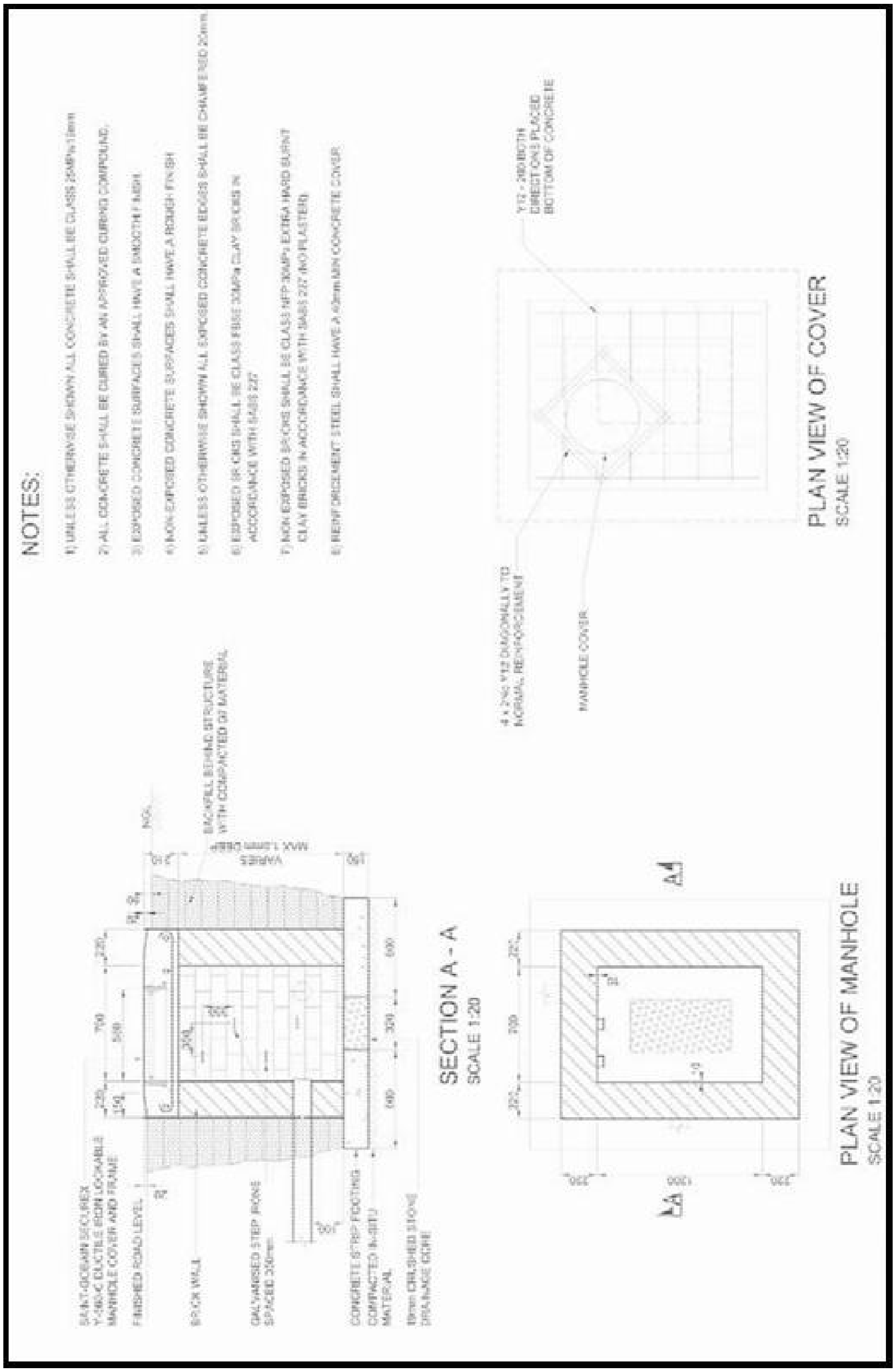

NOTES:
SECTION A - A
SCALE 1:20
PLAN VIEW OF MANHOLE
SCALE 1:20
PLAN VIEW OF COVER
SCALE 1:20

Figure 4-2: SERVICE MANHOLE

4.11 TESTING

4.11.1 Each cable shall be tested after installation in accordance with SANS 1507-1 & 2 (up to 1 kV), SANS 97:2001, SANS 1339:2006 (up to 11 kV) and the requirements of the Local and Supply Authorities.

4.11.2 The Contractor shall make all arrangements, pay all fees and provide all equipment for these tests.

4.11.3 The Contractor shall notify SANRAL timeously so that he may witness the tests.

4.11.4 LV cables shall be tested by means of a suitable megger at 1 kV and the insulation resistance shall be tabulated and certified.

4.11.5 MV cables shall be pressure tested in accordance with Table 2 and the exact leakage current shall be tabulated and certified.

TABLE 4-2: MV CABLE TEST VOLTAGE

Cable Rating (kV)	TEST VOLTAGE (kV applied for 15 minutes)				
	Paper-insulated cables				XLPE-insulated cables
	Between conductors		Conductors to sheath		Conductors to screen
	AC (rms)	DC	AC (rms)	DC	DC
6,6	12	18	12	18	11
11	20	30	20	30	18

4.11.6 On completion of the tests on any cable, the Contractor shall immediately submit three copies of the certified test reports to SANRAL.

4.12 COMPLETION

4.12.1 SANRAL reserves the right to inspect the installation at any stage during the course of construction. Such inspections however, will not deem the portions inspected as being complete or accepted and the Contractor shall remain responsible to complete the installation fully in accordance with this Contract.

4.12.2 The Contractor shall carry out a final “as built" survey of the cable routes and present “as built" route plans of the complete installation to SANRAL.

4.12.3 The following information shall be reflected on the plans or submitted as separate schedules with the plans:

4.12.3.1 Overall length of each cable.

4.12.3.2 Locations of all joints (if any) in relation to permanent reference points. Dimensions shall be shown and the method of triangulation i.e. two dimensions to each joint, shall be used.

4.12.3.3 The location of all cable markers in relation to permanent reference points.

4.12.3.4 Identification numbers of all cables.

4.12.4 The Works will be deemed incomplete until all tests have been conducted and certified successfully and all "as built" drawings and schedules have been handed to SANRAL.

4.13 PVC INSULATED CABLES 600/1 000 V GRADE

4.13.1 The cables shall be manufactured in accordance with SANS 1507-1 & 2.

4.13.2 Cables shall be constructed as follows:

4.13.2.1 Unarmoured cables: PVC- insulated/PVC-sheathed

4.13.2.2 Armoured cables: PVC-insulated/PVC-bedded/armoured/ black extruded PVC outer sheath

4.13.2.3 ECC cables: PVC insulated/PVC-bedded/armoured, with copper earth continuity wire in armour/black extruded PVC outer sheath

4.13.2.4 Single core cables: PVC insulated and unsheathed (for installation in wireways and switchboards).

4.13.3 The insulation shall be general purpose PVC, 600/1 000 V Grade.

4.13.4 The bedding shall consist of a continuous impermeable sheath of PVC, extruded to fit the core or cores closely and, in the case of multi-core cables, to fill the interstices between the cores. The bedding may be extruded as part of the PVC sheathing.

4.13.5 Where armouring is specified herein or in SANRAL's Requirements, it shall consist of one layer of galvanised steel wire in the case of multi-core cables and non-magnetic metallic wire in the case of single-core cables. Aluminium strip or tape armouring is not acceptable.

4.13.6 Where specified herein or in SANRAL's Requirements, an earth continuity conductor shall be provided in the armouring in accordance with SANS 1507-1 & 2.

4.13.7 At the request of SANRAL, tests shall be carried out on production runs of the cable in accordance with SANS 1507-1 & 2.

4.13.8 The correct size and type of gland shall be used for the particular cable and application. Glands shall be fitted in accordance with the cable and gland manufacturer's instructions.

4.13.9 Glands shall be suitable for general-purpose 600/1 000 V grade cable with steel armouring and shall be made of heavily nickel-plated bronze or brass provided with ISO threads.

4.13.10 The glands shall consist of a barrel carrying a cone bush screwed into one end and a nickel-plated brass nipple carrying a nickel-plated brass lock nut screwed into the other end.

4.13.11 For unarmoured cables, the cone bush and compression ring of the gland shall be replaced with a synthetic rubber compression bush and ring to provide the required grip on the outer sheath of the cable.

4.13.12 Suitable accessories shall be provided with glands to be used on ECC-armoured cables to facilitate a bolted lug connection of the earth continuity conductors. Grooves cut into the barrel or cone bush to accommodate the earth continuity conductors, are not acceptable.

4.13.13 Non-watertight glands must be easily converted to watertight glands by means of a waterproofing shroud and inner seal kit. On the cable entry side of the barrel, a concave groove shall be provided to accommodate the top rim of the waterproofing shroud.

4.13.14 The shrouds shall be made of non-deteriorating neoprene or other synthetic rubber, and shall be resistant to water, oil and sunlight. The shrouds shall fit tightly around the glands and cable.

4.14 XLPE-INSULATED CABLES

4.14.1 The cables shall be manufactured in accordance with SANS 1339.

4.14.2 XLPE Cable shall consist of high conductivity annealed or hard-drawn stranded copper or aluminium conductors, a stress equalising layer of extruded semi-conducting cross-linked polyethylene, extruded cross-linked polyethylene insulation, a core screen of semi-conductive tape or a layer of extruded semi-conducting compound applied over a semi-conducting coating or a layer of extruded semi-conducting compound applied directly to the dielectric. A collective metallic screen of annealed copper tape enclosing all the cores and interstitial filler shall be protected by an extruded PVC sheath.

4.14.3 Where armoured cables have been specified herein or in SANRAL's Requirements, a bedding consisting of a continuous impermeable layer of PVC shall be provided. The galvanized steel wire armour shall be enclosed in an outer sheath of PVC.

4.14.4 All terminations and joints shall be done with heat-shrinkable kits.

4.14.5 The copper tapes of the earth screen on the cable shall be bonded to the main earth bar of the switchgear or transformer, but the bond shall be easily removable for testing purposes.

4.14.6 Where clamping blocks or cleats have not been provided with the equipment on which the cables are to be terminated, the Contractor shall provide these to relieve the cable termination of any mechanical stress.

4.14.7 Where glands are required for use with armoured XLPE cable the "CCG" type of glands shall be employed.

4.15 FLAME-RETARDANT CABLES

4.15.1 Where a flame-retardant cable is specified herein or in SANRAL's Requirements, it shall be capable in its completed form of passing the resistance to fire propagation test in accordance with SABS test method No. 494 without showing any traces of burning higher than 3,5 m above the top of the furnace. The critical oxygen index of PVC component of the cable shall be determined at the time of the resistance to fire propagation test in accordance with ASTM D2863 and the values recorded.

4.15.2 All flameproof glands shall comply with SANS 808, groups 1, 2 and 2b.

4.16 SINGLE-CORE CABLES

4.16.1 Where a three-phase circuit uses single-core cables, the cables shall be installed in trefoil formation and bound together with substantial plastic cable ties in accordance with the SABS Code of Practice for "The Selection, Handling and Installation of Electric Cables". Cables with a cross-sectional area of up to 16 mm² shall be bound together at 500 mm intervals.

4.16.2 In trefoil formation, the cables shall be clamped touching one another in triangular formation, the apex of the triangle being uppermost by means of purpose-made trefoil clamps or cleats shaped to maintain this formation.

4.16.3 The Contractor shall satisfy SANRAL that the cleats to be used for securing single-core cables in a three-phase group, are capable of withstanding without deformation, the dynamic stresses resulting from short-circuit faults of the magnitude and duration on which the design is based.

4.16.4 Single-core cables carrying alternating current shall be fixed to cable trays, ladders and structures by means of cleats of hardwood or other approved material shaped to suit the formation of the cables and clamped in such a way that no magnetic circuit is maintained through any iron work supporting or forming part of the rack.

4.17 EXTRA LOW-VOLTAGE, FIBRE OPTIC AND DATA CABLES

4.17.1 General

4.17.1.1 This section covers the installation only of fibre optic and extra low-voltage (<-50V) communication cables.

4.17.1.2 All cables shall be new and unused.

4.17.1.3 All cables shall comply with the required SABS or international standard where applicable.

4.17.1.4 Cables shall be manufactured and supplied in one length to the lengths specified unless these lengths exceed a standard drum length, in which case a ruling shall be obtained from the Operations Manager.

4.17.1.5 Unless otherwise specified or approved, all un-armoured cable shall be installed in metal trunking, sleeves or conduit.

4.17.1.6 Jointing and Testing of Fibre Optic and Communication Cables

4.17.1.7 Joints in cable runs will not be allowed unless authorised by the Operations Manager.

4.17.1.8 Jointing / splicing shall only be carried out by personnel competent in jointing the types of cable used and shall be carried out strictly in accordance with the applicable SABS/IEC standards at time of installation and with the manufacturer's instructions. For single-mode splicing, only fusion splicing will be accepted.

4.17.1.9 The Operator shall notify the Operations Manager timeously of the day on which jointing/splicing is to be carried out in order that an inspection may be arranged if so required. Any cable joint/splice not inspected by the Operations Manager because of insufficient notice being given, shall be opened for inspection and redone at the discretion of the Operations Manager.

4.17.1.10 The Operator shall arrange for OTDR testing of the fibre optic link following any damage to it or repairs taking place and make the results available to the Operations Manager. OTDR testing shall be performed in both directions on each fibre within a cable, and the results shall be properly identified to allow comparison of the “before” and “after” results, allowing for the verification of the integrity of all fibres after repairs have been affected. The Operator shall perform an inspection of all fibre optic cable section joints in manholes or other enclosures 6 months prior to the expiration of the Contract. The Operator should inform the Operations Manager of this inspection, should he wish to attend. A full inspection report detailing the condition of the cable joint terminations, manholes etc. shall be provided by the Operator. If moisture ingress in the joints is noted, the condition of the fibre cable in the immediate vicinity should be checked for possible damage. The Operator shall also perform an OTDR test of the fibre optic link and submit the results to the Operations Manager 6 months prior to the expiration of the Contract.

4.17.1.11 The OTDR test report shall be complete and must also indicate all the possible joints on the tested fibre. Each fibre shall be tested from both sides. Cable db signal losses shall be indicated if outside the tolerances in the table below.

4.17.1.12 The Operator shall ensure that the losses recorded in 4.17.1.10 above are within the parameters specified below:

Fibre Cable	Loss Tolerance
Single mode (1310 nm)	< 0.4 dBm/Km
Single mode (1550 nm)	< 0.3 dBm/Km
Multi mode (850 nm)	< 3.5 dBm/Km

Multi mode (1300 nm)	< 1.2 dBm/Km
Single mode splice	< 0.025 dBm
Multi mode splice	< 0.1 dBm

4.17.1.13 All joints / splices that are not located in a protected equipment cabinet shall have at least an IP66 rating.

4.17.2 Fibre optic cabling

4.17.2.1 Fibre optic cable shall be protected by means of a 100 mm wide plastic marking tape installed 300 mm above the cable. The tape shall be red and white and the words "FIBRE OPTIC CABLE" shall be printed on 500 mm distances on it.

4.17.2.2 If it is not possible to split the power and data network the Contractor shall install fibre optic cable to eliminate interference and comply with safety requirements.

4.17.2.3 To protect electronic equipment and data networks, fibre optic cabling shall be used to connect separate building to the data network. The lanes shall be seen as a separated building.

4.17.3 Cable Spacing:

4.17.3.1 Cables for telephone, communication and alarm systems and all other extra low voltage systems (less than 50 V), shall be separated from power cables. In building ducts a physical barrier shall be provided between power cables and cables for other services. Where armoured cables are used for such other services, they shall be at least 1 m away from power cables or shall be installed on separate cable trays. In the case where unarmoured cables are used for these other services, they shall be installed in separate metal channels or conduits

4.17.3.2 Should manholes and sleeves be installed for telephone, communication and data system it shall be a separated close system form any other service.

4.17.4 Testing

4.17.4.1 The Operator shall make all arrangements, pay all fees and provide all Equipment for these tests.

4.17.4.2 The Operator shall notify the Operations Manager timeously so that he may witness the tests.

4.17.4.3 On completion of the tests on any cable, the Operator shall without delay, submit three copies of the certified test reports to the Operations Manager.

4.18 CABLE DATA AND COMPLIANCE SHEET

TABLE 4-3: CABLE DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
4.17.1	SANS 1507-1	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 1: General.				
4.17.2	SANS 1507-2	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 2: Wiring cables.				
4.17.3	SANS 10142-1	The wiring of premises Part 1: Low-voltage installations				
4.17.4	VDE 0278-629-1:2002-06	Test requirements on accessories to use on power cables of rated voltage from 3.6/6(7.2)kV up to 20.8/36(42)kV				
4.17.5	SANS 10142-2	The wiring of premises Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 000 kW installed capacity				
4.17.6	Act 22 of 1941	Factories, Machinery and Building				
4.17.7	SANS 97:2001 (SABS 97)	Electric cables - Impregnated paper-insulated metal-sheathed cables for rated voltages 3,3/3,3 kV to 19/33 kV (excluding pressure assisted cables)				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
4.17.8	SANS 1339:2006 (SABS 1339)	Electric cables - Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV				
4.17.9	ASTM D2863					
4.17.10	SABS TEST METHOD NO. 494					
4.17.11	SANS 808:1967 (SABS 808)	Cable glands for use on flameproof enclosures				
CABLES						
	CLAUSE					
4.17.12	4.3	Cable Terminations				
4.17.13	4.4	Connection of Cable Conductors				
4.17.14	4.5	Cable Joints				
4.17.15	4.6	Cable and Cable Route Identification				
4.17.16	4.7	Trenching Excavations				
4.17.17	4.8	Installation of Cables in Purpose-built Trenches (CABLE DUCTS)				
4.17.18	4.9	Installation of Cables on Trays, Ladders and Structures				
4.17.19	4.1	Installation of Cables in REINFORCED CONCRETE ENCLOSED Trenches (HIGH RISK AREAS)				
4.17.20	4.12	Testing				
4.17.21	4.13	Completion				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
4.17.22	4.14	PVC insulated Cables 600/1 000 V Grade				
4.17.23	4.15	XLPE-Insulated Cables				
4.17.24	4.16	Flame-retardant Cables				
4.17.25	5.17	Single-core Cables				

5. WIRING

5.1 GENERAL

5.1.1 All wiring shall be done in accordance with the latest edition of SANS 10142-1 as amended.

5.1.2 PVC insulated conductors for general wiring shall consist of high conductivity annealed copper wire strands with polyvinyl chloride insulation (PVC). The insulation shall be compounded and stabilised to comply with SANS 1411-2 as amended.

5.1.3 Conductors shall be finished in the required colours and shall be manufactured in accordance with SANS 1507-1 & 2 as amended.

5.1.4 Any special requirement regarding the type and size of wiring to be installed in a specific installation shall be specified herein or in SANRAL's Requirements.

5.1.5 All joints shall be within boxes with required IP rating for the location of installation. Hellermann-Tyton type or similar approved connectors may be used.

5.2 DRAWING IN OF CONDUCTORS

5.2.1 Wiring shall only be carried out after the wire way installation is completed, but before painting has commenced. No conductors shall be installed before the wireways have been cleaned of all debris and moisture. Wireways shall contain no sharp edges.

5.2.2 When conductors are drawn through conduit, care shall be taken that they are not kinked or twisted.

5.3 WIRING METHOD

5.3.1 All wiring shall be carried out according to the loop-in system. When earth continuity conductors are looped between terminals of equipment, the looped conductor ends shall be twisted together and ferruled to ensure that earth continuity is maintained when the conductors are removed from a terminal.

5.3.2 When connecting more than one conductor in a terminal, the strands shall be securely twisted together. Under no circumstances shall strands be cut off.

5.4 SIZE OF CONDUCTORS

5.4.1 Where conductor sizes are not specified, the following minimum conductor sizes shall be used:

Bell circuits	=	1,5 mm^2
Clock circuits	=	1,5 mm^2
Lighting circuits	=	2,5 mm^2

Plug circuits	=	4 mm^2
All the above	=	2,5 mm^2 earth conductor
Stove circuit	=	10 mm^2
Stove circuit	=	4 mm^2 earth conductor
Motor circuits	=	4 mm^2
Motor circuits	=	2,5 mm^2 earth conductor

5.5 DIFFERENT PHASES

5.5.1 With the exception of three-phase outlets, circuits connected to different phases shall not be present at light, switch or socket outlet boxes.

5.6 WIRING DATA AND COMPLIANCE SHEET

TABLE 5-1: WIRING DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
5.6.1	SANS 1411-2:2009	Material of insulated electric cables and flexible cords Part 2: Polyvinyl chloride (PVC)				
5.6.2	SANS 10142-1	The wiring of premises Part 1: Low-voltage installations				
5.6.3	SANS 1507-1	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 1: General.				
5.6.4	SANS 1507-2	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) – Part 2: Wiring cables.				

WIRING						
	CLAUSE					
5.6.4	5.2	Drawing in of Conductors				
5.6.5	5.3	Wiring method				
5.6.6	5.4	Size of Conductors				
5.6.7	5.5	Different Phases				

6. CONDUIT AND CONDUIT ACCESSORIES

6.1 GENERAL

6.1.1 Conduit and conduit accessories shall comply with SANS 10142-1 as amended and the various SABS or BS codes referred to in SANS 10142-1. Any special requirement regarding the type and size of conduit and conduit accessories to be installed in a specific installation shall be specified in the Project Specification.

6.2 CONDUITS AND RELEVANT WIRING ACCESSORIES

6.2.1 Accessories for a specific conduit system shall not be used in an alternative conduit system.

6.2.2 Care shall be taken to prevent any debris or moisture from entering the conduit during and after installation of conduit. All conduit ends shall be sealed by means of solid plugs, which shall be screwed to the conduit end couplings.

6.2.3 The Contractor shall ensure that conduits are not blocked.

6.2.4 Galvanised steel draw wires shall be installed in all unwired conduits.

6.2.5 All conduit installations, other than surface mounted, shall be of the loop-in system.

6.2.6 Where light fittings are to be secured directly to conduit boxes, the boxes shall be independently fixed to roof beams or walls to carry the full weight of the light fitting.

6.2.7 Where conduits are provided for future systems, these shall, in addition to the draw wires, be labelled with indelibly marked labels fixed to the draw wire at both ends to identify the conduit. The labelling shall be clearly indicated on 'as-built' drawings to identify these 'spare' conduits and routes.

6.3 TERMINATIONS AND JOINTS

6.3.1 Conduit ends shall be cut at right angle to ensure that ends butt squarely at joints.

6.3.2 Conduit shall only be threaded if so designed and approved by the SABS.

6.3.3 In addition to SANS 10142-1 the following requirements shall be applicable:

6.3.3.1 Screwed Conduit.

6.3.3.2 Screwed metallic conduit and conduit accessories shall comply with the relevant section of the latest edition of SANS 61386-1 & SANS 61386-2.

6.3.3.3 All conduit ends shall be reamed and all joints tightly screwed. Threads shall not be visible at joints and terminations.

6.3.3.4 A female bush and two lock nuts shall be installed where conduits are terminated in spoutless equipment.

6.3.3.5 Unscrewed Conduits

6.3.3.6 Unscrewed metallic conduits and conduit accessories shall comply with the relevant requirements of SANS 61386-1 & SANS 61386-2. Non-metallic conduits and accessories shall comply with the requirements of SANS 950.

6.3.3.7 Only purpose made couplers and end pieces may be used as recommended by the manufacturer.

6.3.3.8 All accessories used for the termination and jointing of non-metallic conduits shall be glued to the conduits. The type of glue used shall be as recommended by the conduit manufacturer.

6.4 SURFACE INSTALLATION

6.4.1 The Contractor shall take measures to ensure a neat installation. Where conduits are to be installed directly alongside doorframes, beams, etc. that are not true, conduits shall be installed parallel to the frames, beams, etc. When in doubt, the Contractor shall consult SANRAL or the Independent Engineer before installation is commenced.

6.4.2 Conduits shall be installed in a squared configuration i.e. level, plumb and parallel to walls, beams and slabs. If this is not possible, SANRAL or the Independent Engineer's ruling shall be obtained beforehand. All conduit offsets shall be uniform and inline.

6.4.3 Conduit shall be firmly secured by means of saddles. Where saddles are used to secure lengths of conduit connected to surface mounted boxes, the saddles shall be spaced so that the intervals between the box and the first saddle, between any two successive saddles and between the last saddle and the ceiling are equal.

6.4.4 Parallel conduit runs shall be equidistant 2 and saddles shall be installed in line. Alternatively, a special clamp may be used to secure all conduits in unison. In the case of conduits of different diameters, the latter method shall only be used if a purpose-made clamp designed to accommodate the various conduit sizes is installed.

6.4.5 Where conduits are to be installed on uneven surfaces, the conduits shall be installed on raised saddles.

6.4.6 Unless otherwise specified all surface mounted conduits and accessories shall be painted with a high quality enamel paint. The colour shall comply with the colour code specified for the installation, or where no code has been specified, shall match the colour of the surrounding finishes.

6.5 INSTALLATION IN CONCRETE

6.5.1 In order not to delay building operations, the Contractor shall ensure that all conduits and accessories which are to be cast in concrete are placed in position in good time. The Contractor or his representative shall attend when the concrete is cast. SANRAL or the Independent Engineer shall be called for an inspection of the conduit installation before the concrete is cast.

6.5.2 Draw boxes, expansion joints and ceiling boxes shall be installed where required and shall be neatly finished to match the finished slab or wall surface. Round ceiling boxes shall be of the deep type.

6.5.3 Draw boxes shall be limited to a minimum and the position shall he confirmed with SANRAL or the Independent Engineer before the installation thereof. Draw boxes, where possible, shall be grouped together under a common approved cover plate.

6.5.4 All conduits shall be installed as close as possible to the neutral axis of concrete beams, slabs and columns.

6.5.5 The conduit shall be rigidly secured to the reinforcing to prevent movement towards the surface of the concrete.

6.5.6 All draw boxes shall be securely fixed to the shuttering to prevent displacement when concrete is cast. Where draw boxes or outlets are installed adjacent to each other the Contractor shall ensure that the correct alignment and spacing are maintained. Draw boxes and outlet boxes shall preferably be secured by means of a bolt and nut installed from the back of the box through the shuttering. Fixing lugs may also be used to screw the boxes to the shuttering. Wire will not be accepted for securing boxes to the shuttering where off-shutter finishes are required. Where fibreglass shuttering is used by the builder, the equipment shall be fixed to the steel only and no holes shall be drilled or made in shuttering. All draw boxes and outlet boxes shall be plugged with wet paper before they are secured to the shuttering.

6.5.7 As far as possible, conduits shall not be installed across expansion joints. Where this is unavoidable, conduit expansion joint shall be provided.

6.5.8 The installation of conduits in floor screed shall be kept to a minimum. Where conduits are installed in screed, the top of the conduit shall be at least 20 mm below the surface of the screed.

6.5.9 All draw boxes, conduits, etc. which are installed in concrete shall be cleaned and provided with draw wires two days after removal of the shuttering. Errors that occur during the installation of the conduits, or any lost draw boxes, or blocked conduits shall be immediately reported to SANRAL or the Independent Engineer in order than an alternative route can be planned by the Contractor and approved by SANRAL or the Independent Engineer before the additional concrete is cast.

6.6 FLUSH INSTALLATION

6.6.1 In order not to delay building operations, the Contractor shall ensure that all conduits and accessories, which are to be installed flush with walls, are placed in position in good time.

6.6.2 Conduits shall be installed at least 20 mm below the finished wall surface.

6.6.3 All boxes shall be installed where required and shall be neatly finished to match the finished wall surface.

6.6.4 All boxes shall be installed level and plumb.

6.7 FLEXIBLE CONDUIT

6.7.1 In installations where the equipment has to be moved frequently to enable adjustment during normal operation for the connection of motors or any other vibrating equipment, for the connection to thermostats and sensors on equipment, for stove connections and where otherwise required by SANRAL or the Independent Engineer, flexible conduit shall be used for the final connection to the equipment.

6.7.2 Flexible conduit shall preferably he connected to the remainder of the installation by means of a draw box. The flexible conduit may be connected directly to the end of a conduit if an existing draw box is available within 2000 mm of the junction and if the flexible conduit can easily be rewired.

6.7.3 Flexible conduit shall be suitable for the application and ambient conditions or the type as specified in the Project Specification.

6.8 FUTURE EXTENSIONS

6.8.1 Open Roof Spaces

6.8.1.1 Conduit for future switch and socket outlets in roof spaces with more than 900 mm free space shall terminate 40 mm above the tie beams. The conduit end shall be threaded and provided with a coupling and brass or galvanised plug.

6.8.2 Concrete Slabs

6.8.2.1 Conduit ends shall protrude 150 mm from the concrete to facilitate the installation of future extensions above, below or to the side of the concrete slabs. All these conduits shall be connected to a draw box, which is cast into the concrete within 2 meters of the end of the concrete. Conduit ends shall be threaded and provided with a coupling and brass plug. In cases where holes cannot be drilled through the shuttering to accommodate the conduit end, a deep draw box with rear entry may be placed around the conduit end. After removal of the shuttering, it shall be possible to connect additional conduits to the conduit end.

6.8.3 Cover Plates

6.8.3.1 All unused boxes for switches and socket outlets shall be covered with metal cover plates. All unused boxes for light fittings shall be covered with round galvanised metal cover plates that fit tightly against the finished surface. The cover plate shall overlap the outlet box to mask uneven edges of the structure. Only plated fixing screws supplied by the cover plate manufacturer shall be used.

6.8.4 Galvanised Conduit

6.8.4.1 Galvanised conduit shall be installed at all free ends intended for future extensions. The conduit shall be treated with a paint that will prevent corrosion and white rust.

6.9 EXPANSION JOINTS

6.9.1 Where conduits cross expansion joints in the structure, approved type draw boxes that provide a flexible connection in the conduit installation shall be installed.

6.9.2 The draw box shall be installed adjacent to the expansion joint of the structure and a conduit duct one size larger than that specified for the circuit shall be provided on the side of the draw box nearest to the joint. The one end of the duct shall terminate at the edge of the joint and the other shall be secured to the draw box by means of locknuts.

6.9.3 The circuit conduit passing through the duct shall be terminated 40 mm inside the draw box and the conduit end fitted with a brass bush. The gap between the duct and the conduit at the joint shall be sealed to prevent the ingress of wet cement. An earth clip shall be fitted to the conduit projection inside the draw box and the conduit bonded to the box by means of 2,5 mm² bare copper earth wire and a brass bolt and nut.

6.9.4 In addition to an earth wire, which may be specified for the circuit, a 2,5 mm² bare copper wire shall be provided with a suitable steel cover plate fixed to the box by means of screws. The cover plates shall be installed before the ceilings are painted.

6.9.5 Draw boxes at the expansion joints shall be provided with a suitable steel outer plate fixed to the box by means of screws. The cover plates shall be installed before the ceilings are painted.

6.9.6 Where a number of conduits are installed in parallel, they shall cross the expansion joints of the structure via a single draw box. A number of draw boxes adjacent to each other shall not be allowed.

6.9.7 Cover plates shall be painted to match the surrounding area or as specified in the Project Specification.

6.10 CHASES AND BUILDER'S WORK

6.10.1 Except where otherwise specified the Electrical Contractor shall be responsible for the builder's work connected with conduits, outlet boxes, switchboard trays, bonding trays and other wall outlet boxes as well as the necessary chasing and cutting of walls and the provision of openings in ceilings and floors for light fittings and other electrical outlets. The Electrical Contractor shall notify the Builder of his requirements and the responsibility lies with the Contractor to ensure that these requirements are met.

6.10.2 Electrical materials to be built in must be supplied, placed and fixed in position by the Electrical Contractor when required by the Contractor. The Contractor shall ensure that these materials are installed in the correct positions.

6.10.3 Where no Builder is available the Contractor is required to cover conduits installed in chases by a layer of 4:1 mixture of coarse sand and cement, finished 6 mm below the face of the plaster and roughened. In all cases, chases shall be deep enough to ensure that the tops of conduits are at least 12 mm below the finished plaster surface.

6.10.4 Where the Contractor is responsible for cutting of chases, building in of conduits or other equipment, he will be held responsible for all damage as a result of this work and will be required to make good to the satisfaction of SANRAL or the Independent Engineer. This ruling is applicable especially but not exclusively to the rewiring and renewal of existing installations. Chases shall be made by means of a cutting machine.

6.10.5 Under no circumstances shall face brick walls or finished surfaces be chased or cut without the written permission of SANRAL or the Independent Engineer. Where it is necessary to cut or drill holes in a concrete structure, the prior permission of the Structural Engineer shall be obtained to ensure that the structure is not weakened.

6.10.6 The Contractor shall maintain close co-operation with other contractors throughout the course of the Contract. Should the Contractor not comply with this requirement, any additional costs resulting from lack of his co-operation will be recovered from him.

6.11 FIXING OF MATERIALS

6.11.1 Responsibility

6.11.1.1 It is the responsibility of the Contractor to position and securely fix conduits, ducts, cables and cable channels, switchboards, fittings and all other equipment or accessories as required for the installation. The Contractor shall provide and fix all supports, clamps, brackets, hangers and other fixing materials.

6.11.2 Finishing

6.11.2.1 All supporting steel work shall be wire brushed and given one coat of rust-resistant primer, followed by one coat of high quality enamel paint to match the surrounding area, or as specified in the Project Specification, before any other equipment is fixed.

6.11.3 Welding

6.11.3.1 Supports, brackets, hangers, etc. may only be welded to steel structural members where prior permission has been obtained.

6.11.4 Screws and Bolts

6.11.4.1 Where holes exist in equipment to be fixed, bolts and fixing screws as specified shall be used. Where sizes are not specified, the largest bolt or screw that will fit into the hole shall be used. Bolts and fixing screws shall be painted to prevent rust or shall be of the plated type.

6.11.5 Wall Plugs

6.11.5.1 Where the fixing holes in brick or concrete walls are smaller than 10 mm dia, and where the mass of the equipment is less than 15 kg, wall plugs may be used to fix conduits, cables and other equipment. Aluminium, fibre or plastic plugs only may be used. Wooden plugs are not acceptable. Plugs installed in seams between bricks are not acceptable. A masonry drill of the recommended size shall be used to drill holes for plugs. Round-headed brass screws shall be used throughout.

6.11.6 Anchor Bolts

6.11.6.1 Where the fixing holes are 10 mm and larger or where the mass of the equipment is 15 kg or more, equipment shall be fixed by means of expanding anchor bolts or by means of bolts cast into the concrete.

6.11.7 Shot-Fired Fixing

6.11.7.1 This method shall only be used with prior written permission from SANRAL or the Independent Engineer.

(a) Materials such as metal cable ducts or channels may be fixed against walls and concrete slabs by means of the shot-fired method designed for this purpose.

(b) The Contractor shall ascertain whether this method of fixing will carry the weight of the material including conductors, cables and other items of equipment to be installed later. Should it be found that the method of fixing is inadequate and joints tend to loosen the Contractor will, at this own expense, be required to fix the material by an alternative method to the satisfaction of SANRAL or the Independent Engineer. Where the shot-fired method is used, warning signs shall be placed at all entrances leading to the area where this work is in progress. The Contractor shall take all reasonable precautions to prevent accidents. Nails and cartridges recommended by the manufacturer of the shot-fired equipment only shall be used.

6.12 INSPECTION AND ACCEPTANCE OF CONDUIT INSTALLATIONS

6.12.1 Inspections of conduits shall be carried out in accordance with the Standard Specification.

6.13 CONDUITS AND CONDUITS ACCESSORIES DATA AND COMPLIANCE SHEET

TABLE 6-1: CONDUITS AND CONDUITS ACCESSORIES DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
6.13.1	SANS 10142-1	The wiring of premises Part 1: Low-voltage installations				
6.13.2	SANS 61386-1	Metal conduits and fittings (screwed-end and plain-end) for electrical wiring – Part 1: Metal conduits.				
6.13.3	SANS 61386-2	Metal conduits and fittings (screwed-end and plain-end) for electrical wiring – Part 2: Metal fittings.				
6.13.4	SANS 950	Unplasticized polyvinyl chloride rigid conduit and fittings for use in electrical installations.				
CONDUITS						
	CLAUSE					
6.13.5	6.3	Terminations and Joints				
6.13.6	6.4	Surface Installation				
6.13.7	6.5	Installation in Concrete				
6.13.8	6.6	Flush Installation				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
6.13.9	6.7	Flexible Conduit				
6.13.10	6.8	Future extensions				
6.13.11	6.8.1	Open Roof Spaces				
6.13.12	6.8.2	Concrete Slabs				
6.13.13	6.8.3	Cover Plates				
6.13.14	6.8.4	Galvanised Conduit				
6.13.15	6.9	Expansion Joints				
6.13.16	6.1	Chases and Builder's Work				
6.13.17	6.11	Fixing of Materials				
6.13.18	6.11.1	Responsibility				
6.13.19	6.11.2	Finishing				
6.13.20	6.11.3	Welding				
6.13.21	6.11.4	Screws and Bolts				
6.13.22	6.11.5	Wall Plugs				
6.13.23	6.11.6	Anchor Bolts				
6.13.24	6.11.7	Shot-Fired Fixing				
6.13.25	6.12	Inspection and Acceptance of Conduit Installations				

7. DUCTS AND TRUNKING

7.1 GENERAL

7.1.1 Ducts, trunking and relevant accessories shall fully comply with SANS 10142-1 as amended as well as to the various SABS or BS codes referred to in SANS 10142-1.

7.1.2 Any special requirement regarding the type and size of ducts, trunking and accessories to be installed in a specific installation shall be specified in the Project Specification.

7.1.3 Ducts, trunking and accessories shall be hot-dipped galvanised unless otherwise specified in the Project Specification.

7.1.4 Cover plates and end covers shall be pre-galvanised.

7.1.5 Where galvanising has been damaged, these areas shall be properly treated with cold galvanising.

7.1.6 Ducts and trunking shall be supplied with cover plates and end caps.

7.1.7 Ducts and trunking shall be installed horizontally or vertically as determined by the route and the Contractor shall take all measures to ensure a neat installation.

7.1.8 Bush type adaptors, to accommodate wiring, shall be utilized for the fixing of the fittings to the ducts or trunking, one for each high bay light fitting and two for each fluorescent fitting.

7.1.9 Where ducts or trunking are to be installed across expansion joints the ducts or trunking shall be terminated both sides of the expansion joint and a splice fixed to the one side only.

7.1.10 Ducts or trunking shall be jointed with purpose-made splices, corners, or tees, which shall be pop riveted to the ducts or trunking.

7.1.11 Earth continuity shall be maintained across joints. Each section of the trunking shall be electrically connected to the adjoining sections. If paint or other protective coating should prevent electrical continuity, then a copper through-connection tape shall be installed. In coastal regions and for all outdoor applications, copper banding strips shall be installed across all joints of ducts and trunking.

7.2 SURFACE MOUNTED INSTALLATION

7.2.1 Where specified, the ducts or trunking shall be surface mounted.

7.2.2 The ducts or trunking shall be properly fixed to carry the full weight of the installation including equipment mounted on the ducts or trunking.

7.2.3 Where ducts or trunking are used for the installation of wiring for different types of services i.e. lighting, power, telephones, computers, etc., these ducts or trunking shall be colour coded at intervals not exceeding 3 m, by means of 50 mm wide bands painted on the ducts or trunking.

7.3 SUSPENDED INSTALLATION

7.3.1 The ducts or trunking shall be installed horizontally and sufficient supports shall be installed to prevent it from sagging.

7.3.2 Where specified, the ducts or trunking shall be suspended from the roof structure with M12 galvanised threaded rods.

7.3.3 The threaded rods shall be fixed to purlins and roof beams with CADDY type suspension clamps.

7.3.4 The rods shall be fixed to suspension clamps by nuts. The ends of the rods shall be riveted to prevent the nuts from loosening.

7.3.5 The lower ends of the rods shall be fixed to the wiring channels by purpose-made hanger fittings.

7.3.6 A rod shall be installed at the centre of each light fitting mounted on the duct.

7.3.7 Between each two threaded rods, evenly spaced chain hangers shall be installed to ensure supporting points at a maximum of 2500 mm intervals for the full length of the wiring channel.

7.3.8 Chains shall be hot-dipped galvanised.

7.3.9 The chain support shall be fixed to the roof purlins or beams with spring-loaded CADDY type clips.

7.3.10 The chain supports shall be fixed to the wiring channels with purpose made hanger fittings.

7.3.11 Care shall be taken to ensure that the hangers and chains hang vertically and the wiring channels hang horizontally.

7.3.12 Unless specified to the contrary in the Project Specification the ducts or trunking shall be installed with the openings facing upwards to facilitate ease of wiring.

7.4 DUCTS AND TRUNKING DATA AND COMPLIANCE SHEET

TABLE 7-1: DUCTS AND TRUNKING DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
7.4.1	SANS 10142-1	The wiring of premises				

		Part 1: Low-voltage installations				
EARTHING						
	CLAUSE					
7.4.2	7.2	Surface Mounted Installation				
7.4.3	7.3	Suspended Installation				

8. THE INSTALLATION OF SOCKET OUTLETS AND LIGHT SWITCHES

8.1 GENERAL

8.1.1 All boxes shall be as described in SANS 10142-1 and the various SABS or BS Codes referred to in SANS 10142-1.

8.1.2 Any special requirements relating to a specific installation shall be specified in the Contractor's detailed specification.

8.1.3 Boxes shall be manufactured of heavy gauge sheet steel and shall be hot dip galvanised. The boxes shall be fitted with the necessary lugs for the fixing of cover plates.

8.1.4 The necessary knockouts shall be provided for proper terminations of conduit.

8.1.5 Surface mounted boxes shall consist of a metal switch box and cover plate specially manufactured for the purpose. Boxes shall be fixed to the surface as specified herein. All access holes shall be securely blanked off to render the installation vermin proof.

8.1.6 Circular group type boxes shall be of the long spout pattern manufactured of malleable cast iron and stove enamelled jet black or galvanised unless otherwise specified herein or in SANRAL's Requirements. The two cover fixing holes shall be diagonally opposite each other, drilled and tapped at 50 mm centres. The boxes shall be in accordance with SANS 164-1: 1997 as amended where applicable.

8.1.7 Appearance

8.1.7.1 The sides of adjacent switches, plugs, pushbuttons, and all other installed extension boxes used shall be parallel or perpendicular to each other and uniformly spaced. A common escutcheon plate shall be used for flush mounted outlets and accessories where the cover plates do not cover the cut outs in the finishes.

8.1.8 Cover Plates

8.1.8.1 Bevelled cover plates which overlap the switchbox and which fit tightly against the wall finishes shall be installed in the case of flush mounted switchboxes. Suitable spiral type steel-wire spacers shall be used to fix the cover plate to deep-set flush switch boxes. All fixing screws in cover plates and switch grids shall be supplied and securely fitted.

8.1.8.2 Cover plates shall be finished in ivory baked enamel, oxidised bronze, aluminium or as otherwise specified herein or in SANRAL's Requirements, to match wall finishes.

8.1.8.3 Cover plates shall be in accordance with SANS 164 as amended.

8.1.9 Cutting of Cover Plates

8.1.9.1 Cover plates shall under no circumstances be cut unless specifically authorized in exceptional cases by SANRAL.

8.1.10 Building Lines

8.1.10.1 All boxes and cover plates shall be installed parallel to and in line with the relevant horizontal and vertical building lines.

8.2 SOCKET OUTLETS

8.2.1 Mounting heights

8.2.1.1 For new installations, conduit outlets shall be installed at the following heights above finished floor level:

Flush mounted socket outlets in general	450 mm
Surface mounted socket outlets in general	1100 mm
Kitchens and laundries, surface or flush mounted	1100 mm
Shops - surface or flush mounted	1100 mm
Factories and workshops - surface or flush mounted	1400 mm
Servants’ rooms – surface or flush mounted	1400 mm
Garage - surface or flush mounted	1400 mm
Passages - surface or flush mounted	450 mm
Offices - surface or flush mounted	450 mm

8.2.1.2 All mounting heights shall be measured from finished floor level to the centre of the outlet box.

8.2.1.3 New installations shall comply with the recommendations of the South African Federal Council on Disability.

8.2.2 Mounting

8.2.2.1 Walls

Where the lower portions of brick walls consist of face bricks and the upper portion of the wall is plastered, the outlets shall be installed in the plastered portion of the wall. If however, the plastered portion of the wall commences 650 mm above floor level, the outlets shall be installed in the face bricks. Where a wall has different surface finishes, the outlets shall be installed in one of the types of wall finish only. The outlets shall not be installed in the joints between the different surface finishes. All outlets shall be installed at least 150 mm away from doorframes.

8.2.2.2 Waterproof Socket Outlets

Socket outlets that are exposed to the atmosphere or installed in damp areas, shall be rated at IP 56.

8.2.2.3 Flush Socket Outlets

(a) Flush socket outlets shall each consist of a switch and 3-pin plug receptacle with 2 shuttered poles and an earth socket suitable for mounting in a standard pressed steel box under a common cover plate.

(b) Sockets and switches shall be rated at 250 V, 16 A, unless otherwise specified herein or in SANRAL's Requirements.

(c) A miniature circuit breaker (M.C.B) of the correct rating in lieu of a switch contained under the same cover plate is also acceptable.

(d) Switches shall comply with SANS 164-0 to 6. The sockets shall comply with SANS 164-1 to 6.

8.2.2.4 Surface Mounted Socket Outlets

(a) Sockets shall be rated at 250 V, 16 A unless otherwise specified herein or in SANRAL's Requirements.

(b) A miniature circuit breaker (M.C.B) of the correct rating in lieu of a switch contained under the same cover plate is also acceptable.

(c) The unit shall comply with SANS 164-0 to 6 where applicable and shall be tested in accordance with SANS 109 as amended.

8.2.2.5 Iron Clad Switch and Socket Outlet Combinations

(a) The unit shall consist of a weatherproof switch without fuses, a socket outlet with spring-loaded lid at the bottom of the switch and a plug suitable for voltages up to 500 volts.

(b) The switch shall be either double pole or triple pole with heavy gauge copper contacts and a robust quick acting spring mechanism.

(c) The plug shall be fully interlocked with the switch so that it cannot be inserted or withdrawn unless the switch is in the "off" position. The plug shall have a cast metal case with an entry gland for a flexible cable with the necessary clamp for the cable to prevent stress on the leads to the terminals.

(d) Three pins and five pins shall be provided for the double pole and triple pole units respectively. An earth pin shall be provided in all cases. The pins shall be arranged so that the plug can only be inserted in one position.

(e) Provision shall be made so that all external metal parts of the switch plug unit are earthed when the plug is in position.

(f) The conduit entry hole shall be drilled and tapped for electrical conduit.

(g) The switch socket outlet plug shall be supplied with a matching male plug top.

8.3 LIGHT SWITCHES

8.3.1 Mounting

8.3.1.1 All light switches shall be installed 1400 mm above the finished floor level unless otherwise specified herein or in SANRAL's Requirements. Mounting heights given shall be measured from the finished floor level to the centre of the switch.

8.3.1.2 New installations shall comply with the recommendations of the South African Federal Council on Disability.

8.3.2 Doors

8.3.2.1 Unless otherwise specified herein or in SANRAL's Requirements, switches adjacent to doors shall be installed on the side containing the lock. If the position of the lock is not shown on the drawings, the position shall be verified before the switch box is installed. Switch boxes in brick or concrete walls shall be installed 150 mm from the doorframe. Light switches installed in doorframes shall be of the type designed for that purpose.

8.3.3 Walls

8.3.3.1 Where the lower portion of a wall is face brick or tiles and the upper portion plastered, light switches shall be installed completely in the plaster provided that the lower edge of the plaster is not higher than 1600 mm above the finished floor level. In general, where different wall finishes are used in the same area, switches shall be installed within the same finish and not on the dividing lines between finishes.

8.3.4 Partitions

8.3.4.1 Light switches installed in partitions shall preferably be of the type designed for this purpose to be accommodated in the partition design. Switches installed in the metal support do not require switch boxes.

8.3.5 Flush Wall Switches

8.3.5.1 All flush wall switches shall comply with SANS 163 as amended and shall bear the SABS mark.

8.3.5.2 Switches shall have rocker or toggle action and shall be rated at 16 A and must be suitable for mounting in a standard 100 x 50 x 50 pressed steel or PVC wall box.

8.3.6 Surface Mounted Switches

8.3.6.1 The switch units shall bear the SABS mark and shall comply with SANS 164 as amended where applicable and with the test requirements of SANS 164 as amended.

8.3.7 Watertight Switches

8.3.7.1 Watertight switches that are exposed to the atmosphere or installed in damp areas shall be rated to IP 56 and shall be 10 A single pole, suitable for surface mounting.

8.3.7.2 The switch interior shall be a 10 A switch with ceramic base and strong quick acting spring mechanism, with heavy gauge brass contacts.

8.3.8 Ceiling Mounted Pull Switches

8.3.8.1 Ceiling switches shall be rated either 5 or 10 A as required and shall be suitable for ceiling mounting. They shall have heavy brass contacts and strong quick acting mechanisms, and be suitable for operation on AC.

8.3.8.2 The base of the switch shall be ceramic. The cover may be either bronzed, brass or powder coated steel. Where switches with ceramic covers are offered, the covers shall have brass screw ring inserts. Each switch shall be complete with 1,25 m of cord.

8.3.9 Multiple switches

8.3.9.1 Where specified, multi-gang switches shall be installed in a common switch box. Switches controlling different circuits shall be installed in separate switch boxes.

8.4 THE INSTALLATION OF SOCKET OUTLETS AND LIGHT SWITCHES DATA AND COMPLIANCE SHEET

TABLE 8-1: THE INSTALLATION OF SOCKET OUTLETS AND LIGHT SWITCHES DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
8.4.1	SANS 10142-1	The wiring of premises Part 1: Low-voltage installations				
8.4.2	SANS 164-0	Plug and socket outlet systems for household and similar purposes for use in South Africa – Part 0: General and safety requirements.				
8.4.3	SANS 164-1	Plug and socket outlet systems for household and similar purposes for use in South Africa – Part 1: Conventional system, 16 A 250 V a.c.				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
8.4.4	SANS 164-2	Plug and socket outlet systems for household and similar purposes for use in South Africa – Part 2: IEC system, 16 A 250 V a.c.				
8.4.5	SANS 164-3	Plug and socket outlet systems for household and similar purposes for use in South Africa – Part 3: Conventional system, 6 A 250 V a.c.				
8.4.6	SANS 164-4	Plug and socket outlet systems for household and similar purposes for use in South Africa – Part 4: Dedicated system, 16 A 250 V a.c.				
8.4.7	SANS 164-5	Plug and socket outlet systems for household and similar purposes for use in South Africa – Part 5: Two-pole, non-rewirable plugs, 2,5 A 250 V a.c., with cord, for connection of class II equipment.				
8.4.8	SANS 164-6	Plug and socket outlet systems for household and similar purposes for use in South Africa – Part 6: Two-pole systems, 16 A 250 V a.c. for connection of class II equipment.				
SSO & LS						
	CLAUSE					
8.4.12	8.2	Socket Outlets				
8.4.13	8.2.1	Mounting heights				
8.4.14	8.2.2	Mounting				
8.4.15	8.3	Light Switches				
8.4.16	8.3.1	Mounting				
8.4.17	8.3.2	Doors				
8.4.18	8.3.3	Walls				
8.4.19	8.3.4	Partitions				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
8.4.20	8.3.5	Flush Wall Switches				
8.4.21	8.3.6	Surface Mounted Switches				
8.4.22	8.3.7	Watertight Switches				
8.4.23	8.3.8	Ceiling Mounted Pull Switches				
8.4.24	8.3.9	Multiple switches				

9. LUMINAIRES

9.1 GENERAL

9.1.1 The Contractor shall allow for all luminaires as specified in the detail specification drawings.

9.1.2 Where the term “similar and equivalent” is used in the description of luminaires, the Contractor may offer alternative makes and describe these by means of code numbers. A manufacturer's catalogue number quoted shall not imply that the luminaire complies with the specification. The decision whether or not these luminaires are in fact similar and equivalent to the specified equipment shall rest solely with the Contractor to prove that the luminaires comply to the same standards as the specified equipment.

9.1.3 The Contractor shall send the alternative luminaires to the SABS for certification and testing entirely at its own expense. The final decision whether or not these alternative luminaires are acceptable and to the specification will be taken by SANRAL.

9.1.4 SANRAL may order the Contractor to install the exact specified Luminaires.

9.1.5 When the term "similar and equivalent" is not used in the specification, Contractor shall have no choice but to install the specific luminaires as specified.

9.1.6 All the luminaires, associated equipment and control gear shall be new and unused and shall be complete with fluorescent tubes, lamps, control gear, diffusers, mounting brackets and all other accessories required to make the luminaires fully operative. The luminaires shall be delivered to Site in a protective covering.

9.1.7 All luminaires shall be equipped with an earth terminal and shall be properly earthed.

9.1.8 The Contractor shall be responsible for purchasing, taking delivery, storing, installation, testing and Commissioning all luminaires as specified herein or in SANRAL’s Requirements.

9.1.9 All luminaires shall be mounted and suspended in accordance with the manufacturer's requirements and as specified herein or in SANRAL’s Requirements.

9.1.10 All luminaires shall be mounted in such a way to ensure that the complete luminaire can be removed without difficulty.

9.1.11 The Contractor shall submit full descriptive information of the luminaires offered. Photometric data, i.e. polar curves and coefficient of utilization, certified by the SABS shall be submitted for all luminaires offered.

9.1.12 All internal wiring in all luminaires shall consist of heat resisting, non-deteriorating, insulated, flexible stranded conductors and shall terminate in a suitable marked terminal block. The insulation of the wiring shall be suitable for all normal operating conditions.

9.2 MOUNTING OF LUMINAIRES

9.2.1 Positions

9.2.1.1 The mounting positions of luminaires shall be verified on Site. All luminaires shall be placed symmetrically with respect to ceiling panels, battens, beams, columns or other architectural features of the space. The layout as shown in the detail design shall generally be adhered to, but any discrepancies or clashes with structural or other features must be referred to SANRAL before commencing erection of the installation. All conduit Works for luminaires above false ceilings shall be co-ordinated with all the sub-contractors concerned.

9.2.2 Cover Plates

9.2.2.1 Cover plates shall be fitted over all draw boxes and outlets intended for luminaires that are not covered by the luminaire canopy, lamp holder, ceiling rose or similar accessories.

9.2.3 Hangers and Supports

9.2.3.1 Where provision has not been made for the fixing of luminaires, the Contractor shall supply the necessary supports, hangers, conduit extensions, angle brackets or any other fixing method approved by SANRAL. The Contractor shall include for fender washers with all luminaires for fixing of the same in all cases.

9.2.4 Suspended Luminaires

9.2.4.1 The necessary hangers shall be provided where luminaires that are of the non-suspension type have to be fixed below false ceilings or roof slabs. The use of 20 mm conduits fixed to the roof slab or ceiling is preferred. Provision shall be made for adjustments to enable the levelling of luminaires. Suspended conduits shall be fixed to the ceiling by means of screwed dome lids, bolts and nuts. Ball-and-spigot type dome lids shall be used where conduit lengths exceed 600 mm. Wiring shall be installed in the conduit hangers.

9.2.5 Suspended Cable Channels

9.2.5.1 Luminaires (especially fluorescent luminaires) may also be suspended from ceilings by means of suspended metal channels. The metal channel may be supported by conduits or threaded rods. Should metal rods be utilised, these shall be screwed to anchor bolts fixed to the metal channel or in the metal channels, covered with a suitable cover plate. Purpose-made clamps shall be used to fix the luminaires to the cable channel.

9.2.6 False Ceilings

9.2.6.1 In all cases where luminaires are fixed to false ceilings, the Contractor shall ensure that the ceilings are capable of carrying the weight of the luminaires before commencing installation. Should any doubt exist in this regard, the matter shall be referred to SANRAL. In cases where the weight of the luminaire is not carried by the ceiling but by a support or other suspension method, provision shall be made to prevent relative movement between the ceiling and luminaire, ceiling rose or connection point. Where luminaires are mounted on ceilings consisting of panels, care shall be taken that the Works are performed symmetrically.

9.2.7 Ceiling Battens

9.2.7.1 Where wooden blocks are used to suspend luminaires, ceiling battens shall not be cut. The wooden blocks shall be cut to fit around battens and shall be screwed to the ceiling. Battens may, however, be cut where fluorescent or incandescent luminaires with metal canopies have to be installed against a false ceiling.

9.2.8 Mounting to Draw-Boxes

9.2.8.1 Where an outlet box or draw box provides the necessary support for a luminaire, all luminaires with the exception of fluorescent luminaires mounted against ceilings, shall be fixed directly to the box. Luminaires with a mass in excess of 10 kg shall, however, be suspended independently of the outlet box. Fluorescent luminaires and luminaires with a mass in excess of 10 kg in addition to being screwed to outlet boxes, shall be fixed with expansion bolts as specified under clauses covering the fixing of luminaires.

9.2.9 Luminaires Mounted to Concrete Slabs

9.2.9.1 Fluorescent luminaires to be installed directly against concrete slabs or walls shall be mounted to the outlet box and at two additional points.

9.2.9.2 The additional fixing can be effected by:

(a) Bolts built into the ceiling or wall,

(b) Screws and approved plugs, or

(c) Expanding rawl bolts.

9.2.9.3 Shot-fired fixings are not acceptable. Fluorescent luminaires may in general be installed against "O-LINE" or similar channels in which the wiring is housed. The metal channel fixing may in this case be shot-fired or fixed by any of the above-mentioned methods. Purpose-made fluorescent adaptors shall be used to mount luminaires to cable channels.

9.2.10 Luminaires Mounted to Ceilings

9.2.10.1 Surface-mounted fluorescent luminaires shall mount firmly against the ceiling without leaving gaps between luminaires and ceilings. The luminaires shall be fixed directly to the ceiling beams by means of 40 mm round-head wood screws and washers or alternatively 50 x 76 mm wooden supports that are fixed to the ceiling beams. In the case of tiled ceilings with exposed or concealed T-section supports, surface-mounted luminaires shall be fixed to the metal supports by means of butterfly screws or bolts with nuts and washers. Self-tapping screws may not be used. Luminaires shall be mounted in neat relation to the ceiling layout.

9.2.11 Continuous Rows of Luminaires

9.2.11.1 In cases where fluorescent luminaires are installed in tandem, only one connection outlet need be supplied per circuit. All luminaires shall be coupled to one another by means of nipples or brass bushes and locknuts to ensure that wiring is not exposed and that earth continuity is maintained. Luminaires on the same circuit may be wired through the channel formed by the luminaire canopies. In this case, silicon-rubber insulated conductors shall be used and internal connections shall be made at terminal blocks. "SCREW-IT" or similar dome connectors are not acceptable. The wiring for any other circuits or outlets, even though these may be in the same row, may not be installed through the luminaire canopies. The Contractor shall ensure that continuous rows are straight and parallel to the relevant building lines.

9.2.12 Recessed Luminaires

9.2.12.1 Where recessed luminaires are required, the Contractor shall maintain close liaison with the ceiling contractor (if applicable). In the case of tiled ceilings, the luminaires shall be installed while the metal supports are being installed and before the tiles are placed in position. The Contractor shall be responsible for the co-ordination of the cutting of ceiling tiles with any other contractors concerned. All mounting rings and other accessories shall fit closely into cut outs to ensure a proper finish.

9.2.13 Special Ceilings

9.2.13.1 In cases where special ceilings, e.g. insulated panels, aluminium strips, decorative glass, metal leaves, etc. are to be installed, the Contractor and the Manufacturer of the ceiling shall agree upon the method of mounting of luminaires to the ceiling.

9.2.14 Glass Bowl Luminaires

9.2.14.1 Unless otherwise specified herein or in SANRAL's Requirements, suspended glass bowl luminaires shall be installed with the underside at least 2,4 m above finished floor level.

9.2.15 Bulkhead Luminaires

9.2.15.1 Surface-mounted bulkhead luminaires shall not be screwed directly to conduit ends. The conduit shall terminate in a round draw box at the top or rear of the luminaire. The PVC insulated conductors shall terminate in a porcelain terminal strip in the draw box. Silicone-rubber insulated conductors shall be installed from the terminal strip to the luminaire lamp holder. "SCREW-IT" or similar dome connectors are not acceptable.

9.2.16 Wiring to Enclosed Luminaires

9.2.16.1 The wiring within enclosed, unventilated luminaires shall consist of tinned copper conductors insulated with silicone rubber, braided with a heat resistant fibrous material. Several parallel strands of nickel-chrome or "KANTHAL" resistance wire insulated with porcelain beads may be used as an alternative.

9.3 CONNECTIONS TO LUMINAIRES

9.3.1 Connectors

9.3.1.1 Connectors to the wiring or luminaires and other appliances where connectors are used, shall be effected by means of brass screw couplers shrouded in porcelain, neoprene or PVC or by means of approved spring steel locking connectors insulated in unbreakable material. Other types of connectors are not acceptable.

9.3.2 Knock-outs

9.3.2.1 Where knock-outs are used for the wiring of luminaires and other appliances, brass bushes or gripper glands shall be used.

9.3.3 Type of Conductor

9.3.3.1 In luminaires capable of housing lamps above 60 W, the wiring from the lamp holder to the general wiring shall be heat resisting silicon compound insulated conductors. Refer also to the provisions of the relevant Wiring Codes and practices in this regard.

9.3.4 Incandescent Luminaires

9.3.4.1 Connections to luminaires with incandescent lamps shall be installed in a box situated behind the luminaires. Where luminaires are secured directly to draw boxes in false ceilings or where ceiling roses or special connections are used, flush-mounted rear-entry round draw boxes which are independently fixed to roof beams, shall be provided.

9.3.5 Fluorescent Luminaires

9.3.5.1 Connections to luminaires with fluorescent tubes may be installed inside the metal canopy on condition that the frame and/or diffuser holder, where applicable, can be removed without disconnecting the conductors.

9.3.6 Compact Fluorescent Luminaires (CFL)

9.3.6.1 Connections to luminaires with Compact Fluorescent lamps shall be installed in a box situated behind the luminaires. Where luminaires are secured directly to draw boxes, in false ceilings or where ceiling roses or special connections are used, flush-mounted rear-entry round draw boxes which are independently fixed to roof beams, shall be provided.

9.3.6.2 Compact fluorescent lamps shall be supplied with PL-C (GX24d) or similar approved plug in base for PLC lamp holder.

9.3.7 Screwed Lamp holders

9.3.7.1 The central terminal of Edison Screw (ES) lamp holders shall be connected to the phase conductor (i.e. conductor with red insulation) and the screwed housing to the neutral conductor (i.e. conductor with black insulation).

9.3.8 Gas Discharge Lamps

9.3.8.1 Where it is necessary to connect the conduit directly to a luminaire with a gas discharge lamp, the conduit shall be connected to the metal canopy by means of brass bushes and locknuts.

9.4 TECHNICAL REQUIREMENTS OF LUMINAIRES

9.4.1 Technical Requirement

9.4.1.1 General

(a) All luminaires shall bear the SANS 475 & SANS 60598-2-1 safety mark.

(b) SANRAL reserves the right to have samples of luminaires offered tested by the SABS for compliance with SANS 475:2006.

(c) The maximum permissible wattage of lamps that may be used in the luminaires shall be clearly inscribed on the base of the Luminaires close to the lamp holder.

(d) The voltage rating, lamp wattage and control gear losses shall be clearly and indelibly marked on the luminaires.

9.4.1.2 Luminaire - indoors

(a) A luminaire shall consist of a body manufactured of cold rolled sheet steel not less than 0,8 mm thick.

(b) Except for mounting holes and/or slots and the required openings in air-return luminaires, the back of the body channel shall be closed over the full length of the luminaire.

(c) In the case of surface-mounted channel luminaires, three sets of mounting slots and knock-outs suitable for mounting to standard round conduit boxes and/or 20 mm dia conduit pendant rods shall be provided in the rear of the channel, one in the centre and one approximately one sixth from each end.

(d) A knock-out suitable for a 20 mm diameter conduit entry shall be provided at each end of the channel. The distance between the back of the luminaire and centre of the knock-out shall be approximately 25 mm.

(e) The knock-outs shall be positioned on the centre line of the channel.

(f) The body channel housing the electronic control gear, terminals and internal wiring of surface-mounted open tube type luminaires shall incorporate a removable cover acting as a reflector, manufactured of cold rolled steel not less than 0,8 mm thick designed and mounted to completely cover the interior of the body channel and its contents and extending over the full length of the luminaire up to the lamp holders.

(g) The reflector shall be firmly held in position with a latching device consisting of knurled, coil slot, captive screws. Plastic, used as a spring mechanism, is not acceptable as a fixing device for reflectors. The action of the latching device shall not deteriorate due to use and/or ageing.

(h) Safety chains shall be provided to retain the reflector should the latching device fail.

(i) All components, including screws, bolts and nuts utilised in the construction of the luminaire or fixing of its components, shall be corrosion proof.

(j) An earthing terminal, welded to the fixing plate, shall be provided. To ensure good earth continuity, care must be taken during manufacturing stages that this earthing terminal is not spray-painted.

(k) Industrial type luminaires shall be fitted with detachable side reflectors manufactured of cold rolled steel not less than 0,8 mm thick. The reflectors shall be designed to improve the downward light output ratio and decrease the upward light output ratio to a value of less than 2 %.

(l) Surface-mounted decorative type luminaires shall incorporate an injection-moulded prismatic acrylic diffuser or a high-grade optical reflector covering the entire reflecting surface of the luminaire.

(m) The diffuser shall be hinged or easily removable for maintenance and lamp replacement. All optical reflectors shall be hinged.

(n) Decorative luminaires with diffusers shall be constructed to prevent the ingress of dust and insects.

(o) Recessed luminaires shall be suitable for mounting in the ceiling structure specified.

(p) The prismatic diffuser or reflector shall have four catches for attachment.

(q) The diffuser or reflector shall fit flush with the ceiling and the only visible portion shall be the reflector or diffuser. Should the luminaire be so designed that a surrounding frame is visible, then this frame shall be manufactured of anodised aluminium. The corners of the surrounding frame shall be mitred and reinforced.

(r) The voltage rating shall be clearly and indelibly marked on the luminaire.

9.4.1.3 Luminaire - outdoors

(a) The luminaire housing shall be manufactured out of die cast aluminium.

(b) The lamp compartment shall be rated minimum IP 65.

(c) The control gear compartment shall be rated minimum IP 65.

(d) Thermal separation shall exist between the lamp and control gear compartment.

(e) The luminaire shall have easily removable control gear.

(f) Electronic control gear shall be used.

(g) The control gear and lamp compartment must be easily accessible via a hinged cover or glass.

(h) Preference shall be given to road lighting luminaires that can be maintained from the top.

(i) Due to lighting pollution and especially glare, all road lighting luminaires shall be provided with flat glass.

(j) A single-piece aluminium reflector shall be used for road light luminaires.

(k) Stainless steel clips shall be used for road lighting luminaires.

(l) The road lighting luminaire shall be able to be supplied with the following:

i. Bottom or side entry spigot.

ii. Incorporated recessed miniature daylight switch.

iii. Incorporated 5 A/2,5 kA circuit breaker.

iv. Plug-in 5-way terminal block.

9.4.1.4 Lamp holders

(a) Lamp holders shall preferably be of the spring-loaded type. Where twist-lock type lamp holders are provided, the mounting of the holders shall be able to accommodate the tolerances experienced in the length of lamps and in the manufacture of luminaires.

9.4.1.5 Control gear for luminaires

(a) Electronic control gear shall be provided for all luminaires where the option is available. Conventional control gear can be used if approved by SANRAL.

(b) The control gear, ballasts, capacitors and starters shall be designed and manufactured to suit the control circuitry adopted.

(c) Ballasts shall comply with SANS 890-1 & 2 and 891.

(d) Ballasts shall further be suitable for the particular luminaire to ensure that the thermal limits specified in par. 3.5 of SANS 475:2006 are not exceeded. Starters shall comply with BS 3772.

(e) Starters shall be accessible from the outside of the luminaire, and replacing the starter shall not necessitate the removal of lamps.

9.4.2 Capacitors

9.4.2.1 Capacitors shall comply with SANS 1250. The power factor of each complete luminaire shall be corrected to at least 0,85.

9.4.3 Luminaires for Hazardous Areas

9.4.3.1 Luminaires for use in hazardous areas shall comply with the requirements for the relevant classification laid down by SANS 0108.

9.4.3.2 Certificates of proof of compliance for the complete luminaire including glands as issued by the SABS shall be submitted prior to the supply of luminaires.

9.4.3.3 The onus rests on the Contractor to ensure that luminaires offered are suitable for use in the relevant classified areas.

9.4.4 Luminaires for discharge lamps

9.4.4.1 Each luminaire shall be a fully integral unit, consisting of an anodised, spun aluminium reflector, GES lamp holder and a cast aluminium alloy housing for the control gear, capacitors, electrical connections and in the case of the high pressure sodium luminaire a solid state igniter. Alternatively, the control gear, capacitor, igniter and terminal block may be separately mounted remote from the luminaire. Preference shall, however, be given to integral units.

9.4.4.2 The choke shall be encapsulated in a polyester filled, cast aluminium alloy housing, having suitable provision for cooling. It shall be designed for operation at a nominal voltage of 220 V, but shall operate satisfactorily on any voltage between 210 and 240 V, with minimal effect on the life of the lamp.

9.4.4.3 The electronic ignition device shall be of the three-wire type. If the ignition device offered is of the type that continues pulsing on a failed lamp, the Contractor shall guarantee that this will have no detrimental effect on the life and efficient operation of the control gear, lamp holder and ignition device.

9.4.4.4 The electronic ignition device shall operate on the superimposed pulse principle. The circuitry shall be such that on failure of a lamp, high voltage pulses will be confined to the high voltage lead between the igniter and the centre contact of the lamp holder.

9.4.4.5 The luminaires shall be of high quality design and manufacture. All materials used shall be corrosion resistant.

9.4.4.6 Capacitors shall be metal-clad and have a capacity rating suitable for improving the power factor to at least 0,85. They shall have a minimum voltage rating of 250 V at 50 Hz and be fitted with safety discharge resistors.

9.4.4.7 Lamp holders shall incorporate a safety device to ensure that the lamp is firmly held in position.

9.4.4.8 All control gear shall be designed for operation together, suitable for correct and efficient operation of the lamps supplied, as well as other manufacturer's lamps, which may be used when relamping.

9.4.4.9 Provision shall be made on the luminaires for the fixing of safety chains to arrest the fall of the luminaires in the case of failure of the normal supporting system, or accidental dropping of components when working on the luminaires or control equipment. Safety chains between removable components and the provision for external chains shall be part of the luminaire offered.

9.4.4.10 The reflector shall be manufactured from a single piece aluminium reflector or anodised aluminium if approved by SANRAL or the Independent Engineer.

9.4.4.11 The luminaire shall be manufactured form a high-pressure die cast aluminium housing with hardened class cover. Stainless steel clips shall be used to secure the glass in position.

9.4.4.12 The lamp and control gear compartment shall have a minimum IP rating of IP65.

9.5 LAMPS

9.5.1 Incandescent Lamps

9.5.1.1 The installation of incandescent lamps is not allowed except if special written permission was given by SANRAL.

9.5.1.2 All luminaires shall be supplied and installed with new unused lamps suitable for the voltage as specified herein or in SANRAL's Requirement.

9.5.1.3 General service lamps from 25 W to 1000 W and for voltages from 200 V to 250 V shall comply with SANS Specification 56 of 1961, and shall carry the SABS mark.

9.5.1.4 Lamp sizes from 25 W to 200 W shall be required with either clear or internally frosted glass bulbs.

9.5.2 Fluorescent Lamps

9.5.2.1 Fluorescent lamps shall be suitable for the control circuitry used. Lamps shall comply with SANS 1041.

9.5.2.2 If no colour is specified in the detail technical specification, the light colour shall correspond to colour 2 (4300 °K) of SANS 1041.

9.5.2.3 T5 High Efficiency (HE) type lamps with electronic ballasts shall be used with a 20 000 hours lamp life.

9.5.2.4 T8 XT Long-life with electronic control gear shall also be used with a 42 000 hours lamp life.

9.5.3 LED Lamps

9.5.3.1 LED lamp technology shall be used with new luminaires or replace existing lamps as soon as the LED lamp can provide similar or better illumination.

9.5.4 Discharge Lamps

9.5.4.1 The following discharge lamps are available: Metal halide, high-pressure sodium & mercury vapour lamps.

9.5.4.2 The high-pressure sodium lamp provides the highest luminous efficacy and will be used as standard. The other discharge lamps may be used if approved by SANRAL or the Independent Engineer. The Contractor shall use OSRAM, VIALOX NAV SUPER 4Y or similar approved lamps with outstanding luminous efficacy and highest reliability.

9.5.5 Halogen Lamps

9.5.5.1 Only halogen lamps with IRC and ENERGY SAVER low-voltage lamps (12V) shall be used due to their energy saving technology. Any other halogen lamp has to be approved by SANRAL or the Independent Engineer.

9.5.6 Compact Fluorescent Lamps

9.5.6.1 Where possible, compact fluorescent lamps must be used to reduce energy consumption. The Contractor shall ensure that the lamps supplied are from OSRAM or similar approved manufacturer. The Contractor shall ensure that the lamp power factor is within specification. Proof of compliance can be requested by SANRAL or the Independent Engineer.

9.6 OFF PEAK ENERGY REDUCTION

9.6.1 Telemanagement Systems

9.6.1.1 The Telemanagement system employs a pilot wire or wireless networks to switches the power from the permanently energised cables to the selected part of the dual ballast in the luminaire. In the process, the lamp reduces the light output and the power consumption.

9.6.1.2 The system captures data from each luminaire and transmits these data to a central control where it is used for surveillance and maintenance. The system shall also be able to interface with a SCADA system.

9.6.2 Timed power switch

9.6.2.1 A Power Switch is an electronic device, which switches the impedance of the ballast from the nominal rating of typically 400W, to 250W. In the process, the lamp reduces the light output and the power consumption. In the past, the switching was triggered by a control wire, which, by applying either 0V or 230V, switched the status of the light accordingly. The disadvantage of this system was the extra cost of the additional control wire, which had to be provided inside the supply cable.

9.6.2.2 However, with the new generation of Timed Power Switch, the circuitry is as follows:

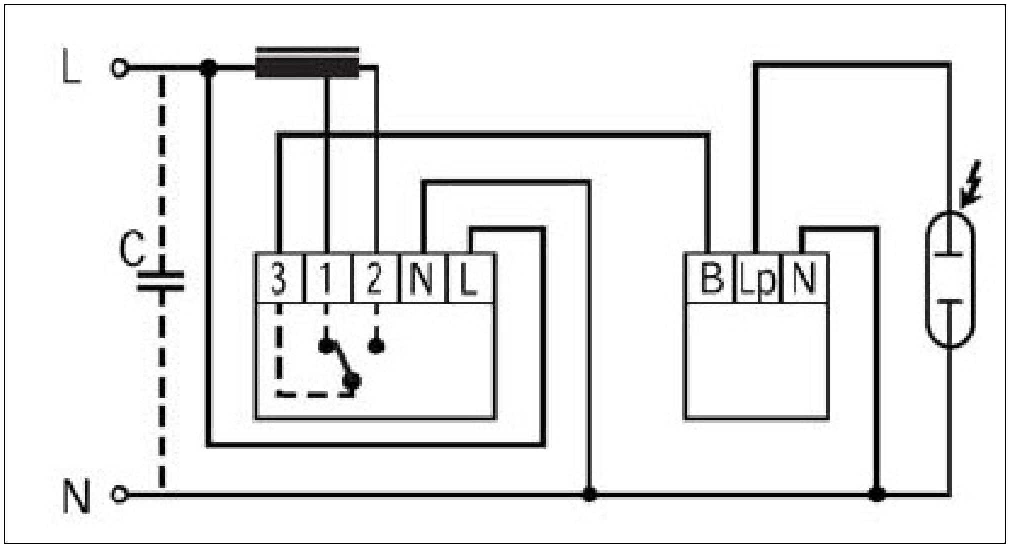


FIGURE 9-1: TIMED POWER SWITCH

9.6.2.3 One can see that no external wiring is provided.

9.6.3 The timed switching functions are as follows:

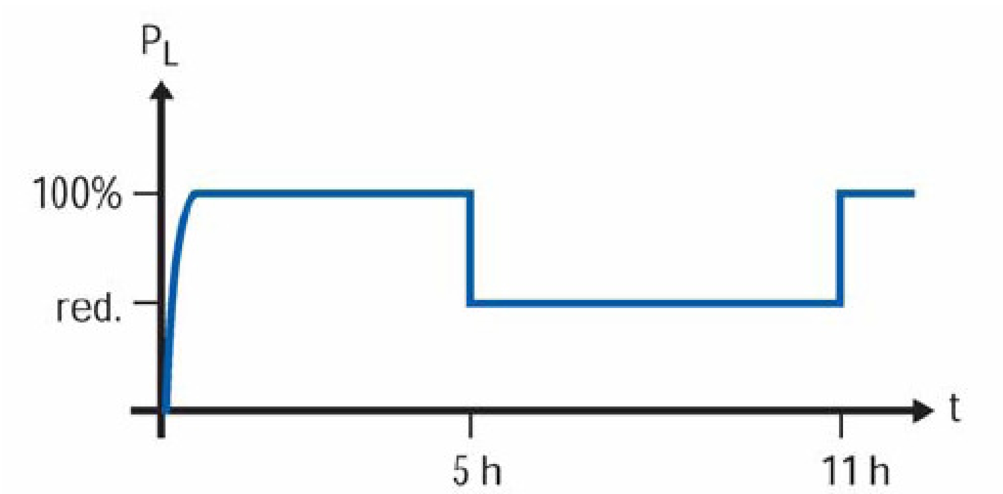


FIGURE 9-2: TIMED POWER SWITCH SWITCHING CURVE

9.6.3.1 5 hours after switch-on the light output is reduced from 100% to 50%

9.6.3.2 11 hours after switch-on the light output is increased from 50% up to 100% again until switch-off.

9.6.4 The timer starts its operation from switch-on.

9.6.5 The behaviour of the Timed Power Switch at power interruptions is as follows:

9.6.5.1 The Timed Power Switch detects short mains interruptions between 3 to 15 seconds without starting the timing sequence from zero. In other words: The threshold is somewhere between 3sec and 15 sec. It depends on the actual mains voltage at the moment when the mains voltage is interrupted.

9.6.5.2 However, if the mains interruption is longer than this period the Timed Power Switch starts the sequence from zero again.

9.6.5.3 If the lamp is in the 5h to 11h period, where it operates at 50%, and the power is interrupted for up to 3 to 15 seconds causing the lamp to extinguish, and the Timed Power Switch does not start from zero again, then the lamp will restart at full load and remain so for 3 minutes before it "falls back" to a 50% operation. This ensures that the lamp starts at full power, thereby providing the correct physical conditions inside the lamp burner during the start-up phase.

9.6.6 Power Reduction Table:

TABLE 9-1: POWER REDUCTION TABLE

LAMP WATTAGE	LAMP TYPE	LUMINOUS FLUX, %	LAMP CURRENT, A		CORRECTED LINE CURRENT, A		CIRCUIT POWER, W	
			A		A		W	
			FULL	REDUCED	FULL	REDUCED	FULL	REDUCED
250	MBF	ca 40	2,15	1,15	1,29	0,67	274	136
250	SON	ca 50	3,00	2,80	1,30	0,85	271	175
400	MBF	ca 50	3,25	2,15	2,05	1,16	427	267
400	SON	ca 45	4,45	3,20	2,00	1,20	435	235

9.6.7 Due to the compelling advantages of this technology, this Timed Power Switch shall be used for all 400W HPS street light applications, whether it is a new or an existing installation. It should also be considered for 250W HPS.

9.6.8 Any other type of power reduction method can be proposed by the Contractor to reduce the overall power usage of a lighting installation to be approved by SANRAL or the Independent Engineer.

9.7 FOG WARNING

9.7.1 Format/Position

9.7.1.1 A fog warning light shall be installed in the bullnose of each Lane and angled to aim the maximum light output in the direction of oncoming vehicles. It shall consist of an amber strobe type beacon. The control switch for the fog warning lights shall be located in the Control room, grouped with the control switches for the Canopy lights and high mast lights (if applicable) and shall be clearly marked “Fog Lights”.

9.7.1.2 Intensity and Flash Rate

9.7.2 The peak intensity of the fog warning light shall be 2,000,000 candelas with a flash rate of ± 80 per minute

9.8 LUMINAIRES DATA AND COMPLIANCE SHEET

TABLE 9-2: LUMINAIRES DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
9.7.1	SANS 475:2006	Luminaires for interior lighting, street lighting and floodlighting - Performance requirements				
9.7.2	SANS 890-1:2007 (SABS 890-1)	Ballasts for fluorescent lamps Part 1: Ballasts for lamps for operation with starters (class A lamps)				
9.7.3	SANS 890-2:2006 (SABS 890-2)	Ballasts for fluorescent lamps Part 2: Ballasts for lamps for operation without starters (class B lamps)				
9.7.4	SANS 891:2006 (SABS 891)	Reference ballasts for class B fluorescent lamps				
9.7.5	SANS 60598-1:2009/IEC 60598-1:2008 (SABS IEC 60598-1)	Luminaires Part 1: General requirements and tests				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
9.7.6	SANS 60598-2-1	Luminaires Part 2: Particular requirements Section 1: Fixed general purpose luminaires				
9.7.7	SANS 60598-2-2	Luminaires Part 2: Particular requirements Section 2: Recessed luminaires				
9.7.8	SANS 60598-2-3	Luminaires Part 2-3: Particular requirements - Luminaires for road and street lighting				
9.7.9	SANS 60598-2-4	Luminaires Part 2: Particular requirements Section 4: Portable general purpose luminaires				
9.7.10	SANS 60598-2-5	Luminaires Part 2-5: Particular requirements - Floodlights				
9.7.11	SANS 60598-2-6	Luminaires Part 2: Particular requirements Section 6: Luminaires with built-in transformers or converters for filament lamps				
9.7.10	BS EN 60155:1995	Glow-starters for fluorescent lamps				
9.7.11	SANS 1041:2004 (SABS 1041)	Tubular fluorescent lamps for general service				
9.7.12	SANS 10064:2005 (SABS 064)	The preparation of steel surfaces for coating				
9.7.13	SANS 0108	The classification of hazardous locations and the selection of apparatus				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		for use in such locations.				
9.7.14	Government Gazette 8928	Electricity regulations for compulsory norms and standards for reticulation services				
LUMINAIRIES						
	CLAUSE					
9.7.15	9.2	Mounting of Luminaires				
9.7.16	9.2.1	Positions				
9.7.17	9.2.2	Cover Plates				
9.7.18	9.2.3	Hangers and Supports				
9.7.19	9.2.4	Suspended Luminaires				
9.7.20	9.2.5	Suspended Cable Channels				
9.7.21	9.2.6	False Ceilings				
9.7.22	9.2.7	Ceiling Battens				
9.7.23	9.2.8	Mounting to Draw boxes				
9.7.24	9.2.9	Luminaires Mounted to Concrete Slabs				
9.7.25	9.2.10	Luminaires Mounted to Ceilings				
9.7.26	9.2.11	Continuous Rows of Luminaires				
9.7.27	9.2.12	Recessed Luminaires				
9.7.28	9.2.13	Special Ceilings				
9.7.29	9.2.14	Glass bowl Luminaires				
9.7.30	9.2.15	Bulkhead Luminaires				
9.7.31	9.2.16	Wiring to Enclosed Luminaires				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
9.7.32	9.3	Connections to Luminaires				
9.7.33	9.3.1	Connectors				
9.7.34	9.3.2	Knock-outs				
9.7.35	9.3.3	Type of Conductor				
9.7.36	9.3.4	Incandescent Luminaires				
9.7.37	9.3.5	Fluorescent Luminaires				
9.7.38	9.3.6	Screwed Lamp holders				
9.7.39	9.3.7	Gas Discharge Lamps				
9.7.40	9.4	Technical Requirements of Luminaires				
9.7.41	9.4.1	Fluorescent Lamp Luminaires				
9.7.42	9.4.2	Capacitors				
9.7.43	9.4.3	Lamps				
9.7.44	9.4.4	Lamps and Incandescent Lamps				
9.7.45	9.4.5	Luminaires for Hazardous Areas				
9.7.46	9.4.6	Gaseous Discharge Luminiare				
9.7.47	9.4.7	High Bay Luminaires				
9.7.48	9.5	Lamps				
9.7.49	9.6	Off peak energy reduction				
9.7.50	9.7	Fog Light				

10. PROVISION FOR TELEPHONE INSTALLATIONS

10.1 GENERAL

10.1.1 The installation of telephones and the cabling thereof will be carried out by Telkom or Neotel personnel or another specialist contractor, unless otherwise specified in the Project Specification.

10.2 CONDUIT INSTALLATION

10.2.1 The conduit installation shall be done in accordance with the Standard Specification for Conduits and Conduit accessories, the drawings and the Project Specification.

10.3 POWER SKIRTING

10.3.1 Where telephone outlet points are indicated on power skirting, they shall be purpose made to suit the particular power skirting. Final positions of telephone points shall be confirmed on site with the Contractor before final installation of covers.

10.4 COVER PLATES

10.4.1 On completion of the telephone installation (wiring, cabling, outlets, etc.) by Telkom, Neotel or the specialist contractor, the Contractor shall ensure that all cover plates on wireways, power skirting draw boxes, etc. are correctly fitted.

10.5 TELEPHONE INSTALLATION DATA AND COMPLIANCE SHEET

TABLE 10-1: TELEPHONE INSTALLATION DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
N/A						
TELEPHONE						
	CLAUSE					
10.5.1	10	Provision FOR TELEPHONE INSTALLATIONS				
10.5.2	10.1	General				
10.5.3	10.2	Conduit Installation				
10.5.4	10.3	Power Skirting				
10.5.5	10.4	Cover Plates				

11. EARTHING AND LIGHTNING PROTECTION

11.1 COMPLIANCE WITH STANDARDS

11.1.1 Standards

11.1.1.1 The earthing and lightning protection of all installations shall comply with the following standards and statutory requirements (as amended):

- (a) SANS 10313: The protection of structures against lightning.
- (b) SANS 10142-1: Code of practice for the wiring of premises.
- (c) SANS 10199: The design and installation of earth electrodes.
- (d) SANS 1063: Earth Rods and coupling.
- (e) SANS 62305-1: Protection against lightning – Part 1: General principles.
- (f) SANS 62305-2: Protection against lightning – Part 2: Risk management
- (g) SANS 62305-3: Protection against lighting – Part 3: Physical damage to structures and life hazard.
- (h) SANS 62305-4: Protection against lightning – Part 4: Electrical and electronic systems within structures.
- (i) SANS 61321-1: Protection against lightning electromagnetic impulse Part 1: General principles.
- (j) SANS 61321-2: Protection against lightning electromagnetic impulse (LEMP) Part 2: Shielding structures, bonding inside structures and earthing.
- (k) SANS 61312-4: Protection against lightning electromagnetic impulse Part 4: Protection of equipment in existing structures.
- (l) SANS 61662: Assessment of risk of damage due to lightning.
- (m) Act 1993: Occupational Health and Safety Act.

11.1.2 Certificate of Compliance

11.1.2.1 The Contractor shall appoint an earthing and lightning protection specialist to perform resistance measurements as specified in Clause 11.3.2.4 & 4. The obtained measurement values shall form part of a Certificate of Compliance issued by the specialist, which shall contain:

- (a) An evaluation of the obtained results (the earth resistance reading at the main earth bar shall not exceed 1 OHM, during dry and wet seasons);
- (b) A statement that the earth network and earth electrode resistances are in accordance with the standards and requirements listed in Clause 11.1.1; and, if necessary;
- (c) Details of areas of non-conformance in this regard.

(d) Two copies of this certificate shall be submitted to SANRAL before handing over of any repair, modification or new installation involving earthing or lightning protection systems.

(e) Additional information in the test points and readings to be submitted.

11.2 BASIC LAYOUT OF THE EARTHING NETWORK AT A TOLL PLAZA

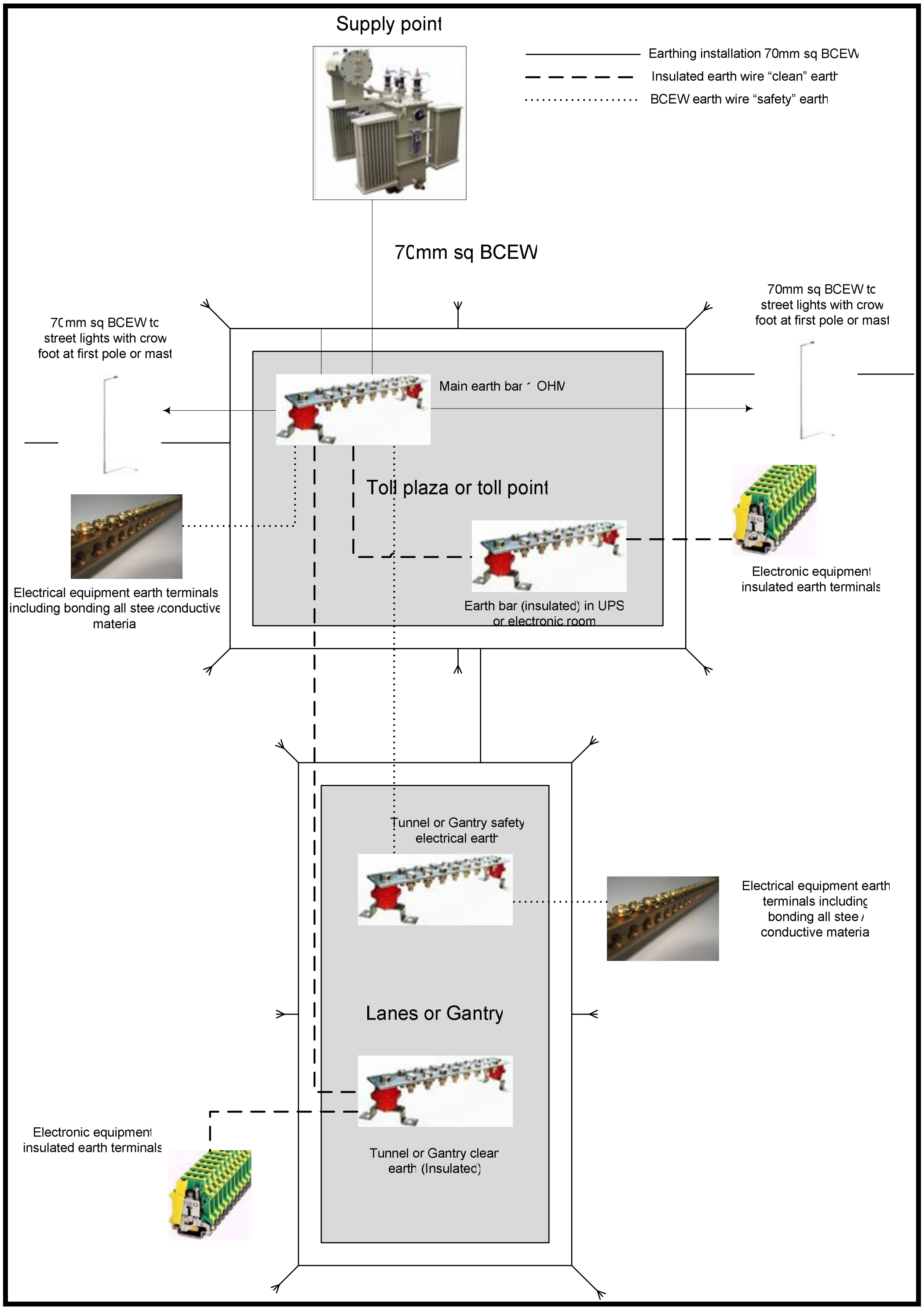


FIGURE 11-1: BASIC EARTHING ARRANGEMENT

The above layout must be used as a guideline only and additional earthing may be required depending on the site and soil conditions.

11.3 EARTHING

11.3.1 Earthing Philosophy

The earthing philosophy is based on two broad principles:

11.3.1.1 Common Earth: The installation shall make use of only one earth system.

11.3.1.2 Bonding: All equipment likely to be subjected to surge currents shall be securely bonded together and to the earth network.

(a) Common Earth

Unless otherwise specified herein or in SANRAL's Requirements, the installation shall make use of only one earth system. This implies the following:

i. Where an installation may typically consist of a main building or plant and one or more satellite subsystems, the various earth networks shall be interconnected to form one earth system.

ii. All main distribution boards and sub distribution boards shall be connected to an earth bar that is connected to the main earth conductor.

iii. Only in the rare instance of a subsystem being totally isolated, with no cables, pipes, fences or other conductive structures connecting it to the rest of the installation, may a system be provided with a separate earth network.

iv. Mains or "safety" earth networks and so called "clean" earth networks shall be connected to each other, preferably somewhere outside the "clean" area.

v. The clean earth shall be an insulated earth connecting the UPS, UPS DB's and essential equipment to earth.

(b) Bonding

i. General

The following items shall all be securely bonded, in an electrically continuous manner, to the earth network:

- Earth busbars.
- All metal parts (e.g. enclosures, lighting masts, frames, steel columns, gates fencing, pipes, cable ladders and trays, roofs and steel reinforcing).
- Cable armouring and glands.
- Cable screens.
- "Safety" or mains earth.
- "Clean" earth (only at main earth bar).
- Steel conduit.

- Earthing electrodes.
- Steel pipes.
- Steel fence.
- Etc.

Bonding leads shall be short and shall run in straight or smoothly contoured routes. Items such as fences, pipes, cables and conduit shall be earthed at both ends.

ii. Bonding Conductors

Unless otherwise specified herein or in SANRAL's Requirements, bonding shall be done by means of 16 mm², green PVC insulated, hard drawn, stranded copper conductor or any other approved conductor and crimping lugs or ferrules.

iii. Lugs

Where the earth network is connected to the electrical system or bonded to structures, the earth or bonding conductor ends shall be fitted with lugs. The lugs shall be secured by means of a hydraulic compression crimping tool with hexagonal dies or by means of brazing or silver soldering. Dimple type indent crimping will not be acceptable.

iv. Cable Armouring

At cable ends, the armouring shall be made off separately and be fitted with lugs. Armouring strands shall not be cut away to fit lugs. Cable armouring shall be bonded to the earth network at both ends of the cable.

v. Cable Screens

Cable screens shall normally be bonded to the earth network at both ends of the cable. In cases where cable screens are used for signalling purposes (e.g. coaxial cables), the screens shall either not be earthed or earthed at one end only, depending on the application. If not specified, the screens shall be earthed at one end only. In addition, either the cable shall run inside earthed steel conduit or a separate earth conductor shall be installed alongside the cable. Screens of 600/1000 V grade single core cables shall be earthed at one end only.

vi. Gates

In addition to the bonding of the gate to the earth system, a 15 mm wide braided copper strap shall be used to bond the gate to the gate frame or gatepost across the gate hinges. The braided strap shall be fitted with M8 lugs and shall be secured to the gates and posts by means of setscrews in drilled and tapped M8 holes.

vii. Cable Ladders and Tray

Where there are breaks in the cable ladder or cable tray installation (e.g. at joints, bends or wall penetrations), the two sections shall be connected to each other. Both ends of cable ladder and cable tray runs shall be bonded to the earth network by means of 35 mm², stranded, bare copper conductor or any other approved conductor.

viii. Roofs

One 10 mm² bare copper conductor shall be installed over the full length of the ceiling void. This conductor shall be fixed to the top purlin and connected to the main earth conductor or earth bar of each distribution board. Conductive roof sections and gutters shall be connected to this conductor, at 15 m intervals, by means of 12 x 0, 8 mm copper strapping and galvanized bolts and nuts. Different roof levels and sections shall be bonded to each other.

ix. Non-conductive Wireways

Cables in PVC conduit or non-conductive ducts shall be installed with stranded, bare copper earth conductors. These conductors shall be bonded to the earth network and other conductive items in the vicinity.

11.3.2 Earth Network

Each installation shall be provided with an earth network, consisting of interconnected trench earths and earth electrodes.

11.3.2.1 Trench Earths

(a) Configuration

The earth network conductors shall be 70 mm², hard drawn, stranded, bare copper or any other approved conductor. Trenches shall have a minimum depth of 600 mm.

(b) Application

In addition to locations specified, trench earths shall be installed around all buildings, installations and plant rooms, to form ring earths. Special care must be taken not to create earth loops.

(c) Joints

Unless standard drum lengths are exceeded, no through jointing of earthing conductors shall be acceptable. Joints detailed hereunder refer to T-junctions and conductor end connections. Earth conductors shall be jointed by means of an exothermal process equal or similar to the “Cadweld" method. All joints and terminations shall be accessible. Where concrete aprons or paved areas cover joints or terminations, suitable arrangements shall be made by the Contractor, whereby these terminations and joints are rendered accessible for future testing.

11.3.2.2 Earth Electrodes

(a) Configuration

The earthing rods shall be of stainless steel or of the copper coated high tensile steel type 16 mm diameter and approximately 3,6m long. The copper coat shall be "molten welded" onto the steel so that an interlocking crystalline union exists between the two metals. The coatings shall be even over the entire rod and shall not be of a thickness less than 0,4 mm. The rod, when broken by successive bending shall show no seams, pit slivers or separation of the copper from the steel. Earth rods shall be hand or power driven with a proper driver. The use of hammers for driving without the use of driving caps is not acceptable.

Threads on the rods shall be protected during driving by the use of the necessary couplings, driving tips, heads and studs.

Jointing of the rods shall be done with the aid of proper couplings tightly screwed onto the rods.

Where the soil resistivity survey indicates a good earth at depth and hard subsoil or rock is encountered, holes must be drilled. After placing the rods, the holes must be filled with sludge.

Rod tops shall be at least 600 mm below ground level. Adjacent rods shall be installed with a minimum separation of 5 m.

(b) Application

In addition to locations specified, earth electrodes shall be installed

i. at the corners of ring earths;

ii. at the bottom of down conductors; and

iii. at the ends of radial earth conductors.

(c) Earth Resistance

The earth resistance of the earth rod, measured before bonding it to any other conductors or electrodes, shall not exceed 200 Ω. Should the earth resistance be too high, the Contractor may be requested to install additional earth rods or earth rod lengths. No additional earth rods or earth rod lengths shall be installed without prior approval by SANRAL.

(d) Connections

Earth electrodes shall be bonded to the earth network by means of 70 mm², hard drawn, stranded, bare copper conductors or any other approved conductor. Connections shall be made by means of an exothermal process equal or similar to the "Cadweld" method.

11.3.2.3 Measurement of soil resistivity

A practical method to determine the soil resistivity distribution of the earth for the purpose of designing an earth electrode system is the four-electrode electrical sounding method.

(a) All tests shall be conducted by means of the Wenner array method, in accordance with SANS 10199, or

(b) By means of the Schlumberger array method, in according with SANS 10199.

11.3.2.4 Resistance Measurements

Each earth point shall be individually tested for earth resistivity over the range 1m to 6m depth and the results submitted to SANRAL. The Contractor shall allow for earth resistance measurements by an earthing specialist:

(a) The earth resistance of each earth electrode shall be measured before bonding it to any other conductors or electrodes.

(b) The earth resistance of the total earth network shall be measured once all its components have been connected and the bonding has been completed.

(c) All tests shall be conducted by means of the Fall-of-potential method, in accordance with SANS 10199. See clause 11.3.2.5, 11.3.2.6 & 11.3.2.8.

(d) The specialist shall certify the actual resistances measured. These values shall form part of the certificate of compliance to be submitted to SANRAL.

(e) The earthing resistance shall also allow for the electronic equipment and the earthing resistance as measured at the main earth bar shall not exceed 1 OHM.

11.3.2.5 Basic layout of an 4 pin Earth Resistance Test

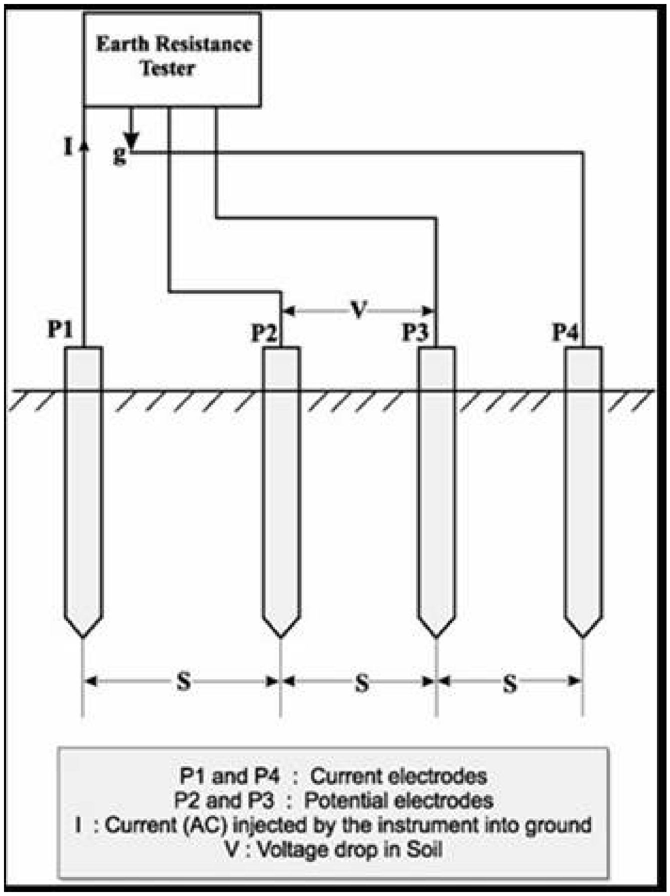


FIGURE 11-2: 4-PIN EARTH RESISTANCE TEST

11.3.2.6 Basic layout of an 3 pin Earth Resistance Test

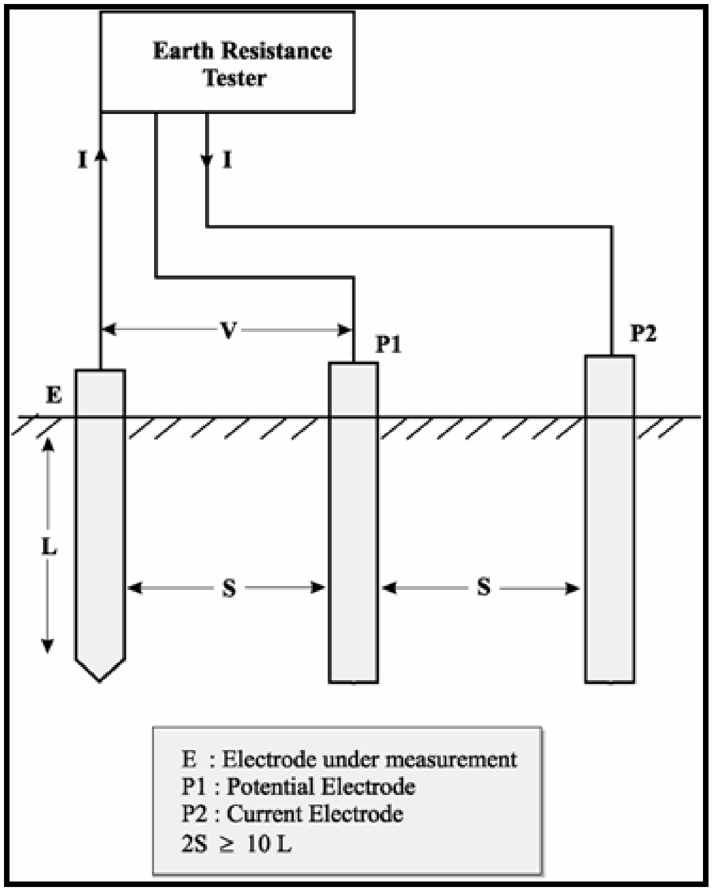


FIGURE 11-3: 3-PIN EARTH RESISTANCE TEST

11.3.2.7 Basic layout of a 3 pin Earth Resistance Test indicating the sphere and ground mat/large earthing installation under test.

11.3.2.8 Point P2 & C2 to be clearly indicated on the "as built" drawings or existing drawing for future reference.

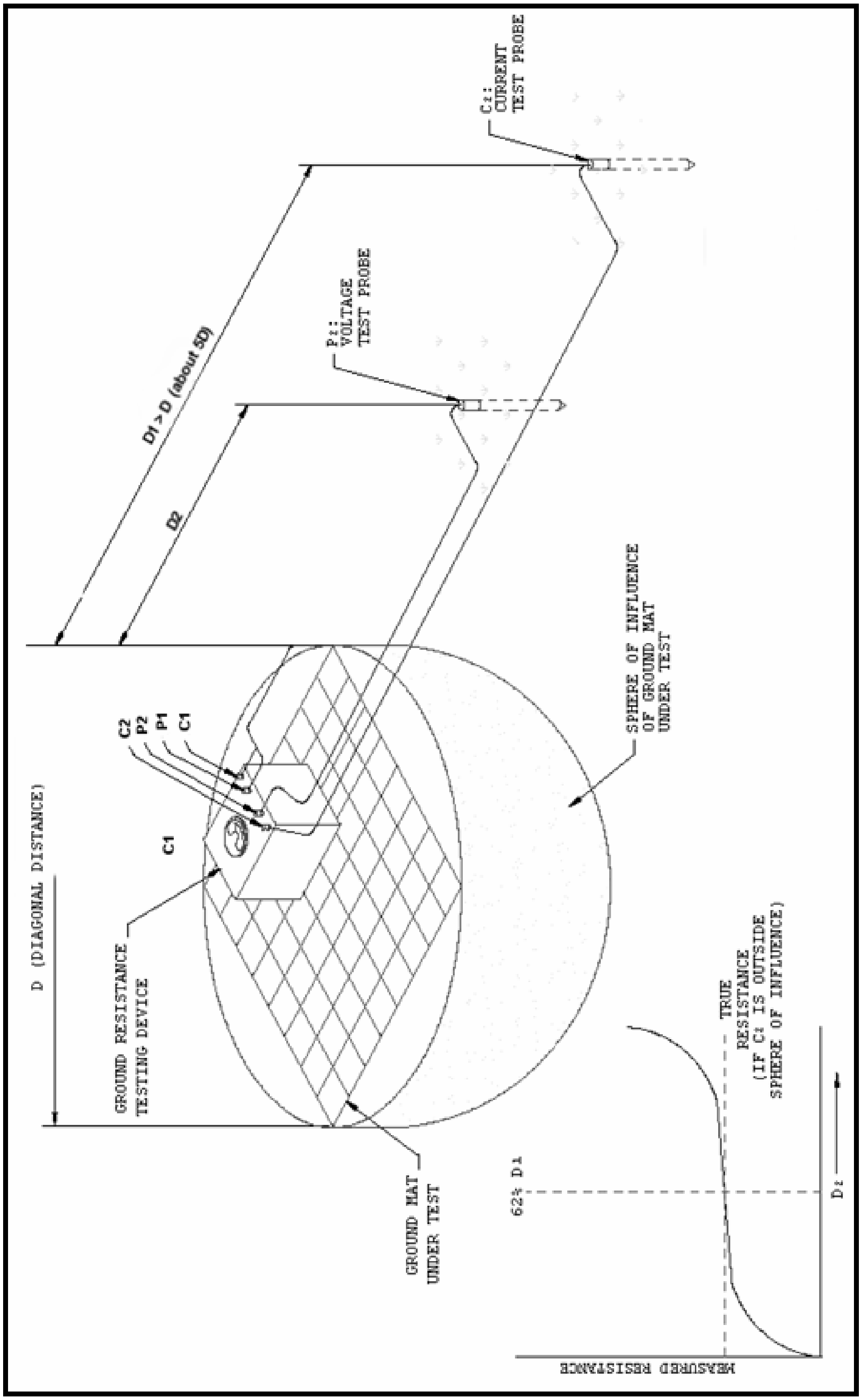


FIGURE 11-4: EARTH RESISTANCE TEST LAYOUT

11.3.2.9 Inspections

(a) The following procedures shall require inspection by SANRAL or their representative:

i. All trench installations and earth electrode excavations shall be inspected prior to any backfilling being done.

ii. All earth resistance measurements by the earthing specialist shall be witnessed. Earth electrode resistance tests shall be witnessed prior to connection to the earthing network.

iii. All exothermal type joints shall be witnessed.

(b) Manholes, draw boxes and distribution boards shall be opened on request for inspection purposes.

(c) The Contractor shall expose the entire earthing installation if any portion is backfilled before successful inspection and approval.

(d) SANRAL shall be notified at least three working days prior to any official inspection or testing being required.

11.3.3 Earthing of Substations

11.3.3.1 Main Earth Bar

A main earth bar, at least 500 mm long, shall be provided and secured to the substation wall or cable trench wall near the transformer low voltage terminals. The earth bar shall be mounted at least 30 mm away from the structure, at 500 mm intervals, by means of spacer bars or resin type insulators. The bar shall be long enough to accommodate the securing of all earth and bonding conductors to the bar, with a minimum spacing of 50 mm between conductors.

The earth bar shall be solid copper, with a minimum cross-sectional area determined according to the installed capacity of the transformers:

0	-	400 kVA	50 mm x 4 mm
500	-	800 kVA	63 mm x 5 mm
1000	-	1600 kVA	80 mm x 8 mm
2000	-	3000 kVA	100 mm x 10 mm

11.3.3.2 Substation Earth Network

An earth network shall be installed in the immediate vicinity of the substation. It shall be connected to the ends of the main earth bar by means of two stranded copper conductors or any other approved conductor, one from each end of the earth network. The cross-sectional area of these conductors shall depend on the installed transformer capacity:

0	-	500 kVA	70 mm²	
800	-	1250 kVA	140 mm²	(or 2 x 70 mm²)

1600	-	2000 kVA	210 mm²	(or 3 x 70 mm²)

Unless otherwise specified herein or in SANRAL's Requirements, the substation earth network shall consist of two separate 30 m trench earths, with four earth electrodes (two electrodes each) connected to them. The electrodes shall be installed at 5 and 30 m distances from the earth bar respectively.

If a separate substation earth network is installed (in the case of a minisub, for instance), this network shall be connected to the main earth network by means of a trench earth.

All specifications relating to an earth network shall apply to the substation earth network.

11.3.3.3 Earthing and Bonding

Each end of the high voltage distribution board and the transformer earthing terminal shall be bonded to the main earth bar by means of 70 mm² earth conductors or any other approved conductor. The neutral busbar and earth bar in the main low voltage distribution board, as well as the transformer neutral terminal, shall be bonded to the main earth bar by means of an earthing conductor (or conductors in parallel), having a cross-sectional area of not less than half the size of the incoming low voltage phase conductor (or conductors in parallel).

11.3.3.4 Miniature Substations

The earthing requirements of minisubs are similar to those of substations described above, except that a main earth bar is not required. The earth bar in the low voltage compartment shall act as the main earth bar.

11.3.3.5 Outdoor Substations

In the case of outdoor substations, the following additional requirements shall be met:

(a) Earthing of Perimeter Fence

The perimeter fence of the substation shall be surrounded by a 70-mm² trench earth, situated 1000 mm outside the fence. The trench earth shall be connected to four corner earth electrodes and bonded to the fence at 5 m intervals. The main earth network shall be bonded to the trench earth at a minimum of two points.

(b) Equipment Earthing:

A 70 mm² BCEW trench earth shall be installed around each transformer, switch and distribution board and shall be bonded to both the main earth network and the earth terminal of the relevant item.

11.3.4 Earthing of Distribution Boards

11.3.4.1 The earth bar or earth terminal of distribution boards and equipment shall be connected to the earth bar of the supplying distribution board in accordance with SANS 10142-1. These connections shall consist of bare, stranded copper conductors, installed along the same routes as the supply cables. If the supply connections consist of conductors in conduit, the earth conductors shall be installed in the same conduit.

11.3.4.2 Each earth bar shall be connected to the earth network by means of M8 lugs, brass bolts, nuts and locknuts. Unless otherwise specified herein or in SANRAL's Requirements, these connections shall be effected by means of a 16 mm^2 copper earth conductor or any other approved conductor. Each earth conductor shall be connected to the busbar with its own bolt and nut.

11.4 LIGHTNING PROTECTION

11.4.1 Lightning Protection Philosophy

The lightning protection philosophy is based on sound earthing and the creation of relatively surge-free areas. These areas will be referred to as protected areas.

11.4.1.1 Earthing

The installation shall be earthed as specified above.

11.4.1.2 Protected Areas

Main installations and subsystems shall be established as so-called protected areas. Protected areas shall be surrounded by a ring earth and all equipment shall be bonded to the earth network as specified herein.

All cables crossing the barriers of the protected area into the unprotected environment shall be supplied with surge protection.

All conductive equipment, such as pipes and fences, crossing the barriers of the protected area into the unprotected environment, shall be securely bonded to the earth network at the point of entry into the protected area.

11.4.2 Surge Protection

Surge protection shall be provided to all power, data and communication cables entering or leaving the protected area.

All types of surge protection utilized shall have a serviceability indication facility.

11.4.2.1 Main Distribution Board

Course protection in the form of a high capacity class I & II combined (or separate if approved by SANRAL or the Independent Engineer) 100KA surge arrester shall be installed at the main low voltage distribution board of the installation. All three phases, as well as neutral, shall be connected to earth via the arrester. These arresters shall be installed between each phase and neutral, as well as between neutral and earth.

The three phases shall be connected to neutral and then from the neutral to earth through the class I & II combined surge arrestor. Appropriate fuses shall be installed to protect the three phases.

The surge arrester shall be solidly bonded to the distribution board earth bar by means of 16 mm² green insulated copper conductor and shall be as accessible as circuit breakers and other distribution equipment fitted to the distribution board. The copper conductor shall be straight without any loops or unnecessary bends.

11.4.2.2 Other Distribution Boards

(a) Distribution boards, other than the main low voltage distribution board, feeding loads outside the protected area or being fed from outside sources, shall be supplied with class II 15kA over voltage arresters. These arresters shall be installed between each phase and neutral, as well as between neutral and earth.

(b) Distribution boards, other than the main low voltage distribution board not feeding loads outside the protected area or being fed from outside sources, shall be supplied with 6.5kA overvoltage arresters. These arresters shall be installed between each phase and earth, as well as between neutral and earth.

(c) The overvoltage arrester units shall be solidly bonded to the distribution board earth bar by means of 4 mm² green insulated copper conductor and shall be as accessible as circuit breakers and other distribution equipment fitted to the distribution board.

(d) Where use is made of more than one set of busbars in the same distribution board, all the busbar sets shall be provided with overvoltage arresters as specified herein or in SANRAL's Requirements.

11.4.2.3 Data and Communication Cables

Data and communication cables entering or leaving the protected area shall be provided with suitable surge protection. The Contractor shall timeously submit detailed proposals of all surge and over-voltage protection equipment to SANRAL for approval. The Contractor shall only utilise devices that are approved by the Independent Communications Authority of South Africa and which have levels of signal attenuation less than that specified as acceptable by the equipment manufacturer.

Additional surge protection may be required for the electronic equipment that will be provided and installed by other.

11.4.2.4 Induced Surge

Cable sections between surge protection equipment and the barrier of the protected area may induce surge currents in nearby cables and shall be regarded as being part of the unprotected environment. No other cables shall be installed in the same trench or wireways as these cables.

In addition, the following sets of cables, along parallel routes, shall not be installed closer than 500 mm from each other:

(a) "Raw" power and UPS power cables.

(b) Data/communication and mains power cables.

11.4.2.5 Specific Surge Protection

The measures specified are aimed at generally limiting the impulse level to 1000 V for the electrical installation. The general surge impulse level for electronic equipment shall be kept under 500V and will require additional protection by the Contractor. The Contractor shall ensure that all electrical and electronic equipment will be suitable for continuous, reliable operation under these conditions and that all such equipment is adequately protected in accordance with their own withstand levels, whether such protection has been specified herein or in SANRAL's Requirements in detail or not.

11.4.3 Lightning Protection of Tall Structures

11.4.3.1 Tall structures, such as buildings and lighting masts, gantries, shall be provided with lightning protection as specified within the applicable standard. This shall consist of:

(a) An air terminal/s;

(b) A down conductor/s; and

(c) An earth network or earth mat.

11.4.3.2 Air Terminals

(a) Building roofs shall be supplied with air terminal conductors and finials in conformance with SABS IEC 61024-1-1 and SABS IEC 61024-1-2 as amended peripheral air terminal conductors shall be solid aluminium straps or aluminium conductors with a minimum cross-sectional area of 50 mm².

(b) No part of the aluminium conductor system shall come into direct contact with the concrete or plaster, but shall be supported on insulated guides at intervals not exceeding 1,2 m.

(c) Conductive roofs and conductive roof structures supporting non-conductive roofs do not have to be supplied with additional air terminals and shall be connected directly to the down conductors. This is not applicable where the structure design includes protruding parapet walls.

(d) Lighting masts shall be supplied with finials. Finial lengths shall be such that a shielding angle of 45° is achieved.

11.4.3.3 Down Conductors

(a) The air terminal(s) shall be connected to the earth network by means of down conductors. In the case of a building, down conductors shall be installed on the four corners of the building and at intervals not exceeding 30 m. A lighting mast shall require a single down conductor only.

(b) The down conductors shall be 50 mm² aluminium and shall be connected to the copper ring earth by means of bi-metallic test points (300 mm above ground level), to prevent any electrolytic corrosion. Down conductors shall be installed in 20 mm ø galvanized conduit, in locations as approved by SANRAL. The test points shall be connected to the ring earth by means of 50 mm² bare copper earth conductors or any other approved conductor.

(c) All joints and terminations shall be accessible. Where concrete aprons or paved areas cover joints or terminations, suitable arrangements shall be made by the Contractor, whereby these terminations and joints are rendered accessible for future testing.

11.4.3.4 Earth Network for Tall Structures

(a) The earth network shall be installed as specified in clause 11.3.2.

(b) Prominent, tall structures, such as water towers, antenna masts and chimneys, shall be provided with a lightning protection system as specified in 11.4.3. The lightning protection system shall be connected to the earth network. If no earth network is available, these structures shall be provided with their own earth network. Such an earth network shall consist of a crow's foot design with a minimum of three 15 m radial trench earths. Earth electrodes shall be installed at the centre and at each end of all the radials.

11.4.3.5 High-mast earthing

(a) The Contractor shall determine the exact manner of earthing to obtain a value of better than 50 ohms, but shall comprise at least the following:

(b) High-Masts shall be earthed against lightning by means of interconnecting conductors.

(c) All earth conductors shall be connected to the High-Mast earth connector in such a manner that no earthing conductor is exposed.

(d) Where possible, the Contractor shall connect the foundation reinforcing steel to the earthing system.

(e) The Contractor shall install the following earthing arrangement (crow's foot) at the first mast that is found on every supply line closest to the Toll Plaza building:

i. A circular 70 mm² stranded copper earth at 1m depth surrounding the mast foundation. From this circular earth, the Contractor shall install two separate 70 mm² conductors through two separate 50 mm diameter PVC pipes set in the mast foundation, to the mast body earth stud;

ii. Two radials from circular earth, each 30 m long at 180 degrees to each other (along the road or along the stand boundary) at a depth of 1 m;

iii. Earth spikes at the base of the mast in order to achieve the resistivity specified. These earth spikes shall be securely bonded to the main mast body earth stud.

11.4.4 Basic layout of the surge protection device installation per Toll Plaza.

11.4.4.1 The layout below provides a basic installation layout of class I & II SPD devices for the electrical installation. The Contractor shall provide any additional SPD devices required to protect sensitive electronic devices.

11.4.4.2 Diagram A provides an overview of the lightning and surge waveforms that the SPD devices will be exposed to according to IEC 61643-1.

11.4.4.3 Diagram B provides the surge withstand voltage waveform for electrical and electronic devices. All electrical and electronic devices shall comply with the surge withstand capability as defined within IEC 60664-1. The Contractor shall also ensure that all equipment is supplied with an overvoltage category and rated surge voltage value.

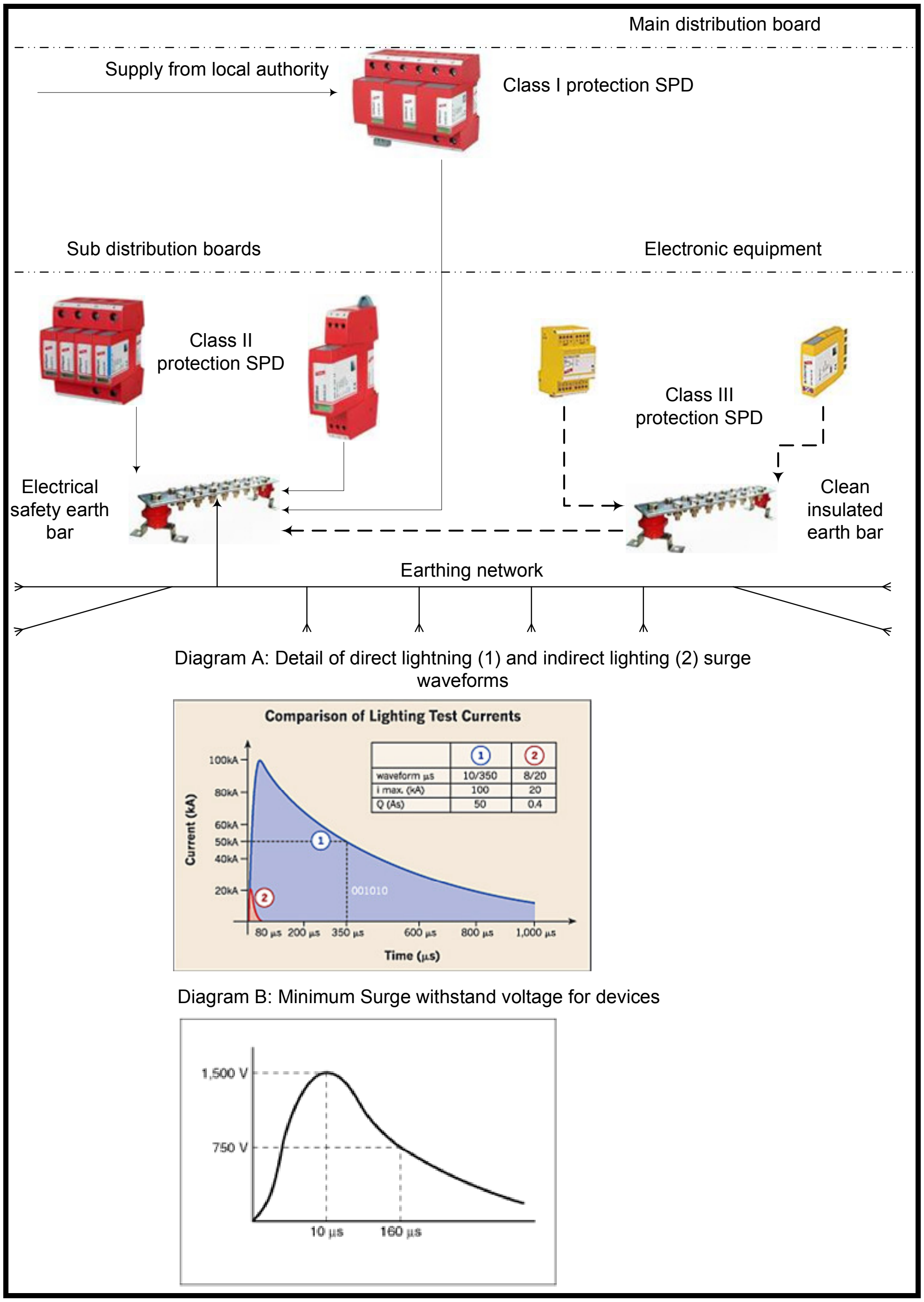


FIGURE 11-5: SPD INSTALLATION LAYOUT

11.5 EARTHING DATA AND COMPLIANCE SHEET

TABLE 11-1: EARTHING DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
11.5.1	SANS 10313	The protection of structures against lightning.				
11.5.2	SANS 10142-1	The wiring of premises Part 1: Low-voltage installations.				
11.5.3	SANS 10199	The design and installation of an earth electrode.				
11.5.4	SANS 1063	Earth Rods and coupling.				
11.5.5	SANS 62305-1/IEC 62305	Protection against lightning – Part 1: General principles.				
11.5.6	SANS 62305-2/IEC 62305-2	Protection against lightning – Part 2: Risk management..				
11.5.7	SANS 62305-3/IEC 62305-3	Protection against lightning – Part 3: Physical damage to structures and life hazard.				
11.5.8	SANS 62305-4/IEC 62305-4	Protection against lightning – Part 4: Electrical and electronic systems within structures.				
11.5.8	SANS 61321-1 & IEC 61321-1:1995	Protection against lightning electromagnetic impulse Part 1: General principles.				
11.5.9	SANS 61321-2 & IEC/TS 61321-2:1999	Protection against lightning electromagnetic impulse (LEMP) Part 2: Shielding structure, bonding inside structures and earthing.				
11.5.10	SANS 61312-4 & IEC 61312-2:1999	Protection against lightning electromagnetic impulse Part 4: Protection of equipment in existing structures.				
11.5.11	SANS 61662 & IEC 61662:1995	Assessment of risk of damage due to lightning.				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
11.5.12	IEC 60664-1	Insulation coordination for equipment within low-voltage systems Part 1.				
EARTHING						
	CLAUSE					
11.5.13	11.1.2	Earthing Test Certificate by specialist				
11.5.14	11.3.1.3	Common earth				
11.5.15	11.3.1.3	Safety earth network				
11.5.16	11.3.1.3	Clean earth network				
11.5.17	11.3.1.4	Bonding				
11.5.18	11.3.2	Earth Network				
11.5.19	11.3.2.1	Trench Earths (all terminations and joints as accessible)				
11.5.20	11.3.2.2	Earth Electrodes				
11.5.21	11.3.2.3	Measurements of soil resistivity (Attach additional documentation for all the readings and indicate the test points on the "as built" drawings).				
11.5.22	11.3.2.4	Resistance Measurements (Attach additional documentation for all the readings and indicate the test points on the "as built" drawings).				
11.5.23	11.3.2.5	Inspections				
11.5.24	11.3.3	Earthing of Substations and Switch and UPS rooms				
11.5.25	11.3.3.1	Main Earth Bar				
11.5.26	11.3.3.2	Earth Network				
11.5.27	11.3.3.3	Earthing and Bonding				
11.5.28	11.3.3.4	Miniature Substation				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
11.5.29	11.3.3.5	Outdoor Substation				
11.5.30	11.3.4	Earthing of Distribution Boards				
LIGHTNING PROTECTION						
	CLAUSE					
11.5.31	11.4.1	Philosophy				
11.5.32	11.4.2	Surge Protection				
11.5.33	11.4.2	Class I protection				
11.5.34	11.4.2	Class II protection				
11.5.35	11.4.2	Class III protection (by others) additional protection for electronic equipment				
11.5.36	11.4.3	Lightning Protection of Tall Structures				
EARTHING & LIGHTNING PROTECTION MAINTENANCE						
	MAINTENANCE					
11.5.37		Resistance Measurements every 6 months as indicated on the “as built” drawing (Attach additional documentation for all the readings and indicate the test points on the “as built” drawings).				
11.5.38		Provide table to reflect earthing readings in chart format.				
11.5.39		Load earthing readings into SCADA database if a SCADA system is available.				
11.5.40		Earthing report to be submitted every 6 months with reference to above clauses when an item does not conform to the				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		standard. Report must be generated by the SCADA system and completed on the SCADA system when done. All the reports shall be stored on the SCADA database.				
11.5.41		If the resistance increased more than 20% it must be investigated and problem rectified.				
11.5.42		Measurements to be taken and reported on in the 6-monthly reports				
11.5.43		1. Soil resistivity.				
11.5.44		2. Fall-of-potential				

12. PAINTING OF SHEET METAL FABRICATIONS

12.1 FINISH REQUIRED

12.1.1 Metal components of the framework, panels and chassis shall be finished with a high quality paint applied according to the best available method. Baked enamel, electrostatically applied powder coating or similar proven methods may be used unless a specific method is specified in the Detail Technical Specification. Care shall be taken to ensure that all edges and corners are properly covered.

12.2 BAKED ENAMEL FINISH

12.2.1 Prior to painting, all metal parts shall be thoroughly cleaned of rust, mill scale, grease and foreign matter to a continuous metallic finish. Sand or shot blasting or acid pickling and washing may be employed for this purpose. Immediately after cleaning, all surfaces shall be covered by electrolytically applied rust-inhibiting, tough, unbroken metal phosphate film and then thoroughly dried. Within forty eight (48) hours after phosphating, a passivating layer consisting of a high quality zinc chromate primer shall be applied, followed by two (2) coats of high quality baked enamel according to SANS 783 type 1. The minimum paint thickness after baking shall be 0,09 mm. The paint shall have a shock resistance of 25 kg cm on 0,9 mm soft steel plate and a scratch resistance of 2000 g.

12.3 POWDER COATED FINISH

12.3.1 Prior to painting, all metal parts shall be thoroughly cleaned of rust, mill scale, grease and foreign matter to a continuous metallic finish. Sand or shot blasting or acid pickling and washing may be employed for this purpose. The metal parts shall be preheated and then covered by a micro structured paint powder applied electrostatically. The paint shall be baked on and shall harden within 10 minutes at a temperature of 190 °C. The minimum paint thickness after baking shall be 0,07 mm. The paint shall have a shock resistance of 25 kg cm on 0,9 mm soft steel plate and a scratch resistance of 200 g.

12.4 TOUCHING UP

12.4.1 Before the installation is handed over, the Contractor shall ensure that all paint surfaces are cleaned and undamaged. Final coats of paint may be applied on site immediately prior to completion. A tin of matching touch-up paint (not smaller than 1,0 litre) shall be provided in all instances where ten or more pieces of equipment are supplied for a contract.

12.5 COLOUR

12.5.1 The colour shall be in accordance with the requirements specific for the specific equipment.

12.6 PAINTING OF SHEET METAL FABRICATIONS DATA AND COMPLIANCE SHEET

TABLE 12-1: PAINTING OF SHEET METAL FABRICATION DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
12.6.1	SANS 783	Coats of high quality baked enamel				
PAINTING METAL						
	CLAUSE					
12.6.2	12.1	Finish Required				
12.6.3	12.2	Baked Enamel Finish				
12.6.4	12.3	Powder Coated Finish				
12.6.5	12.4	Touching Up				
12.6.6	12.5	Colour				

13. PHOTO-ELECTRIC DAYLIGHT SENSITIVE SWITCH FOR OUTSIDE LIGHTING

13.1 GENERAL

This section covers the manufacture and supply of photo-electric sensitive switches for outside lighting. The switches shall be used for controlling streetlights and outside lighting.

13.2 CONSTRUCTION

13.2.1 The cover of the unit shall be manufactured from a tough, durable material providing protection against tampering. The cover shall have good weathering properties. It shall be ultraviolet-resistant and shall not deteriorate when exposed to sunlight for prolonged periods.

13.2.2 The units shall be supplied with a standard NEMA plug and socket. The socket shall have a suitable bracket for mounting against a wall or pole.

13.2.3 All parts shall be treated to be corrosion proof.

13.2.4 The units shall be capable of operating in dusty conditions between temperatures of -5°C and 55°C.

13.2.5 The operational level shall be factory preset for “ON” at a light level of approximately 40 lx and "OFF" at approximately 100 lx. Voltage variations shall not materially affect the operational levels.

13.2.6 A time delay of not less than 15 min shall be provided to prevent the unit from functioning due to lightning or other short period changes in illumination.

13.2.7 The unit shall be effectively safeguarded against voltage surges by means of a suitable surge protector, which shall preferably form an integral part of the unit.

13.3 INSTALLATION

13.3.1 Individual outside lighting circuits on a building may be connected directly to the daylight sensitive switch if the total current does not exceed 20 A.

13.3.2 Where two or more lighting circuits are to be controlled by a single daylight sensitive switch, a contactor actuated by the unit shall be provided in the switchboard.

13.3.3 A bypass switch, enabling the lights to be turned on at any time, shall be provided wherever daylight sensitive devices are utilized.

13.4 DAYLIGHT SWITCH DATA AND COMPLIANCE SHEET

TABLE 13-1: DAYLIGHT SWITCH DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
N/A						

DAYLIGHT SWITCH						
	CLAUSE					
13.4.1	13.1	13.1 General				
13.4.2	13.2	13.2 Construction				
13.4.3	13.3	13.3 Installation				

14. STREET LIGHTING POLES

14.1 GENERAL

14.1.1 This specification covers the manufacture and supply of mild steel and fibreglass street lighting poles. The poles shall be aesthetically pleasing in appearance and shall comply with the following requirements.

14.2 CONSTRUCTION

14.2.1 Street lighting poles shall be manufactured of tapered tubular mild steel or seamless fibreglass-reinforced polyester as specified herein or in SANRAL's Requirements.

14.2.2 Mild Steel Poles

14.2.2.1 The galvanising shall be bright overall, showing no coloured spots or dull patches. Discoloured galvanising appearance attributable to the silicon, phosphorus or carbon content of the mild steel will not be acceptable and will be rejected. SANRAL will not enter into negotiations with the SA Hot dip Galvanising Association in this regard.

14.2.2.2 Poles made of loose sections, which slide into each other are not acceptable.

14.2.2.3 The poles shall preferably be tapered and shall be circular or polygonal in shape. The poles shall preferably be curved and be designed to withstand a wind velocity of at least 120 km/h, with the luminaire mounted, with a deflection of less than 1:40. The minimum quality of the steel used shall be BS EN 10113-1:1993 Gr 43 A. A competent structural engineer, appointed by the Contractor, shall certify the soundness of the design at the maximum wind velocity recommended for the area.

14.2.2.4 Additional corrosion ducts shall be welded to the poles at the ground line. The ducts shall be 600 mm long and shall extend for 300 mm above and below the ground line.

14.2.2.5 Each pole shall be bitumen-coated on the inside and outside for a distance of at least 500 mm above ground level.

14.2.2.6 The spigot size shall be suitable for the type of luminaire to be mounted on the pole.

14.2.2.7 A baseplate complete with two 20 mm hook bolts, nuts and washers shall be provided with each pole. For poles up to 10 m in height above ground, the baseplate shall be 400 x 400 x 4 mm and for longer poles, the size shall be increased to 500 x 500 x 6 mm. The complete pole, baseplate, bolts, nuts and washers shall be hot dip galvanised to SANS 121:2000/ISO 1461:1999 as amended.

14.2.3 Fibreglass Poles

14.2.3.1 Poles made of loose sections, which slide into each other are not acceptable. The poles shall preferably be tapered and shall be circular or polygonal in shape.

14.2.3.2 The poles shall be manufactured from GRP laminates to SANS 141 as amended.

14.2.3.3 The fibreglass layers shall be protected against humidity by means of a resin coat of 1 mm minimum thickness.

14.2.3.4 The surface shall consist of a special resin coat to achieve a smooth, waterproof, flame and ultra-violet resistant surface.

14.2.3.5 Poles shall be postcured under temperatures of 60°C for 150 hours to ensure long-term stability.

14.2.3.6 Poles shall be designed to withstand a minimum wind velocity of at least 144 km/h, with the luminaires mounted, with a deflection of less than 1:14.

14.2.3.7 The spigot shall be suitable for the type of luminaire to be mounted on the pole.

14.2.3.8 A steel baseplate, 400 x 400 mm, complete with two 20 mm hook bolts, nuts and washers shall be provided with each pole. The baseplate, nuts, bolts and washers shall be hot dip galvanised to SANS 121:2000/ISO 1461:1999 as amended.

14.3 OPENINGS

14.3.1 A cable entry opening, approximately 100 x 50 mm, shall be provided on the back of the pole 400 mm below ground level. The edges of the opening shall be smooth to prevent damage to the cable.

14.3.2 An access door also on the back of the pole shall be provided, the bottom of which shall be approximately 400 mm above ground level, to allow access to the cable glands and mounting plate. The opening shall be approximately 230 x 90 mm and a hot-dipped galvanised mounting plate of at least 250 x 80 mm shall be provided on the inside of this opening for the mounting of the fuses or circuit breakers. The mounting plate shall be predrilled to accept 3 off 10 mm^2 x 4 core cables with glands as well as an earth stud.

14.3.3 The access door shall be at least 3 mm thick and shall overlap the opening by at least 20 mm all round to provide total protection against moisture. The door shall be fastened with captive stainless steel Allen screws and shall be fitted with a water resistant/weatherproof seal.

14.3.4 The pole shall be fitted with a mini-frame, and each phase shall be fed via an individual single pole circuit breaker of a rating suitable for the application and a removable neutral link mounted on the mounting plate in the pole.

14.3.5 An earth stud shall be provided in close proximity to the cable gland.

14.3.6 A connector block shall be provided to terminate and loop the cables and to tee-off the wiring to the circuit breaker or fuses.

14.3.7 1,5 mm^2 Stranded PVC wire shall be used to connect the circuit breaker or fuse and neutral link to luminaires and the connector block.

14.4 INSTALLATION

14.4.1 The Contractor shall be responsible for determining the exact position of each pole. If no spacing intervals between poles are indicated on drawings, poles shall be evenly spaced along the length of the route or section.

14.4.2 All poles in straight lines shall be accurately lined up and plumbed taking into account the taper of the pole.

14.4.3 Poles shall be planted at the following depths, unless otherwise specified herein or in SANRAL's Requirements:

Mounting height Luminaire (m)	Planting depth (m)
Up to 6	1,0
6 to 8	1,2
8 to 10	1,5
10 to 12	1,8
12 to 15	Bolt flange to plinth

14.4.4 Should the soil conditions be inadequate to support the pole and/or maintain it in the upright position under the wind and luminaire loadings specified, SANRAL shall be advised before installation so that increased planting depths or other methods of support can be device d.

14.4.5 The planting excavation around each pole shall be filled with a 1:12 (soilcrete) concrete mixture. The soilcrete shall be cast in 150 mm layers and each layer shall be thoroughly compacted around the circumference of the pole before the next layer is poured. The Contractor shall ensure that no rocks or sharp objects are included in the backfill material.

14.4.6 Poles shall be installed leaning back approximately three degrees from the vertical to allow for settling. The Contractor shall re-align all poles after settling, i.e. one month before the end of the guarantee period.

14.5 STREET LIGHT POLE DATA AND COMPLIANCE SHEET

TABLE 14-1: STREET LIGHT POLE DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
14.5.1	SANS 121:2000/ISO	Hot dip galvanized coatings in fabricated iron				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
	1461:1999	steel articles – Specifications and test methods				
14.5.2	SANS 141:2006 (SABS 141)	Glass-reinforced polyester (GRP) laminates				
14.5.3	BS EN 10113-1:1993	Hot-rolled products in weldable fine grain structural steels. General delivery conditions				
STREET LIGHTING POLES						
	CLAUSE					
14.5.4	14.2	Construction				
14.5.5	14.2.1	Mild Steel Poles				
14.5.6	14.2.2	Fibreglass Poles				
14.5.7	14.3	Openings				
14.5.8	14.4	Installation				

15. LIGHTING MASTS

15.1 GENERAL

15.1.1 This specification covers the manufacture and supply of mild steel roadway lighting masts for mounting heights of 12m and higher mounted on concrete foundations. The masts shall be aesthetically pleasing in appearance and shall comply with the requirements as specified herein.

15.2 CONSTRUCTION

15.2.1 Roadway lighting masts shall be manufactured of continuously tapered tubular mild steel.

15.2.2 Masts shall be hot dip galvanised to SANS 121:2000/ISO 1461:1999. The galvanising shall be bright overall, showing no coloured spots or dull patches. The Contractor shall submit details of the measures that they will take to ensure a uniform bright overall finish taking the possible fluctuations in the carbon content of the steel used for production of the masts into consideration. Furthermore the Contractor shall submit SABS approved certificates that all galvanising complies with SANS 121:2000/ISO 1461:1999.

15.2.3 If masts made of loose sections which slide into each other are offered, the Contractor shall provide full details of the design features which prevent the masts from separating when hit by a vehicle or when subjected to severe wind gusts.

15.2.4 Masts manufactured in sections shall be joined together on Site by means of Site slip joints. The overlapping distance of two sections shall be more than 1,5 times the diameter of the mast at the joint. The Contractor shall also state the length of the mast sections.

15.2.5 The above sections may be constructed from sub-sections, which shall be continuously welded with an overlapping distance of 50 mm minimum. No welding shall be allowed on Site without the written permission of SANRAL.

15.2.6 The masts shall be tapered and shall preferably be polygonal in shape. The minimum quality of the steel used shall be BS EN 10113-1:1993 Gr 43 A with a minimum wall thickness of 4 mm.

15.2.7 The masts shall be designed to withstand a wind velocity of at least 150 km/h, measured at a height of 10 m above ground level, with the luminaires mounted. The above wind forces shall not cause any permanent deflection of the masts.

15.2.8 The masts shall furthermore be designed to deflect less than 0,04 times the height of the mast (measured from the baseplate to the luminaire mounting position) at a wind velocity of 100 km/h. A competent professional structural engineer appointed by the Contractor shall certify in writing that the pole design and materials used have the required structural strength for the intended use at the intended Site.

15.2.9 The mast shall have a factor of safety of at least 2,5.

15.2.10 Masts shall also be designed to limit deflection from the vertical to less than 1° due to uneven expansion from heat generated by the sun.

15.2.11 Concrete bases for masts shall be designed by competent professional structural engineers, appointed by the Contractor, who shall take mast and luminaire load, tipping moment due to wind force as well as geotechnical ground conditions into consideration. The concrete bases shall be allowed to cure for 21 days before the masts are mounted.

15.2.12 Mast shall be bolted to a concrete base with hot dip galvanised foundation bolts in the form of a bolt cage cast into the concrete. Each foundation bolt shall be equipped with three nuts and two flat washers. The base shall rest on the lower nuts and washers (which shall be used for levelling) and the middle nuts and top washers shall keep the mast in position. The top nuts shall be locking nuts. The foundation bolts and templates for correct positioning shall be supplied with the masts, or sooner if so required by the construction programme.

15.2.13 Looping in and out of cables shall be via non-ferrous slow bend ducts of minimum diameter of 100 mm cast into the concrete foundations.

15.2.14 Cross arms, a suitable framework, brackets, etc., shall be fitted to the top of the mast for the mounting of the luminaires. These mounting brackets, cross arms, brackets or luminaire mounting rings shall be compatible with the luminaires specified herein or in SANRAL's Requirements. All Equipment shall be bolted down with at least 2 bolts per item.

15.2.15 Base plates shall be designed for the loading of the masts, etc., with holes for the passage of foundation bolts. Gussets shall be incorporated to disperse the high stress concentrations between the bottom of the masts and the base plates. The base plates shall be welded to the bases of the masts.

15.2.16 Sufficient space for mounting of the polycarbonate distribution box accommodating the electrical equipment such as circuit breakers, a multi-pin plug, a 16 A industrial type switched socket outlet and a gland plate for the termination of cables, shall be provided in the base of the mast. A vandal proof door locket with an M10 steel stud welded to the mast and protruding through a 12 mm hole in the access door, threaded to accept a 7-sided brass nut, shall be supplied. The nuts and five unused 7-sided brass nuts shall be supplied. The nuts and five unused 7-sided socket-type operating tools shall be provided to SANRAL at handover at the termination or Contract Completion Date.

15.2.17 The door as well as the top of the mast shall be equipped with vermin-proof ventilation openings to ensure sufficient ventilation. The bottom section of the door gasket shall be preferably adapted to form the lower ventilation opening.

15.2.18 The ventilation openings shall be designed to limit the humidity and temperature inside the masts to acceptable values for the equipment to be installed inside the masts. The openings shall be weatherproof. The doorframe shall form a drip tray over the door openings. The Contractor shall submit full details of the vermin proofing of the masts.

15.2.19 The mast shall be provided with all the necessary brackets to support the specified cabling internally. Brackets shall be welded all the way up the mast at intervals not exceeding 1,5 m for retaining of power cables. This clause shall not apply to trailing type masts.

15.2.20 The Contractor shall be entirely responsible for the design of the masts and bolt cages. However, the Contractor shall submit to SANRAL the full calculations for the design as well as the methods employed for reducing the wind-induced oscillations for scrutiny. The calculations shall also show the forces that will act on the concrete foundations.

15.2.21 The Contractor shall submit a full set of dimensioned drawings of the mast structure, concrete base, bolt cage, baseplate connection, door opening, strengthening around the door opening and luminaire mounting details. These drawings shall be signed by a competent registered structural engineer appointed by the Contractor.

15.2.22 The hinges and locking pins of hinged masts shall be designed to prevent the mast from collapsing or portions breaking off (luminaires included) forming secondary projectiles when hit by a dynamic mass of 2 000 kg at 15 m/s, 1 meter above the baseplate.

15.2.23 Unless otherwise specified herein or in SANRAL's Requirements or indicated on the drawings, the tops of all foundations shall be 300 mm above the final ground level and they shall be sloped to allow proper drainage. All surfaces shall be smooth with all edges neatly bevelled.

15.2.24 The Contractor shall be required to submit test certificates of all concrete cast in foundations to prove compliance to designed values. If so requested by SANRAL, additional test cubes shall be sent to an independent testing authority for strength tests. All concrete and testing thereof shall comply with the requirements of SANS 1200G.

15.3 OPENINGS

15.3.1 Cable entry shall be via slow bend cable duct pipes (non-ferrous) protruding through the baseplate at least 150 mm above the top of the concrete foundation.

15.3.2 An access door facing in a direction parallel to the roadway shall be provided, the bottom of which shall be approximately 700 mm above the baseplate. The width of the openings shall be approximately 0,5 times the cross-sectional diameter of the mast at the door level and the height of the opening shall be approximately 750 mm.

15.3.3 The opening perimeter shall be reinforced to restore the section modulus of the mast shaft and shall have a curved top and bottom to prevent stress concentrations and buckling.

15.3.4 The access door shall be at least 3 mm thick and shall render the mast tamperproof when in the closed position. A water resistant/weatherproof seal shall be provided in the opening.

15.4 EQUIPMENT

15.4.1 Each mast shall be fitted with a weatherproof polycarbonate distribution box. The distribution board shall be equipped as required by the luminaire installation.

15.4.2 If fuses are specified, the mast shall be fitted with one black "GEC RED SPOT" HRC fuse base and fuse carrier and HRC fuse link in accordance with SABS ARP 035, as amended, for each luminaire plus one white base and carrier fitted with a solid copper link rated at 20A for a neutral link.

15.4.3 A 1 000 mm long 16 mm² stranded copper conductor tail shall be exothermally welded to the mounting frame of the equipment as the earthing point. The luminaire earth wires, cable earth wires, cable armouring and lighting protection earths shall be crimped to the end of this tail in a common crimping ferrule. The equipment mounting frame shall also be exothermally bonded to the mast body with an equally sized stranded copper jumper.

15.4.4 The wiring to the luminaires shall be in 2,5 mm² minimum standard PVC insulated multi-core cable.

15.4.5 For masts higher than 20 m, a lightning-conductor spike of a minimum cross sectional area of 70 mm² shall be fitted on top of the mast. The length of the spike shall be determined in accordance with SANS 03-1985. A bare 70 mm² braided copper conductor shall be installed across the hinge in the case of a hinged mast. The braid shall be bonded with Cadweld joints.

15.4.6 Where luminaires are used in clusters and where they are not aesthetically pleasing or damaged by perching birds, a suitable and approved reinforced glass fibre canopy for aesthetical and functional weather guarding of the luminaires shall be fitted to the top of the mast. Wind, hail and ultra-violet radiation from the sun shall have no detrimental effect on the canopy.

15.4.7 All exposed cables shall be strapped to the cross arms or luminaire rings by means of stainless steel straps.

15.5 RAISING AND LOWERING OF LUMINAIRES

15.5.1 Mid-Hinged or Scissor Masts

[Note: Hinged masts are not recommended for use in areas where high winds are usually experienced.]

15.5.1.1 The lower half of the mast shall be divided into two fully enclosed half sections, which shall form a prolonged section in the operating position with no unsightly steps or protrusions.

15.5.1.2 The pivot shall be located approximately at the mid-point of the mast and shall consist of two full-length stainless steel ducts and not a shaft and hinge plates. Provision shall be made to prevent damage to the trailing cable during raising and lowering operations.

15.5.1.3 The mast shall be capable of withstanding the specified wind forces in the hinged or partly hinged position. The Contractor shall indicate the maximum deflection of the mast due to the weight of the luminaires and counter weights in the half lowered position, i.e. with the hinging part horizontal. Mast design shall be checked and certified by a competent professional structural engineer appointed by the Contractor that the design and materials used have the required structural strength for the intended use at the intended Site.

15.5.1.4 Raising and lowering shall be done with a lightweight but robust manually operated portable winch. The winch unit shall be attached to the base of the mast and the winch cable shall be secured to the pivoting section of the mast.

15.5.1.5 The winch shall be easily coupled to and uncoupled from the mast. The use of more than one locking device for this purpose is unacceptable. Raising or lowering of the mast by one person shall not take longer than 5 minutes.

15.5.1.6 A carrying handle for ease of Site use shall be incorporated with the winch.

15.5.1.7 A spring loaded gravity ratchet shall ensure that the moving parts will stop in whatever position it is in when the operating handle is released during the raising or lowering operation. A lever, which must be depressed with a constant force to allow operation of the winch handle, shall be incorporated in the winch mechanism.

15.5.1.8 The mast shall hinge in a direction parallel to the roadway. The hinged section shall be counterbalanced for the weight of the luminaires fitted to the top of the mast. All luminaires shall be easily accessible from ground level with the mast in the lowered position.

15.5.1.9 It shall be possible to test the luminaires in the lowered position without any changes to the wiring.

15.5.1.10 The distribution board shall be accessible with the mast in the lowered position.

15.5.1.11 A special locking device (lockable with a padlock) shall prohibit unauthorized lowering of the mast. This locking device shall be robust and capable of withstanding all possible forces that might act onto the mast. The integrity of the locking device shall be maintained if the mast is hit by a vehicle. All padlocks shall use the same key.

15.5.1.12 The Contractor may offer masts that will be lowered without the help of a winch, in which case all relevant aspects regarding the safety of the raising and lowering operation shall be clearly outlined.

15.5.1.13 The lantern carriage and cross arms shall be firmly mounted to the top of the mast. This mounting shall be by means of welding or a stainless steel bolt and nut passing through the mast and capping unit.

15.5.2 Trailing Cable Masts

15.5.2.1 Where specified, masts shall be fitted with raising and lowering gear to facilitate maintenance to luminaires from ground level.

15.5.2.2 A luminaire mounting ring designed to suit the type and number of luminaires to be used shall be incorporated in the raising and lowering gear.

15.5.2.3 Special care shall be taken to ensure exact and positive docking of the luminaire ring into the headgear. The luminaire ring shall dock in the correct position to ensure that the aiming angles do not change due to the lowering and raising of the luminaires.

15.5.2.4 The luminaire ring shall be manufactured in two halves and shall be bolted together on Site using stainless steel bolts and nuts in order to facilitate removal from the mast.

15.5.2.5 The headgear shall be designed to fit the specified mast and to carry the specified luminaires attached to the luminaire ring. It shall be weatherproof.

15.5.2.6 Where applicable, all parts of the raising and lowering gear shall be hot diphot dip galvanised to SANS 121:2000/ISO 1461:1999.

15.5.2.7 Special care shall be taken to separate the electrical trailing cable from the steel wire ropes used for lowering and raising the luminaire ring. It shall not be possible to lower the luminaires unless the electrical trailing cable has been unplugged from the distribution board and a suitable extension cable has been plugged in. The Contractor shall submit full details of the above interlocking requirement to SANRAL. Alternatively, the trailing cable shall be of sufficient length to facilitate lowering of the luminaires without disconnection of the cable. The mechanism shall be designed such that the cable shall not jam during raising and lowering operations nor shall excessive heat be generated by the cable if stowed in a coil during normal operation.

15.5.2.8 The trailing cable shall at the one end be terminated in a junction box mounted on the luminaire ring using ‘KLIPPON” type “RSF 1” terminals. The cable shall be clamped below the crutch to prevent mechanical stresses being applied to the terminals. The trailing cable shall not be load bearing and shall be connected to the electrical distribution board via a multi-pin plug and socket arrangement.

15.5.2.9 The steel wire ropes shall be fixed to the luminaire ring by means of stainless steel bolts and nuts. It shall be possible to detach the luminaire ring, and hoist a special maintenance cage for inspection of the headgear. The Contractor shall submit full details of a maintenance cage with emphasis on the safety of maintenance personnel.

15.5.2.10 The luminaires shall be lowered by means of a self-sustained type of winch designed to carry the specified load. When in the fully lowered position, the luminaires shall be at least 1 m from ground level.

15.5.2.11 The winch shall be designed to be fixed onto the mast on straps welded onto the mast.

15.5.2.12 The winch shall consist of the following:

(a) A rope drum and easily accessible rope anchorage.

(b) A gear ratio of at least 30:1 for ease of operation by hand.

(c) An appropriate length of stainless steel wire rope, which shall be fitted. With the luminaire ring in the fully lowered position, at least 4 turns of the wire rope shall remain on the winch drum.

(d) Lubrication points, all of which shall be easily accessible and to the front of the winch.

(e) A special locking device to prevent lowering of the luminaire ring without the use of the winch.

(f) A torque limiting handle for operation by hand; or

(g) A power tool for ease of lowering and raising. The power tool shall operate from a 16 A, 220 V single phase, 50 Hz switched socket outlet built into the mast distribution board.

(h) An automatic locking device on the driving spindle that locks the spindle when the winch is not being operated.

15.5.2.13 All winch ropes shall be terminated in such a manner that distortion or twisting of the ropes is prevented.

15.5.2.14 Winches may be of the single or double drum type, depending on the height of the mast and weight of the specified luminaires. However, a single drum winch is not acceptable for use with a maintenance cage, and if a single drum winch is offered for luminaire winching, a separate double drum winch shall be allowed for in the tendered rate for the maintenance cage.

15.5.2.15 A maintenance cage will be required for all masts higher than 20 m.

15.5.2.16 Although this specification does not call for a portable winch, preference shall be given to an externally mounted, portable winch.

15.5.2.17 The winch assembly shall not hamper access to the electrical distribution board.

15.5.2.18 The winch ropes shall only be detachable with the luminaires in the fully raised position. The winch drum shall be designed to prevent the ropes from slackening on the drum when detached from the lowering mechanism. This requirement shall only be applicable to portable winches.

15.5.2.19 It shall be possible to switch power to all the luminaires when in the lowered position for testing purposes. An extension trailing cable may be used for this purpose.

15.5.2.20 Hoisting ropes shall be inspected annually and the results of the inspections noted and countersigned in an inspection logbook.

15.6 INSTALLATION

15.6.1 The Contractor shall be responsible to determine the exact position of each mast. If no spacing intervals between masts are indicated on drawings, masts shall be evenly spaced along the length of the route or section.

15.6.2 All masts in straight lines shall be accurately lined up.

15.6.3 Masts shall be bolted onto reinforced concrete foundations. These foundations shall be designed to withstand all forces likely to act on them. Unless otherwise specified herein or in SANRAL's Requirements, the concrete foundations shall be designed to withstand the transferred impact forces of a dynamic mass of 2 000 kg hitting the mast at 15 m/s, 1 m above the baseplate. For design purposes the equivalent static forces to act on the foundations at the baseplate can be taken as follows:

(a) Bending moment: 70 kNm

(b) Shearing force: 50 kN

15.6.4 A geotechnical report describing the general soil conditions that may be encountered shall be provided by the Contractor. The Contractor shall drill one test hole at each actual mast position. This hole shall be logged and a maximum allowable bearing pressure for the mast foundation shall be specified by the professional geotechnical Engineer appointed by the Contractor, and the final mast footing design (to be signed by a professional Engineer) shall be based on this. Both the soil investigation and the final mast footing design shall be submitted to SANRAL for scrutiny.

15.6.5 Masts shall be installed vertically. The Contractor shall re-align all masts should settling occur.

15.6.6 After erection and levelling of the masts, the space between the top of the concrete foundation and the underside of the baseplate shall be filled with a suitable grout (similar to SICA). Caution shall be taken with the installation of the grout not to obstruct the cable entry pipes. Provision shall be made in the grout for a vermin proof drainage hole.

15.7 LIGHT MASTS DATA AND COMPLIANCE SHEET

TABLE 15-1: LIGHT MASTS DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
15.7.1	SANS 121:2000/ISO 1461:1999	Hot dip galvanized coatings in fabricated iron steel articles – Specifications and test methods.				
15.7.2	BS EN 10113-1:1993	Hot-rolled products in weldable fine grain structural steels. General delivery conditions.				
15.7.3	BS 7668:1994, BS EN 10029:1991, BS EN 10113-1:1993)	Specification for weldable structural steels.				
15.7.4	ARP 035:2007 (ARP 035)	Guidelines for the installation and maintenance of street lighting.				
15.7.5	SANS 10225:1991 (SABS 0225)	The design and construction of lighting masts.				
15.7.6	SANS 10313:2008 (SABS 0313)	Protection against lightning – Physical damage to structures and life hazard.				
LIGHTING MAST						
	CLAUSE					
15.7.7	15.2	Construction				
15.7.8	15.3	Openings				
15.7.9	15.4	Equipment				
15.7.10	15.5	Raising and Lowering of luminaires				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
15.7.11	15.5.1	Mid-Hinged or Scissor Masts				
15.7.12	15.5.2	Trailing Cable Masts				
15.7.13	15.6	Installation				

16. UNINTERRUPTABLE POWER SUPPLY SYSTEMS UP TO 50KVA

16.1 SCOPE

16.1.1 This specification provides the requirements for free-standing ups systems up to 50 kVA as typically employed in the UPS rooms.

16.2 GENERAL FREE-STANDING

16.2.1 This section applies to the supply and installation of suitably rated UPS units, complete with battery cabinets, batteries and interconnecting cables.

16.2.2 The Contractor shall indicate the arrangement of the equipment within the accommodation provided.

16.2.3 As space in the equipment rooms is usually limited, preference shall be given to systems where the cabinet footprint can be minimized by stacking the UPS section on top of the battery cabinet.

16.2.4 UPS backup batteries shall be supplied with formal certification of a 10-year design life.

16.2.5 The UPS shall be selected to limit harmonics and shall be compatible with the standby generator.

16.2.6 The UPS shall comply with the standards as listed under the UPS data and compliance sheet.

16.2.7 Suitable fuses shall be installed in the DC circuit between the battery bank and the UPS unit. The fuses shall be housed in an enclosure.

16.3 TECHNICAL REQUIREMENTS

16.3.1 Each online UPS shall comply with the following:

16.3.1.1	Make:	Double conversion Similar or approved equal to Meissner Powerwave 9355, 9390 or Eaton 9355 (previously MGE).
16.3.1.2	Power factor	High 0.9 output rated server and computer loads
16.3.1.3	Rectifier:	Minimum twelve pulse
16.3.1.4	Low current distortion:	Less than 12%
16.3.1.5	Input Voltage:	323 to 444 V 3-phase, 4 wire
16.3.1.6	Input Frequency:	47 Hz to 63 Hz

16.3.1.7	Output Voltage:	400 V, 3 phase, 4 wire
16.3.1.8	Efficiency:	92% full load
16.3.1.9	Output Voltage Dynamic Regulation:	± 4%
16.3.1.10	Output Voltage Steady State Regulation:	± 1%
16.3.1.11	Voltage Recovery Time within Stable Regulation Limits:	3 ms
16.3.1.12	Overload:	150 % for 10 s, 110 % for 10 min.
16.3.1.13	Battery Backup Time:	Minimum 30 minutes on 100 % load
16.3.1.14	Metering:	Output voltage, frequency and current, all phases.

16.3.2 The following events and alarm functionally shall be available from the UPS controller:

16.3.2.1	UPS on line	Event (Green)
16.3.2.2	Inverter off, Load on reserve	Critical alarm (Red)
16.3.2.3	Battery voltage out of limits	Critical alarm (Red)
16.3.2.4	Battery voltage low	Alarm (Amber)
16.3.2.5	Inverter overload	Critical alarm (Red)
16.3.2.6	Inverter over temperature	Alarm (Amber)
16.3.2.7	Rectifier off	Critical alarm (Red)
16.3.2.8	Rectifier overcurrent	Alarm (Amber)
16.3.2.9	Rectifier over temperature	Alarm (Amber)
16.3.2.10	Reserve out of limits	Alarm (Amber)
16.3.2.11	Static switch lockout	Event (Blue)
16.3.2.12	Manual bypass on	Alarm (Amber)
16.3.2.13	External over temperature	Alarm (Amber)
16.3.2.14	Battery warning	Alarm (Amber)
16.3.2.15	Battery failure	Critical alarm (Red)

16.3.3 The following general functionality and data communication shall also be provided:

16.3.3.1	General:	The UPS shall be supplied with a standard data communication protocol i.e. Ethernet, RS232, RS485, etc. The data communication will be used to link the UPS to a SCADA system through an RTU, PLC, switch or any other communication device. Remote control shall also be available for maintenance and testing purposes.
16.3.3.2	Heat loadings:	The heat loading and the design ambient limitations for the UPS shall be supplied with the technical documentation for evaluation.
16.3.3.3	Batteries:	Batteries developed for static standby applications with a 10 year design life batteries.
16.3.3.4	Audible Alarm:	Required with all visual alarms
16.3.3.5	Cabinet Finish:	Epoxy powder coated, colour to be advised.

16.4 NATURE OF UPS LOAD

The UPS shall be suitably rated to:

16.4.1 Support the specified continuous load values;

16.4.2 Support inrush demands under 1 step full load acceptance conditions; and

16.4.3 Remain within specified parameters under these conditions.

16.5 INSTALLATION

16.5.1 The Contractor shall take special note of the stairs and door restrictions in the UPS room.

16.5.2 General

16.5.2.1 The Contractor shall submit full technical details of the UPS to SANRAL.

16.5.2.2 The information shall include physical dimensions.

16.5.2.3 The UPS shall have a full set of schematics, which are permanently located in a folder on the inside face of the Inverter panel.

16.5.2.4 A wall-mounted cupboard shall be provided and installed to contain the spares, maintenance manual and log sheets for the UPS units.

16.5.2.5 The Contractor shall allow for a SCADA or similar approved computer based software package for local and remote monitoring and management of the UPS system.

16.5.2.6 If more than 2 (two) UPS units are installed the UPS power supply installation shall be such that alternative adjacent lanes are powered from a different lane in one direction. This will allow the Contractor to operate 50% of the lanes should one UPS fail.

16.5.2.7 SANRAL or their representative shall be allowed remote access to the SCADA or similar approved computer based system.

16.5.3 Inspections, Tests, Commissioning and Handing Over.

16.5.3.1 The UPS and battery unit will be inspected by the Contractor at the manufacturer's premises before delivery takes place.

16.5.3.2 The manufacturer shall carry out the following tests, in order that the Contractor may witness compliance of the unit to specified requirements. The manufacturer shall submit a proposed detail test procedure at least two weeks before testing, to the Contractor and SANRAL.

16.5.3.3 Performance tests

(a) Input

(b) Output

(c) Output overload

(d) Regulation

(e) Efficiency

(f) Transfer time

(g) Battery load test

(h) 1 step full load acceptance

(i) Full load discharge for 30 minutes

(j) Harmonic transfer characteristics

16.5.3.4 Simulation test

(a) Each alarm condition to be simulated

(b) Each visual alarm to be tested

(c) Each audible alarm to be tested

(d) Verify all events and alarms on the SCADA or other approved software.

16.5.3.5 The Contractor shall submit a copy of the UPS test results to SANRAL or their representative.

16.5.3.6 All necessary equipment and test gear shall be available during these tests.

16.5.3.7 The Contractor shall provide and prepare comprehensive technical data catalogues, operating instructions, maintenance procedures and fault-finding instructions for each item supplied.

16.5.3.8 A full and complete Factory Acceptance Test (FAT) shall be carriedout at the manufacturer's premises. A full and complete Site Accetpance Test (SAT) shall be carried out during the Commissioning phase.

16.5.3.9 One set of A4 sized comprehensive operation and maintenance manuals shall be supplied in both hard and soft copy (PDF file format), to enable SANRAL to maintain and adjust the system.

16.5.3.10 These manuals shall be submitted to SANRAL for approval prior to final Commissioning. The contract will not be regarded as complete until all requirements in this regard have been met.

16.6 MAINTENANCE CONTRACT

16.6.1 The Contractor shall obtain from the UPS manufacturer the following information:

(a) Service interval details.

(b) Spares holding.

16.7 UPS INFORMATION TO BE PROVIDED BY THE CONTRACTOR

16.7.1 UPS information

TABLE 16-1: UPS INFORMATION

ITEM	DESCRIPTION OF ENGINE
1.	Manufacturers name:
2.	Country of origin and year of manufacture:
3.	Manufacturers type No.:
4.	True on-line UPS (Yes/No)?
5.	Double conversion UPS (Yes/No)?
6.	Isolation transformer (Yes/No)?
7.	IGBT technology 12 pulse rectifiers used (Yes/No)?
8.	Input voltage:
9.	Input frequency:

ITEM	DESCRIPTION OF ENGINE
10.	Output voltage:
11.	Efficiency:
12.	Output voltage dynamic regulation:
13.	Output voltage steady state regulation:
14.	Voltage recovery time within stable regulation limits:
15.	Overload:
16.	Battery backup time:
17.	Metering:
18.	Visual alarm indication:
19.	Available data communication protocol i.e. Ethernet, RS485, RS232, Modbus?
20.	Compatible with SCADA?
21.	Overall dimensions of UPS in mm L =……………… W =……………… H =………………
22.	Overall dimensions of battery cabinet in mm L =……………… W =……………… H =………………
23.	UPS available alarm 1
24.	UPS available alarm 2
25.	UPS available alarm 3
26.	UPS available alarm 4
27.	UPS available alarm 5
28.	UPS available alarm 6
29.	UPS available alarm 7
30.	UPS available alarm 8
31.	UPS available alarm 9
32.	UPS available alarm 10
33.	UPS available alarm 11
34.	UPS available alarm 12
35.	UPS available alarm 13
36.	UPS available alarm 14

ITEM	DESCRIPTION OF ENGINE
37.	UPS available alarm 15
38.	UPS available alarm 16
39.	Battery make and model:
40.	General alarm and information ....
41.	UPS overall mass .... kg
42.	Battery cabinet overall mass .... kg

16.7.2 Deviations information

TABLE 16-2: DEVIATION FROM THE SPECIFICATION

DEVIATION FROM THE SPECIFICATION (State Briefly)

16.7.3 Guarantee information

TABLE 16-3: GUARANTEE

GUARANTEE
(a) Guarantee in months……...……………………………………………………

(b)	State conditions of guarantee

16.7.4 Delivery & completion time

TABLE 16-4: DELIVERY PERIOD AND INSTALLATION

DELIVERY PERIOD AND INSTALLATION		
(a)	State no. of weeks required from date of order to complete set assembly, full factory testing and delivery to site of all equipment	weeks
(b)	Time required for complete installation and Commissioning test on site	weeks
TOTAL TIME REQUIRED FOR COMPLETION (a + b)		**weeks**

16.7.5 Spare parts and maintenance facilities information

TABLE 16-5: SPARE PARTS AND MAINTENANCE FACILITIES

SPARE PARTS AND MAINTENANCE FACILITIES	
(a)	Approximate value of spares carried in stock for this particular diesel engine and alternator
(b)	Where are these spares held in stock?
(c)	What facilities exist for the servicing of equipment offered?
(d)	Where are these facilities available?
(e)	Who will be attending to the maintenance during the defects liability period?
(f)	Who will be attending to any breakdowns during the defects liability period?

16.8 GENERAL PRO-FORMA INFORMATION SERVICE/INSPECTION REPORT

IDENTIFICATION	ENVIRONMENT	RECOMMENDATION/CONCLUSIONS
Date of Inspection Site Number of UPS unit	Room temperature State General	

UPS 1		**UPS 2**		**UPS 3**	
Rating		Rating		Rating	
Type		Type		Type	
Serial Number		Serial Number		Serial Number	
Date of Manufacture		Date of Manufacture		Date of Manufacture	
Input Rating		Input Rating		Input Rating	
Output Rating		Output Rating		Output Rating	

Battery 1		**Battery 2**		**Battery 3**	
Rating		Rating		Rating	
Type		Type		Type	
Date of Manufacture		Date of Manufacture		Date of Manufacture	
Number in series		Number in series		Number in series	
Number in parallel		Number in parallel		Number in parallel	

Readings	**R**	**Y**	**B**	**Readings**	**R**	**Y**	**B**	**Readings**	**R**	**Y**	**B**
UPS Output Voltage				UPS Output Voltage				UPS Output Voltage			
UPS Output Current				UPS Output Current				UPS Output Current			

Battery String Voltage		Battery String Voltage		Battery String Voltage	
Block Voltages		Block Voltages		Block Voltages	

30 minutes load test with battery readings at 1-minute intervals.								

The UPS system available reports shall be attached with this report i.e. any alarms recorded and events, voltage, current readings stored by the UPS. The above report shall be electronically available on the SCADA system. The SCADA user shall be able to print and update and save the report after an inspection was done. The Original signed (by specialist contractor) report shall be scanned and saved on the SCADA system.

16.9 UNINTERRUPTABLE POWER SUPPLY SYSTEMS UP TO 50KVA DATA AND COMPLIANCE SHEET

TABLE 16-6: UNINTERRUPTABLE POWER SUPPLY SYSTEMS UP TO 50KVA DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
16.9.1	IEC 61000-3-4	Standard- Limits of input current harmonics (equipment with Input Current >16A/Phase).				
16.9.2	IEC 61000-4-11	Standard- Voltage dips, short interruptions and voltage variations immunity tests (equipment with Input Current <= 16A/Phase).				
16.9.3	IEC 61000-4-34	Standard- Voltage dips, short interruptions and voltage variations immunity tests (equipment with Input Current > 16A/Phase)				
16.9.4	IEC 60146-5	Standard - Switches for Uninterruptible Power Systems				
16.9.5	IEC 60950 (former IEC 950)	Standard –safety of Information Technology equipment (Applicable also to UPS systems).				
16.9.6	IEC 62040-1-1	Standard -General and safety requirements for UPS systems used in restricted access locations				
16.9.7	IEC 62040-1-2	Standard -General and safety requirements for UPS systems used in operator access areas				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
16.9.8	IEC 62040-2	Standard- UPS Electromagnetic compatibility (EMC) requirements				
19.6.9	SANS/IEC 62040-3	Standard- UPS performance requirements and test methods				
16.9.10	SANS/IEC 61744:2006	Calibration of fibre optic chromatic dispersion test sets				
16.9.11	SANS 61000-3-2:2009/IEC 61000-3-2:2009 (SABS IEC 61000-3-2)	Electromagnetic compatibility (EMC) Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)				
UPS						
	CLAUSE					
16.9.12	16.3	Technical Requirements				
16.9.13	16.4	Nature of UPS Load				
16.9.14	16.5	Installation				
16.9.15	16.5.1	General				
16.9.16	16.5.2	Inspections, Tests, Commissioning and Handing Over				
16.9.17	16.6	Maintenance Contract				

17. AUTOMATIC DIESEL STANDBY GENERATORS UP TO 250 KVA

17.1 SCOPE

17.1.1 This specification covers the requirements for the provision of metal clad silenced containerised diesel generators or the installation of a generator within a purposed built room (Generator room).

17.2 ENCLOSURE

17.2.1 The generating set shall be of the containerised type with a duplex base and shall be placed on a concrete plinth in the designated location. The final position of the container shall be determined on Site. The supply and installation of the concrete plinth and the interconnecting ducts to the electrical distribution manhole shall also be the responsibility of the Contractor. Due to the highly corrosive condition on Site, the generator enclosure shall be clad externally with pre-painted 3CR12 sheeting and supporting frame. The generator supporting base may be manufactured from mild steel (3CR12 for coastal applications) provided:

17.2.1.1 The complete frame is hot dip galvanised prior to assembly; and

17.2.1.2 The frame is totally enclosed in the 3CR12 enclosure to prevent exposure to the elements.

17.2.2 The enclosure shall be weatherproof with a single pitch roof. The completed container shall have an earth point, which is earthed to general earth. All components of the container shall be bonded to ensure that all parts of the container are at equipotential.

17.2.3 The container shall be equipped with internal lighting, such that maintenance or repairs may be carried out after dark. The lighting level within the container shall not be less than 360 lux. At least three light fittings shall be installed in the container, one directly above the control panel and one on either side of the diesel engine. The light fittings in the container shall be designed to operate at a voltage equal to that of the generator battery supply and shall be protected by a suitable protection device. Limit switches shall be fitted inside the container in such a manner that the lights are switched on when a canopy door is opened and off when all canopy doors are closed. The fittings shall be of the maintained output type. Full details of the proposed container construction and finish, as well as the electrical services and equipment placement shall be submitted to SANRAL for approval prior to manufacturing.

17.3 GENERATOR ROOM

17.3.1 The generator shall be contained within a purpose-built generator room with the following minimum but not limited to requirements:

17.3.1.1 The generator room shall have a minimum of 1.2 m working space around the generator.

17.3.1.2 Sufficient ventilation shall be provided for the generator.

17.3.1.3 Space shall be provided for the sound attenuator.

17.3.1.4 Cable trenches or ladders shall be provided where applicable to have a safe and neat installation.

17.4 GENERATOR ENGINE

17.4.1 The engine must comply with the requirements laid down in SANS ISO 8528 and must be of a solid injection, compression ignition type, running at a speed not exceeding 1500 rpm. The engine must be amply rated for the required electrical output of the set, when running under the site conditions.

17.4.2 The engine shall be capable of delivering an output of 110% of specified output for one hour in any 12-hour period of continuous running, in accordance with SANS ISO 8528.

17.4.3 Curves furnished by the engine maker, showing the output of the engine offered against the speed, for both intermittent and continuous operation, as well as fuel consumption figures, must be submitted with the tender.

17.4.4 The Contractor shall use John Deere, Cummins or Perkins diesel engines or similar approved. The Contractor shall request approval from SANRAL or the Independent Engineer to deviate from the engine make as listed.

17.5 ALTERNATOR REQUIREMENTS

17.5.1 The emergency power generating set shall be capable of delivering the specified output power at 0,85 power factor. This rating shall be attainable at its output terminals, at the specified altitude, and in the configuration specified. The set shall be mounted on a vibration attenuated, duplex base and otherwise comply with this specification.

17.5.2 The alternator shall be of the self excited brushless type, with enclosed drip-proof housing, and must be capable of supplying the specified output continuously with a temperature rise not exceeding class H as laid down in BS 5000 for rotor and stator windings. The alternator shall be capable of delivering an output of 110% of the specified output, for 1-hour in any 12-hour period of consecutive running. Windings shall be fully impregnated for tropical climate and must have an oil resistant finishing varnish.

17.5.3 Alternator Protection: On the switchboard a multi-pole circuit breaker with instantaneous short circuit trips and thermal overload trips must be installed for protection of the alternator against short circuit and overload.

17.5.4 Regulation: The steady state voltage regulation must not exceed ± 1% of nominal voltage specified between no load and full load with the power factor between unity and 0.8 lagging and within the driving speed variation of 4.5%.

17.5.5 Performance: Following the application of 70% of full load, or the initial one-step load capability of the engine, the transient voltage shall not exceed 15% and will recover to the nominal voltage within 500 ms.

17.5.6 Output Voltage: The set shall have a site output as set out in the detail specification

17.6 GENERATOR BASE FRAME DESIGN

17.6.1 The generator base as well as the floor slab of the generator room shall be designed to attenuate the transfer of vibrations from the generator to the electronic room and adjacent building.

17.6.2 The set shall be mounted on a vibration attenuated, duplex base as specified and otherwise comply with the standard specification.

17.6.3 Vibration attenuation shall be sufficient to enable undisturbed working in the electronic room while the generator is in operation.

17.6.4 The engine and the alternator of the set shall be built together on a common base frame, of simplex/duplex type. For set mounted panels a duplex frame will be preferred, consisting of a heavy duty inner frame on which the alternator and engine are secured with an outer floor standing frame between which purpose-made anti-vibration mountings in “V” formation are mounted.

17.6.5 The panel shall be mounted on the floor standing frame. The simplex type base frame shall consist of a heavy-duty steel frame on which the alternator and engine are secured, fitted with floor standing spring type anti-vibration mountings. The set shall be placed directly on the concrete floor. A drip-tray shall be fitted under the engine. The tray shall be large enough to catch a drip from any part of the engine.

17.7 SYSTEM OPERATION

17.7.1 The changeover from mains (or normal) to emergency power shall take place in the generator changeover panel.

17.7.2 The changeover equipment shall consist of two suitably rated motorised changeover breakers, mechanically and electrically interlocked to prevent the paralleling of the mains and emergency supplies. The sensing and changeover equipment shall all be rated at 10kA.

17.7.3 These breakers shall change the supply mains to emergency power and vice versa in the following manner:

17.7.3.1 Whilst the main supply is healthy, the mains breaker shall be closed.

17.7.3.2 Failure of a phase or failure of the total supply to the normal power distribution board shall be detected on the outgoing side of the mains bus bar. The detection circuit shall initiate the starting cycle of the generator set, after an adjustable 0 to 6 second delay. If the mains supply is restored within the set period, the starting cycle shall be aborted and the control system shall reset to the standby mode.

17.7.3.3 As soon as the emergency supply from the generator set becomes available, a timing circuit shall be initiated to provide an adjustable 0 to 6 seconds delay (preferably 3 seconds) between the opening of the mains breaker and the closing of the emergency breaker.

Note: *The mains breaker shall remain closed during generator start-up and shall not open unless the emergency supply is available and the mains supply is still out.*

17.7.3.4 As soon as the mains supply is restored, a mains return timing circuit shall be initiated to hold the mains breaker open and the emergency breaker closed, for an adjustable period of 0 to 10 minutes (preferably 10 minutes). This is required to prevent the changeover from emergency to mains taking place if the restoration of the mains supply is only temporary.

17.7.3.5 At the end of this mains return delay, the emergency breaker shall open and the mains breaker shall close. An adjustable delay of 0 to 3 seconds shall be provided between the opening of the emergency and closing of the mains breaker.

17.7.3.6 After successful reverse changeover back to mains supply, the engine shall be run on no-load for a pre-set period. This period shall be controlled by a 0 to 6 minute adjustable timer.

17.7.3.7 At the end of the rundown period, the engine shall be shut down and the control system shall revert to the standby mode.

17.7.3.8 Should a mains failure recur during the rundown period, the rundown cycle shall be aborted and the changeover from mains to emergency shall take place as before.

17.7.4 Four-position selector switches, labelled as follows, shall be fitted on the generator control panel, located at the generator:

17.7.5 GEN AUTO START: This switch shall have 4 positions. In the Auto Start position, the changeover sequence shall operate automatically as described. In the Gen. Locked Out position, the changeover sequence shall not be initiated if a mains fail situation occurs. A remote alarm indication is required if the switch is in the latter position. The remote alarm is to be located in the control room.

17.7.6 SIMULATE MAINS FAIL: This switch shall have 4 positions. In the Simulate position, a mains failure shall be simulated. The changeover sequence shall be initiated if the simulation period exceeds the mains failure delay as described in 17.7.3.2. In the Normal position, the system is set to the normal auto standby mode.

17.7.7 Manual: This switch shall have 4 positions. In the Normal position, the generator can be manually started or stopped via a stop/start pushbutton without changing the condition of the changeover breakers.

17.7.8 Off: This switch shall have 4 positions. In the off position, the generator shall be off and shall not be able to start automatically or manually.

17.8 ELECTRONIC GOVERNOR

17.8.1 An electronic governor, Woodward or Cummins or approved equivalent, must be supplied and installed to ensure fast step response recovery and accurate speed control of the diesel engine under varying load conditions to render the set compatible with UPS input tolerances.

17.8.2 A day tank of 200-litre capacity shall be manufactured, supplied and installed in the generator set container. The fuel tank shall be positioned such that free access to the tank may be afforded. The highest level of fuel in the tank shall never be higher than the lowest level of the generator's injectors.

17.8.3 The fuel tank shall be fitted with an alarm to provide an audible alarm on the generator control panel when the fuel level in the tank drops below 75 litres.

17.8.4 A fuel level indicator shall be mounted on the tank in a position that is visible when operating the fuel pump. A transparent gauge tube indicator may not be used.

17.8.5 A stopcock shall be fitted on the lowest point of the day tank to withdraw fuel samples.

17.8.6 A mechanical fusible link across the diesel engine will provide fuel shut-off in case of fire. The day tank outlet shall be fitted with a 16 mm brass ball valve and 8 kg gravity dead-weight to facilitate the shut-off.

17.9 DAY FUEL TANK

17.9.1 The tank shall be supplied complete with all fittings, pipes and valves and installed according to the latest SANS 10131:2004 and SANS 10089-2 as amended and any other regulation that may be applicable. The installation shall also comply with the local fire regulations and OHS Act 1993 and the Environmental Impact Assessment (EIA) regulations.

17.9.2 A day tank of 180 ℓ capacity shall be manufactured, supplied and installed with the generator. The fuel tank shall be positioned such that free access to the tank may be afforded. The fuel tank shall be fitted with an alarm, to provide an audible alarm on the generator control panel and the control room when the fuel level in the tank drops below 135ℓ.

17.9.3 An electrically operated pump with a suitable length of oil resistant hose must be supplied for filling the fuel tank from 200 ℓ drums should it be required.

17.9.4 The inter-connecting fuel piping shall consist of black steel and connection to vibrating components shall be flexible tubing. A water trap shall be provided in the fuel pipeline between the tank and engine. A drain valve must be fitted to the underside of the fuel tank.

17.9.5 The day tank shall be sealed to prevent spillage should the flow control of the aboveground tank fail and the fuel is cavity fed to the day tank.

17.9.6 The Contractor shall fill the day tank with diesel after the installation of the tank or before the final inspection and testing by the engineer.

17.10 BULK FUEL TANK

17.10.1 The tank shall be supplied complete with all fittings, pipes and valves and installed according to the latest SANS 10131:2004 and SANS 10089-2 as amended and any other regulation that may be applicable. The installation shall also comply with the local fire regulations and OHS Act 1993 and the Environmental Impact Assessment (EIA) regulations.

17.10.2 The tank shall be supplied by Springbok or Tseba tanks. The tank shall be connected to the day tank of the generator.

17.10.3 The supply line shall be a 25 mm ∅ copper steel pipe with the required fittings, valves and safety flow control to prevent fuel spillage, day tank overflow, etc.

17.10.4 All other accessories not mentioned shall be supplied by the Contractor to complete the installation according to the required regulations.

17.10.5 The Contractor shall fill the aboveground tank with diesel after the installation of the tank or before the final inspection and testing by the engineer.

17.10.6 The Contractor shall also supply and install a fuel conditioner with a recalculating pump to reverse the process of fuel deterioration and decontaminates to the Independent engineer's approval.

17.10.7 A bulk fuel tank (manufactured from 3CR12 for coastal applications) of 2 250 ℓ (minimum) capacity shall be manufactured, supplied and installed in a position approved by SANRAL in close proximity to the generator.

17.10.8 The bulk tank shall be adequately enclosed to prevent floatation in the case of rising ground water.

17.10.9 The tank installation shall conform to SANS 10131:2004 as amended.

17.10.10 The tank manhole shall have a minimum diameter of 1 000 mm and the manhole shall be 1 m below ground level. The filler cap shall allow dipstick measure access and the neck connection shall be compatible with fuel delivery truck hose connections.

17.10.11 Fuel lines shall be 22 mm ø copper tubing with galvanised support brackets and galvanised protective unistrut sections between the bulk and day tanks. Underground piping shall be steel to SANS 62-1:2003 with allowance for expansion, wrapped with Denso tape, overlapping 15 mm.

17.10.12 The day tank level switch shall switch the 24 VDC solenoid valve at the day tank.

17.10.13 Note that a total of three level switches are required:

(a) Empty tank engine cut out signal

(b) Low fuel alarm

(c) Switching the inlet solenoid valve.

17.10.14 Level switches shall be REMEX or approved equivalent.

17.10.15 In the case of underground bulk tanks and where gravity lines cannot be considered, fuel transfer pumps supplied by 24 V DC will be installed inside the generator enclosure. These jockey pumps shall be positive displacement vane pumps. The pumps shall be controlled by means of the day tank level switch.

17.10.16 The day tank will be fitted with a 32 mm overflow outlet, piped to the bulk tank with similar size return line.

17.10.17 An insulated 16 mm² earth wire shall be provided to bond the bulk tank to the generator day tank.

17.10.18 The fuel line shall be provided with a high capacity water separator and 5 micron fuel filter with replaceable filter cartridges. The water separator shall be VELCO.

17.10.19 A level (Volume) sensor shall be provided and installed for the fuel tank with a digital output to the SCADA infrastructure.

17.10.20 A dropping weight fusible link actuated fuel cut off valve shall be provided to shut off the fuel supply in the event of fire.

17.11 EXHAUST SYSTEM

17.11.1 The exhaust system of the generator shall be designed to operate below 65 dbA sound level measured 1 m from the exhaust outlet. The section outside of the container shall be manufactured from 316 stainless steel.

17.11.2 The entire section of the exhaust in the container shall be lagged with heat insulating material so that the cold surface temperatures do not operate at more than 60º C above ambient.

17.11.3 To prevent sound reflection and echo between the buildings, the exhaust shall face away from the control building. The exhaust shall be fitted with a drain tap at the lowest point of the exhaust, to allow draining of water from the pipe. The exhaust shall be supported independently of the container, on a structure supplied and installed as part of this contract.

17.12 RADIATOR DUCTS AND FLASHINGS

17.12.1 A suitable radiator outlet louver, complete with flashings, shall be supplied and installed. The Contractor shall supply details of radiator outlet louvers.

17.12.2 Suitable weatherproof louvers shall be supplied and installed to provide the required airflow to the radiator for cooling purposes.

17.12.3 The Contractor shall confirm that the generator set position is acceptable for the generating set requirements.

17.13 GENERATING SET COLOUR

17.13.1 The base frame, tank, diesel engine and alternator shall be provided in the manufacturers' standard colours.

17.13.2 For aesthetic considerations, the generator enclosure shall be painted light stone (SABS C37).

17.14 GENERATOR CONTROL PANEL

17.14.1 Relay-logic circuitry is preferred to PLC-based generator control and protection panels owing to the lower surge and transient susceptibility and field serviceability. PLC based control panels shall only be installed after the approval of SANRAL or the Independent Engineer.

17.14.2 The generator shall be supplied with a standard data communication protocol i.e. Ethernet, LAN, RS232, RS485, etc. The data communication will be used to link the generator to a SCADA system through an RTU or PLC, switch or any other communication device to extract the UPS data and record all alarms, etc. All alarms shall be electronically available. Remote control shall be available for maintenance and testing purposes.

17.14.3 The following events and alarm functionally shall be available from the generator controller:

17.14.3.1	Load on normal supply:	Event (Green)
17.14.3.2	Load on emergency supply:	Alarm (Blue)
17.14.3.3	Mains failure:	Critical Alarm (Red)
17.14.3.4	Engine run down cycle:	Event (Blue)
17.14.3.5	Generator set in standby mode:	Event (Green)
17.14.3.6	Water jacket heater failure:	Alarm (Amber)
17.14.3.7	Low fuel level:	Monitor/Critical alarm (Green/Red)

17.14.3.8	Engine start failure:	Critical alarm (Red)
17.14.3.9	Auto-start disabled:	Critical alarm (Red)
17.14.3.10	High engine temperature:	Critical alarm (Red)
17.14.3.11	Battery charger failure:	Critical alarm (Red)
17.14.3.12	Engine overspeed:	Alarm (Amber)
17.14.3.13	Engine underspeed:	Alarm (Amber)
17.14.3.14	Overvoltage:	Alarm (Amber)
17.14.3.15	Undervoltage:	Alarm (Amber)
17.14.3.16	Battery voltage:	Monitor/alarm (Green/Amber)
17.14.3.17	Water temperature:	Alarm (Amber)
17.14.3.18	Engine speed:	Monitor/alarm (Green/Amber)
17.14.3.19	Oil pressure:	Alarm (Amber)
17.14.3.20	Ampere meter:	Monitor/Alarm (Green/Amber)
17.14.3.21	Voltage meter:	Monitor/Alarm (Green/Amber)
17.14.3.22	Dummy load:	Monitor/Alarm (Green/Amber)

17.14.4 Each of the above events or alarms shall generate a “generator critical” and “generator alarm” and “generator event” on the remote SCADA system as defined under section 18. The “generator critical” and “generator alarm” shall be acknowledged.

17.14.5 Should the generator be fitted with a PLC, the PLC shall control all generator functions and it shall be possible to bypass the PLC for manual start and operation.

17.15 SWITCHBOARD

17.15.1 A switchboard that shall incorporate all equipment necessary for control and protection of the generator set, the automatic changeover and battery charging equipment shall be supplied for the set.

17.15.2 The switchboard shall be a totally enclosed unit and shall consist of steel panels.

17.15.3 The steelwork of the boards shall be thoroughly de-rusted, primed with zinc chromate and finished with two coats of signal red enamel, or baked epoxy powder coating.

17.15.4 Suitably rated terminals shall be provided for all circuits. Where cable lugs are used, they shall be crimped. Screwed terminals shall prevent spreading of the strands.

17.15.5 All wiring shall have each wire fitted with a cable or wire marker of approved type and the numbering of these markers must be shown on a wiring diagram of the switchboard.

17.15.6 The automatic control and protection control equipment shall be mounted on a separate easily replaceable small panel and shall preferably be designed and manufactured in the RSA. The automatic control shall be microprocessor based and shall be programmable, unless otherwise specified. The manufacturer shall guarantee the availability of compatible exchange control units for at least 10 years.

17.15.7 All equipment on the switchboard, such as contactors, isolators, bus bars, etc. shall have ample current carrying capacity to continuously handle at least 110% of full load alternator current without overheating.

17.15.8 Wiring between hinged panels shall be in flexible looms.

17.16 EARTHING

17.16.1 An earthing bar must be fitted in the switchboard to which all non-current carrying metal parts shall be bonded.

17.16.2 The neutral point of the system must be solidly connected to this bar. Suitable terminals must be provided on the earth bar for connection of the main earth conductors, which will be supplied and installed by others or as specified in the detailed specification.

17.17 BATTERIES

17.17.1 The diesel generator set's starting batteries shall be Delco Remy Type 1250 supplied and distributed by Willard Batteries, or similar approved by SANRAL. Batteries shall be supplied complete with battery stand as specified. The charger shall be internally supplied from emergency power while the set is operational, (i.e. mains not available). The charger shall be capable to recharge a fully discharged battery under normal operating modes from the mains supply.

17.17.2 The charger shall be constant voltage, current limiting and operate automatically in accordance with the state of the battery and be capable of a continuous RMS current of at least 6 amps with an AC ripple content of less than 1% in order to prolong the life of the battery.

17.17.3 A flush mounted ammeter, suitably scaled, reading the charging current and a flush mounted voltmeter indicating the battery voltage shall be provided on the switchboard. An engine driven alternator must be provided for charging the battery during operation of the set.

17.18 WATER JACKET HEATER

17.18.1 An electrical type water jacket heater system complete with thermostat shall be provided. The temperature of the water shall be monitored by the SCADA system.

17.19 DUMMY LOAD

17.19.1 A 3-step dummy load must be supplied and installed. The dummy loads are used to test the generator during maintenance inspection without switching the critical load between normal and emergency supply. Dummy load shall constitute 70% of the rated generator output. The load monitoring circuit shall select the load in any of three steps, 30 %, 20 % and 20% of the rated kW output. Bypass selector switches and indicators must also be provided to enable the manual selection of any of the three step loads.

17.19.2 The dummy load will only be connected 5 minutes after start-up. Three amber indicators (one per bank) labelled “bank n connected” shall be provided. Preference shall be given to generator systems where the dummy load is an integral part of the radiator cowl and is cooled by the radiator fan.

17.19.3 The Contractor shall allow for the switching of the dummy loads from the SCADA system.

17.20 GAUGES

17.20.1 Where applicable all gauges, i.e. water temperature, oil pressure, battery voltage, battery charge rate and frequency, 3-phase demand current, voltage selector switch and meter shall be provided with engraved labels indicating the "normal" parameters of each gauge. The exact information to be engraved shall be determined upon Commissioning of the installation. Where practical, the gauges shall be mounted on the generator control panel.

17.21 MANUALLY OPERATED FUEL PUMP

17.21.1 A one litre per second electric fuel pump shall be provided at the generator to enable the day fuel tank to be filled from any outside fuel storage facility.

17.21.2 The electric pump shall be fed from the generator control panel with 24V AC emergency power. The pump shall be activated by means of push-button “push to operate” control. This pushbutton shall be installed within sight of the fuel tank visual level indicator.

17.21.3 The electric pump shall be fitted with a 25 mm ø 10 m fuel compatible suction hose. A cartridge type fuel filter shall be provided between the abovementioned electric pump and the tank.

17.22 DE-RATING

17.22.1 The engine shall be de-rated for the site conditions as set out in the detail specification.

17.22.2 The de-rating of the engine shall be in accordance with the engine manufacturer’s de-rating curves. Copies of these de-rating curves or tables shall be included with the tender response.

17.23 HOUR METER

17.23.1 A six-digit hour meter shall be installed on the control panel should the data of the electronic hour meter not be guaranteed by the generator supplier or SCADA system.

17.24 DRIP TRAY

17.24.1 A removable drip tray shall be supplied to collect spillage from the fuel pump and diesel engine.

17.25 FIRE EXTINGUISHERS

17.25.1 One 4,5 kg fire extinguisher suitable for extinguishing electrical and fuel fires shall be supplied and mounted on the inside of the generator enclosure.

17.26 COMMISSIONING AND TESTING OF THE GENERATOR SET

17.26.1 Testing

17.26.1.1 Before delivery to Site, SANRAL or their representative shall be invited to witness a full and complete Factory Acceptance Test (FAT) at the manufacturer's premises. Test shall be carried out in accordance with BS 5514, to prove that the equipment will deliver the specified output. The manufacturer shall submit a proposed detail test procedure to SANRAL at least two weeks before testing.

17.26.1.2 Suitable test gear shall be provided at the manufacturer's premises in order to simulate and prove all aspects of the changeover system as specified.

17.26.1.3 All protective devices and systems shall be fully tested. Injection tests shall be performed to check and test all metering equipment.

17.26.1.4 The making available of all Equipment, Plant and instruments required for testing and Commissioning shall be the responsibility of the Contractor.

17.26.1.5 On-Site tests shall be a repetition of the above and shall also be performed in the presence of SANRAL or their representative. The Contractor shall provide all the test equipment and instruments that may be necessary. Load tests are to be done on both occasions.

17.26.1.6 One hard and/or soft copy of the test reports for the above tests shall be submitted to SANRAL, and shall be included in the maintenance manuals.

17.26.1.7 A laptop computer shall be used to test all the event or alarms generated by the generator controller if the SCADA system is not available.

17.26.2 Commissioning

17.26.2.1 All items shall be pre-checked by the Contractor, prior to Commissioning. A copy of the results of all pre-checks, as well as a detailed Commissioning procedure for each piece of equipment, shall be presented to SANRAL for approval before Commissioning takes place, and shall be kept by the Contractor for future reference should it be required. Note that SANRAL will not Commission the system or any part thereof on behalf of the Contractor. The Contractor shall invite SANRAL to witness a full and complete Site Acceptance Test (SAT) of the generator during the Commissioning. All relevant reports test procedure and relevant information to be provided to the Engineer during the Commissioning.

Note: *SANRAL or the Independent Engineer will not Commission the system or any part thereof on behalf of the contractor. All Commissioning shall be performed by the contractor, to the satisfaction of the engineer. Commissioning shall be witnessed by the engineer.*

17.27 MAINTENANCE AND OPERATING MANUALS

The Contractor shall prepare and provide comprehensive maintenance and operating manuals (one set of each, in electronic (PDF file) format and hard copy) for the generator set in its entirety, in accordance with the standard specifications and comprising the following:

17.27.1 Pre-start Checks

17.27.1.1 These checking procedures shall include pre-start up checks on batteries, fuel pipes, fuel levels, lubricating oil levels, coolant levels, alarm indicator lamps and settings of key operated switches and timer relays.

17.27.2 Operating Instructions

17.27.2.1 The function of each switch or control device shall be detailed.

17.27.2.2 Manual or automatic operation settings and procedures shall be detailed.

17.27.3 Alarm Indication

17.27.3.1 All alarm conditions and remedies to restore these conditions shall be detailed.

17.27.4 Fault Finding

17.27.4.1 Detailed, logical faultfinding procedures, with expected readings for all possible fault conditions, shall be detailed.

17.27.5 Wiring Diagrams

17.27.5.1 Detailed wiring diagrams complete with cable wire and core numbering as well as terminal block and relay numbering shall be provided.

17.27.6 Engine and Alternator Information

17.27.6.1 Relevant detail regarding engine and alternator specifications, lubricants required, recommended service intervals, detailed service procedures, spares lists and dealer network information shall be provided.

17.27.7 Test Sheets and Certificates

17.27.7.1 A copy (electronic (PDF file) format and hard copy) of all Works test sheets and type test certificates for all items shall be provided.

17.27.7.2 The Contractor's attention is drawn to the following:

(a) A draft operation and maintenance manual shall be submitted to SANRAL for approval at least 3 weeks before the anticipated handover date.

(b) The installation will not be regarded as complete until all requirements in this regard have been met.

17.27.8 The maintenance manuals shall include detail information and instructions for the maintenance of the generator set. A complete set of wiring diagrams shall be included in the maintenance manual. The following minimum information shall be provided:

17.27.8.1 Service interval details.

17.27.8.2 Spare holding.

17.28 TRAINING

17.28.1 After the installation has been Commissioned, the Contractor shall train an appointed person to operate and control the generating set. The training procedures shall be submitted to SANRAL or their representative in writing.

17.29 HANDING OVER

17.29.1 The Contractor on handover of the completed Works shall provide a full tank of diesel for the generator to SANRAL.

17.30 OPERATIONAL RECORDS

17.30.1 A generator record book shall be kept in the generator container or plant room. The book shall be filled in and signed by the person conducting each inspection, call-out response or routine maintenance service. The information shall also be transferred to the SCADA system database.

17.31 GENERATOR INFORMATION TO BE PROVIDED BY THE CONTRACTOR

17.31.1 The Contractor shall provide the following detail information on the generator for quick verification and evaluation. The data shall also be stored on the SCADA with complete drawings and manuals.

17.31.1.1 Engine information

ITEM	DESCRIPTION OF ENGINE
1.	Manufacturers name:
2.	Country of origin and year of manufacture:
3.	Manufacturers type No.
4.	Continuous sea level rating after allowing for Ancillary equipment: (a) In b.h.p. ……………………… (b) In kW ………………………
5.	Percentage derating for site conditions, in accordance with BS 5514 (a) For altitude ……………………… (b) For temperature ……………………… (c) For humidity ……………………… (d) Total derating ………………………
6.	Net output on site in kW
7.	Nominal speed in RPM
8.	Number of cylinders
9.	Strokes per working cycle
10.	Strokes in mm
11.	Initial one step load capability in kVA
12.	Cylinder bore in mm
13.	Swept volume in cm^3
14.	Mean piston speed in m/min
15.	Compression ratio
16.	Cyclic irregularity
17.	Fuel consumption of the complete generating set On site in l/h. “Load” is the specified nominal kVA rating: (a) 100% load ………………………

ITEM	DESCRIPTION OF ENGINE
	(b) 50% load ………………………
	(c) 25% load …………………….....
	Note: A tolerance of 5% shall be allowed above the stated value of fuel consumption.

17.31.1.2 Engine Information (continued)

ITEM	DESCRIPTION OF ENGINE
18.	Make of fuel injection system:
19.	Capacity of fuel tank in litre:
20.	Is gauge glass fitted to tank?
21.	What method for filling the fuel tank is included?
22.	Method of starting the engine:
23.	Voltage of starting system:
24.	Method of cooling:
25.	Type of radiator if water-cooled:
26.	Type of heater for warming cylinder heads:
27.	Capacity of water heater in kW:
28.	Method of protection against high temperature:
29.	Method of protection against low oil pressure:
30.	Method of protection against low water level:
31.	Type of governor:
32.	Speed variation in % (a) Temporary ……………………… (b) Permanent ………………………
33.	Minimum time required for assumption of full load in seconds:
34.	Recommended interval in running hours for: (a) Lubricating oil change ……………………… (b) Oil filter element change ……………………… (c) Decarbonising. ………………………
35.	Type of base offered:
36.	Can plant be placed on solid concrete floor?
37.	Are all accessories and ducts included?
38.	Is engine naturally aspirated?

ITEM	DESCRIPTION OF ENGINE
39.	Are performance curves attached?
40.	Diameter of exhaust pipe:
41.	Noise level at tail of exhaust pipe in dB (A):
42.	BMEP (4 stroke) at Continuous rating (kPa):
43.	% Load acceptance to BS 5514 Part 4, with 10% transient speed variation:
43.	Available data communication protocol to SCADA:

17.31.1.3 Alternator information

ITEM	DESCRIPTION OF ALTERNATORS
1.	Manufacturers name:
2.	Country of origin and year of manufacture:
3.	Type of enclosure:
4.	Normal speed in RPM:
5.	Terminal voltage:
6.	Sea level rating kVA at 0.8 power factor:
7.	Derating for site conditions in %:
8.	Input required in kW for site kVA output required:
9.	Method of excitation:
10.	Efficiency at 0.8 pf: (a) 100% load ……………………… (b) 50% load ……………………… (c) 25% load ………………………
11.	Maximum permanent voltage variation in %:
12.	Transient voltage dip on full load application in %:
13.	Voltage recovery on full load application in milli-seconds:
14.	Is alternator brushless?
15.	Class of insulation of windings:
16.	Is alternator tropicalised?
17.	Symmetrical short circuit current at terminals in Amps:
18.	Type of coupling:
19.	Number of bearings:

17.31.1.4 Switchboard/control panel information

ITEM	DESCRIPTION OF SWITCHBOARD/CONTROL PANEL
1.	Manufacturers name:
2.	Country of origin:
3.	Is board floor mounted?
4.	Finish of board:
5.	Make of Volt, Amp, and frequency meters:
6.	Sea level rating kVA at 0.8 power factor:
7.	Scale range of voltmeters:
8.	Scale range of ammeters:
9.	Ratio of current transformers:
10.	Make of hour meter:
11.	Range of cyclometer:
12.	Smallest unit shown on counter (Item 11):
13.	Make of circuit breaker:
14.	Type of circuit breaker:
15.	Rating of circuit breaker in Ampere and fault level in kA:
16.	Setting range of overload trips:
17.	Setting range of instantaneous trips:
18.	Make of changeover equipment:
19.	Make of voltage relay:
20.	Is control and protection equipment mounted on a small removable panel:
21.	Type of control equipment:

17.31.1.5 Dimensions information

ITEM	DESCRIPTION OF DIMENSIONS	
1.	Overall dimensions of set in mm: Panel if separate from generator set:	L =……… W =……… H =……… L =……… W =……… H =………
2.	Is plant room adequate for the installation of the set and panel?	………………………
3.	Overall mass:	kg

17.31.1.6 Battery information

ITEM	DESCRIPTION OF BATTERIES
1.	Manufacturer's name:
2.	Country of origin:
3.	Type of battery:
4.	Voltage of battery:
5.	Number of cells:
6.	Capacity in Ah:
7.	Type of battery housing:

17.31.1.7 Deviation information

DEVIATION FROM THE SPECIFICATION (State Briefly)

17.31.1.8 Guarantee information

GUARANTEE
(a) Guarantee in months: …………………………………………………………………
(b) State conditions of guarantee:

17.31.1.9 Delivery & completion time

DELIVERY PERIOD AND INSTALLATION		
(a)	State no. of weeks required from date of order to complete set assembly, full factory testing and delivery to site of all equipment:	weeks
(b)	Time required for completing the installation and Commissioning test on site	weeks
TOTAL TIME REQUIRED FOR COMPLETION (a + b)		**weeks**

17.31.1.10 Spare parts and maintenance facilities information

SPARE PARTS AND MAINTENANCE FACILITIES	
(a)	Approximate value of spares carried in stock for this particular diesel engine and alternator:
(b)	Where are these spares held in stock?
(c)	What facilities exist for servicing the offered equipment?
(d)	Where are these facilities available?
(e)	Who will be attending to the maintenance during the defects liability period?
(f)	Who will be attending to any breakdowns during the defects liability period?

17.32 GENERAL PRO-FORMA INFORMATION SERVICE/INSPECTION REPORT

Date			Unit Ref No	
Customer			Site	
Service			Order No	

GENERATOR INFORMATION					
Engine Type		Alternator Type		Time of Arrival	
Model		Model		Time of Departure	
Serial No		Serial No			

CHECKS	NORMAL			**ENGINE RUN CHECKS**	
	ABNORMAL			Simulate Low Oil Pressure	
Air Inlet Inspection				Simulate High Engine Temperature	
Air Filter				Simulate Low Water Level	
Oil Filter				Simulate Low Fuel	
Oil Leak				Simulate Over/Under Freq.	
Oil Level				Simulate Over/Under Voltage	
Fuel Filter-Prim/Sec				Simulate Start Attempts	
Fuel Leak				Check Governor Function	
Fuel Water Trap				Check Charging Alt	
Fuel Hoses				Check Coupling Noises	
Radiator/Heat Exchanger				**CONTROL PANEL/CHECKS**	
Coolant				Main Failure Test	Yes/No
Jacket Water Heater "ON"				Check Change Over Timing	Sec
JWH Hoses (Replace Annually)				Check on Load Run Period	Min
Fan Belt Tension/Condition				Check Delay Unit Shut Down	Min
Fan Drive Pulley & Fan				Check Plant Selector (Auto)	
Battery Condition				Check Fan/Motor Isolator's	
Battery Electrolyte Level					
Water Pump Condition				**RECORD**	
Turbo Charger Condition				Frequency	Hz
Crankcase Breather				Kilowatt	kW
Canopy/Plant room Condition				Oil Pressure	KPA/PSI
RECORD				Fuel Pressure	KPS/PSI
Battery Voltage				Engine Temperature	°C
Battery Voltage Drop				Day Tank Fuel Level	%
Charging Current				Bulk Tank Fuel Level	%
Max Demand Amps R W B					
On Load Current R W B					
Voltage R W B					
Hour meter					

OTHER ACTIVITIES (if applicable)

Annual Oil Sample			Drain and Flush Cooling System	
Annual Fuel Sample			Oil Change	
			Fuel Filtration	

COMMENTS/PROBLEM DESCRIPTION

The Generator system available reports shall be attached to this report i.e. any alarms recorded, events, Voltage and Ampere readings, etc. stored by the generator controller. The above report shall be electronically available on the SCADA system. The SCADA user shall be able to print and update and save the report after an inspection has been done. The Original signed (by specialist contractor) report shall be scanned and saved on the SCADA system.

17.33 GENERATOR DATA AND COMPLIANCE SHEET

TABLE 17-1: GENERATOR DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
17.33.1	SANS 10131:2004	Above-ground storage tanks for petroleum products				
17.33.2	SANS 62-1:2003	Steel pipes Part 1: Pipes suitable for threading and of nominal size not exceeding 150 mm				
17.33.3	BS ISO 3046-1:2002	Reciprocating internal combustion engines. Performance. Declarations of power, fuel and lubricating oil consumptions, and test methods. Additional requirements for engines for general use.				
17.33.5	BS ISO 3046-3:2006	Reciprocating internal combustion engines. Performance. Test measurements.				
17.33.6	BS 5514-4:1997	Reciprocating internal combustion engines. Performance. Speed governing.				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
17.33.7	BS ISO 3046-5:2001	Reciprocating internal combustion engines. Performance. Torsional vibrations.				
17.33.8	BS 5514-6:1992	Reciprocating internal combustion engines. Performance. Specification for overspeed protection.				
17.33.9	BS ISO 3046-1:2002	Reciprocating internal combustion engines. Performance. Declarations of power, fuel and lubricating oil consumption, and test methods. Additional requirements for engines for general use.				
17.33.10	BS 5514-1:1996	Reciprocating internal combustion engines. Performance. Standard reference conditions, declarations of power, fuel and lubricating oil consumption and test methods.				
17.33.11	BS 5514-4:1997	Reciprocating internal combustion engines. Performance. Speed governing.				
17.33.12	SANS 8528-1:2008/ISO 8528-1:2005 (SABS ISO 8528-1)	Reciprocating internal combustion engine driven alternating current generating sets Part 1: Application, ratings and performance.				
17.33.13	SANS 8528-2:2008/ISO	Reciprocating internal combustion engine driven				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
	8528-2:2005 (SABS ISO 8528-2)	alternating current generating sets Part 2: Engines.				
17.33.14	SANS 8528-3:2008/ISO 8528-3:2005 (SABS ISO 8528-3)	Reciprocating internal combustion engine driven alternating current generating sets Part 3: Alternating current generators for generating sets.				
17.33.15	SANS 8528-4:2008/ISO 8528-4:2005 (SABS ISO 8528-4)	Reciprocating internal combustion engine driven alternating current generating sets Part 4: Control gear and switchgear.				
17.33.16	SANS 8528-5:2008/ISO 8528-5:2005 (SABS ISO 8528-5)	Reciprocating internal combustion engine driven alternating current generating sets Part 5: Generating sets.				
17.33.17	SANS 8528-6:2008/ISO 8528-6:2005 (SABS ISO 8528-6)	Reciprocating internal combustion engine driven alternating current generating sets Part 6: Test methods.				
17.33.18	SANS 8528-7:1994/ISO 8528-7:1994 (SABS ISO 8528-7)	Reciprocating internal combustion engine driven alternating current generating sets Part 7: Technical declarations for specification and design.				
17.33.19	SANS 8528-8:2006/ISO 8528-8:1995	Reciprocating internal combustion engine driven alternating current generating sets Part 8: Requirements and tests for low-power generating				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		sets.				
17.33.20	SANS 8528-9:2006/ISO 8528-9:1995	Reciprocating internal combustion engine driven alternating current generating sets Part 9: Measurement and evaluation of mechanical vibrations.				
17.33.21	SANS 8528-10:2006/ISO 8528-10:1998	Reciprocating internal combustion engine driven alternating current generating sets Part 10: Measurement of airborne noise by the enveloping surface method.				
17.33.22	SANS 8528-12:2006/ISO 8528-12:1997	Reciprocating internal combustion engine driven alternating current generating sets Part 12: Emergency power supply to safety services.				
17.33.23	BS 5514-6:1992	Reciprocating internal combustion engines. Performance. Specification for overspeed protection.				
GENERATOR						
	CLAUSE					
17.33.24	17.2	Enclosure				
17.33.25	17.3	Alternator Requirements				
17.33.26	17.4	System Operation				
17.33.27	17.5	Electronic Governor				
17.33.28	17.6	Bulk Fuel Tank				
17.33.29	17.7	Exhaust System				
17.33.30	17.8	Radiator Ducts and				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		Flashings				
17.33.31	17.9	Generating Set Colour				
17.33.32	17.1	Generator Control Panel				
17.33.33	17.11	Batteries				
17.33.34	17.12	Water Jacket Heater				
17.33.35	17.13	Dummy Load				
17.33.36	17.14	Gauges				
17.33.37	17.15	Manually operated fuel pump				
17.33.38	17.16	Hour Meter				
17.33.39	17.17	Drip Tray				
17.33.40	17.18	Fire Extinguishers				
17.33.41	17.19	Commissioning and Testing of the Generator Set				
17.33.42	17.19.1	Testing				
17.33.43	17.19.2	Commissioning				
17.33.44	17.2	Maintenance and Operating Manuals				
17.33.45	17.20.1	Pre-start Checks				
17.33.46	17.20.2	Operating Instructions				
17.33.47	17.20.3	Alarm Indication				
17.33.48	17.20.4	Fault Finding				
17.33.49	17.20.5	Wiring Diagrams				
17.33.50	17.20.6	Engine and Alternator Information				
17.33.51	17.20.7	Test Sheets and Certificates				
17.33.52	17.21	Training of a Contractor				
17.33.53	17.22	Maintenance MANUALS				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
17.33.54	17.23	Handing Over				
17.33.55	17.24	Operational records				

18. SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)

18.1 SCADA OPERATIONS REQUIREMENTS

18.1.1 All events, alarms and critical alarms shall be acknowledged by the ORT contractor as part of their operations and maintenance function.

18.1.2 The SCADA system shall report the event, alarm and critical alarm to the Contractor and keep a time line based on the acknowledgments and final sign off.

18.1.3 The SCADA system shall provide the Contractor real time status of all electrical and mechanical equipment, access control, alarm and CCTV events.

18.1.4 The SCADA system shall allow the Contractor Control System to combine functions i.e. to allow access to a site or area by opening an access window to the loaded approved personnel on the system. The access will be acknowledged by the SCADA system with the approved personnel personal card and pin or fingerprint. The access to a site or area shall expire after a period adjustable between 1 and 8 hours.

18.1.5 The Contractor will load all personnel profiles on the SCADA system including a digital photo and access level. The Contractor may require additional policies.

18.1.6 The SCADA system shall keep record of all changes, acknowledgements and upgrades.

18.1.7 The Contractor shall be able to extract and provide monthly reports from the SCADA system.

18.1.8 The SCADA system shall keep track of all maintenance functions and due dates i.e. the generator maintenance shall be loaded on the system with the SCADA system logging the next service date. The maintenance intervals will be provided during the testing and commission phase.

18.2 SCADA SYSTEM

18.2.1 The SCADA system shall provide real time reporting and alarm notification on systems and assist with the successful management and operation of the infrastructure i.e. electrical, security, access control, CCTV, VOIP phone system and other equipment.

18.2.2 All equipment as listed under item 11 to 23 shall be supplied and installed with an RS 232, RS 485 or Ethernet LAN (TCP/IP) communication protocol. Ethernet Modbus or other approved open protocol shall be the preferred communication protocol. A network switch may be required depending on the site and equipment. This communication protocol shall be used to communicate through a local PLC or RTU intelligent interface unit.

18.2.3 All signals shall be processed locally (at each site) before transmission via the communication backbone to the SCADA server located at the ECOC.

18.2.4 Each site shall have a suitability sized 19” cabinet to house the rack-mounted PLC or RTU and communication equipment that are required to interface the different peripherals with the SCADA system. Equipment that will be housed outside the cabinet shall be housed in an extruded aluminium enclosure and shall be suitable for wall mounting. The complete unit shall have a protection rating of IP 55 with keyed-alike lockable door. The cabinet shall be supplied complete with the required Power Outlets and cable management trunking.

18.2.5 Each site may have a dedicated remote site client for onsite maintenance and system repair work. All site related data shall be stored on site for a period of 60 days before it is replaced. Data shall only be replaced or deleted if the data have been sent to the main database at the Central Operational Centre.

18.2.6 Any access to the system or database shall be password protected.

18.2.7 Each site shall have a pre-configured hard drive for quick system repair. The hard drive shall be cloned for safe keeping after commissioning.

18.2.8 Each site shall have a dedicated recovery pack for quick recovery of the system should any failure occur over and above the preconfigured hard drive under item 45.

18.2.9 All sites shall be protected against unauthorised personnel using or accessing the SCADA hardware and software.

18.2.10 The SCADA system shall be able to remotely override, switch or configure any of the hardware controllers or field devices on the network for maintenance, operation and testing purposes.

18.2.11 The SCADA system shall test the communication with each peripheral once every 600 seconds. Failure of any device shall be reported by the SCADA system.

18.2.12 A registered SCADA user shall acknowledge any alarm reported by the SCADA system. The acknowledgement shall be with a user name and password

18.2.13 The SQL database shall record the alarm or event, date, time, registered user details, comments by user (user must provide comments to complete the acknowledgement), and time duration from alarm notification to acknowledgement.

18.2.14 The SCADA system shall allocate a unique serial number to each alarm or event for audit purposes. In addition to each unique number a unique number shall also be provided per discipline i.e. A001 (Access control), S001 (Security), G001 Generator, etc. The serial number shall not have a limit. A separate unique serial number may be required for maintenance or repair actions.

18.2.15 The database shall count each alarm or event and shall provide a report every month on the total alarms or events for the month and overall count. This could form part of a trend report.

18.2.16 The SCADA database shall provide graphs (trends) of all the alarms and events per site and shall highlight any abnormalities or above or below-average occurrences.

18.2.17 The control room shall have a minimum of four 42” LCD screens (preferably wall mounted) to view the overall layout of the architecture, the database with details of the latest alarms and events, and CCTV and alarm access control.

- Full HD (1920 x 1080p)
- 4x HDMI Connections
- High Contrast
- USB 2.0 Interface

18.2.18 The SCADA system shall be able to communicate via a GSM communication device should the fibre optic communication backbone not be available. The GSM communication device shall send Short Text Message System (SMS) messages to several cell phones. The SCADA system shall also store all messages sent, with a date and time stamp in a user-friendly database with report function.

18.2.19 The SCADA system shall be able to communicate via a GSM/GPRS communication device should the fibre optic communication backbone not be available. The GSM/GPRS communication device shall send emails to several addresses. The SCADA system shall also store all messages sent, with a date and time stamp in a user-friendly database with report function.

18.2.20 The SCADA system shall be able to communicate via a SMS or email, several dedicated personnel alarm conditions as may be required by the Tenderer for each site or from the control centre.

18.2.21 The SCADA system shall be maintained by suitably skilled personnel that will ensure that the system gets the required maintenance.

18.2.22 Remote access shall be available for maintenance personnel.

18.2.23 The SCADA architecture shall be based on available drawings for each site with an overlay of all the peripherals that will be easily identified and controlled. Drawings shall be made available in PDF, CAD or DXF file format. Other formats may be available if agreed to by the Engineer.

18.2.24 Required antivirus, antispyware and firewall protection and security shall be provided.

18.2.25 This specification covers the requirements for a complete integrated SCADA system for the remote control and telemetry used to monitor and control the electrical, security, CCTV and access control systems.

18.2.26 The SCADA system shall also provide supervisory control with data management and reporting function on electrical, security, CCTV and access control for local and remote sites.

18.2.27 Some of the SCADA proposed client interface functionality is captured in the layout drawing below:

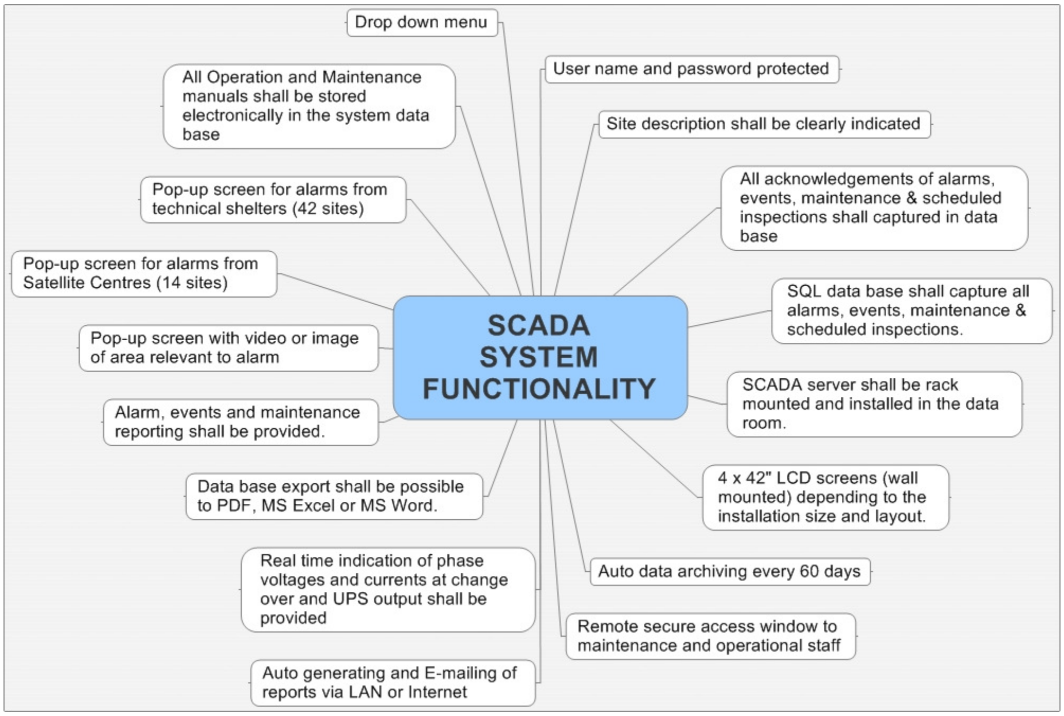


FIGURE 18-1: SCADA SYSTEM FUNCTIONALITY

18.2.27.1 The general SCADA architecture is provided on the following drawing:

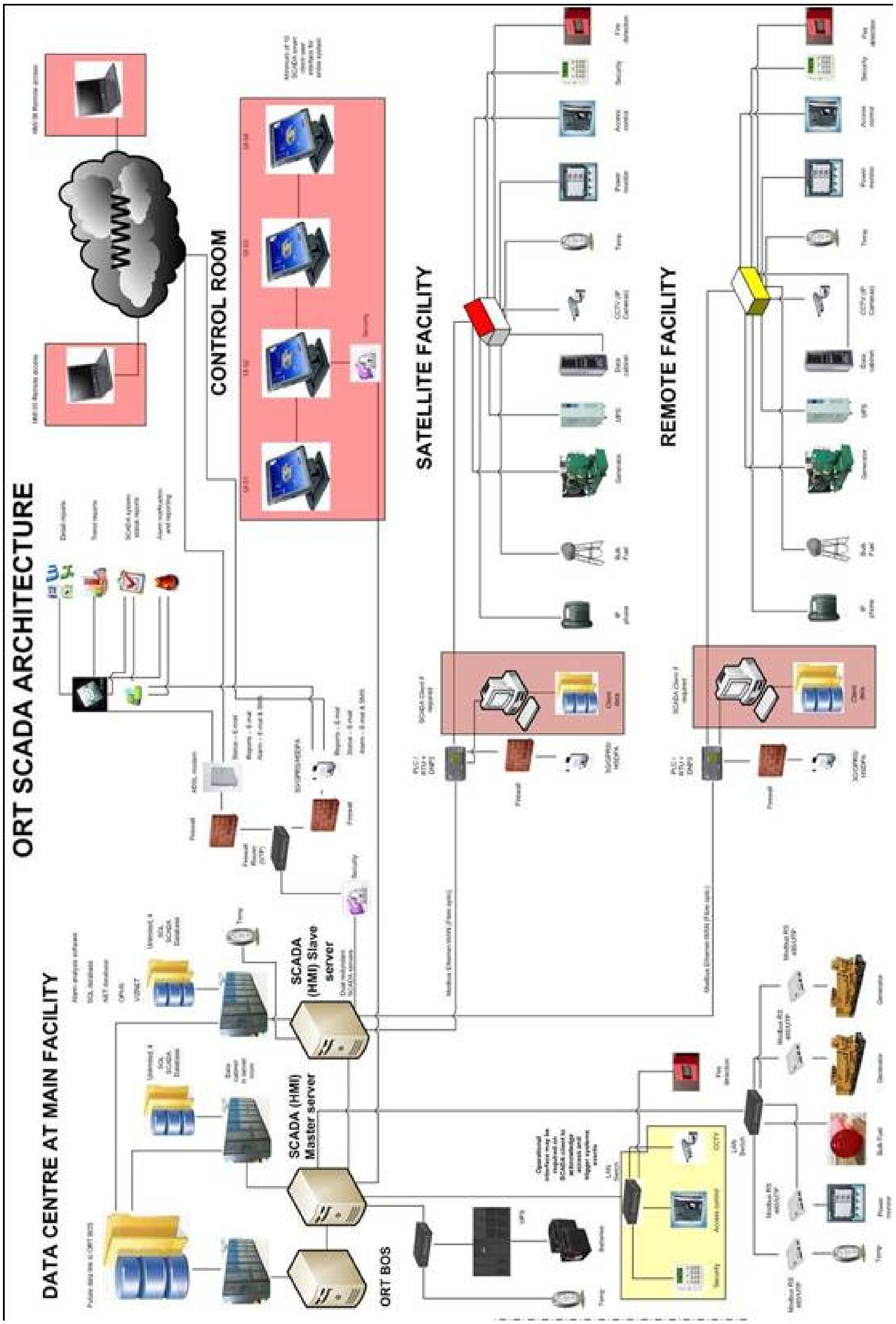


FIGURE 18-2: GENERAL SCADA ARCHITECTURE

18.2.27.2 The SCADA proposed systems and subsystems and possible alarms are captured in the layout drawing on the next page.

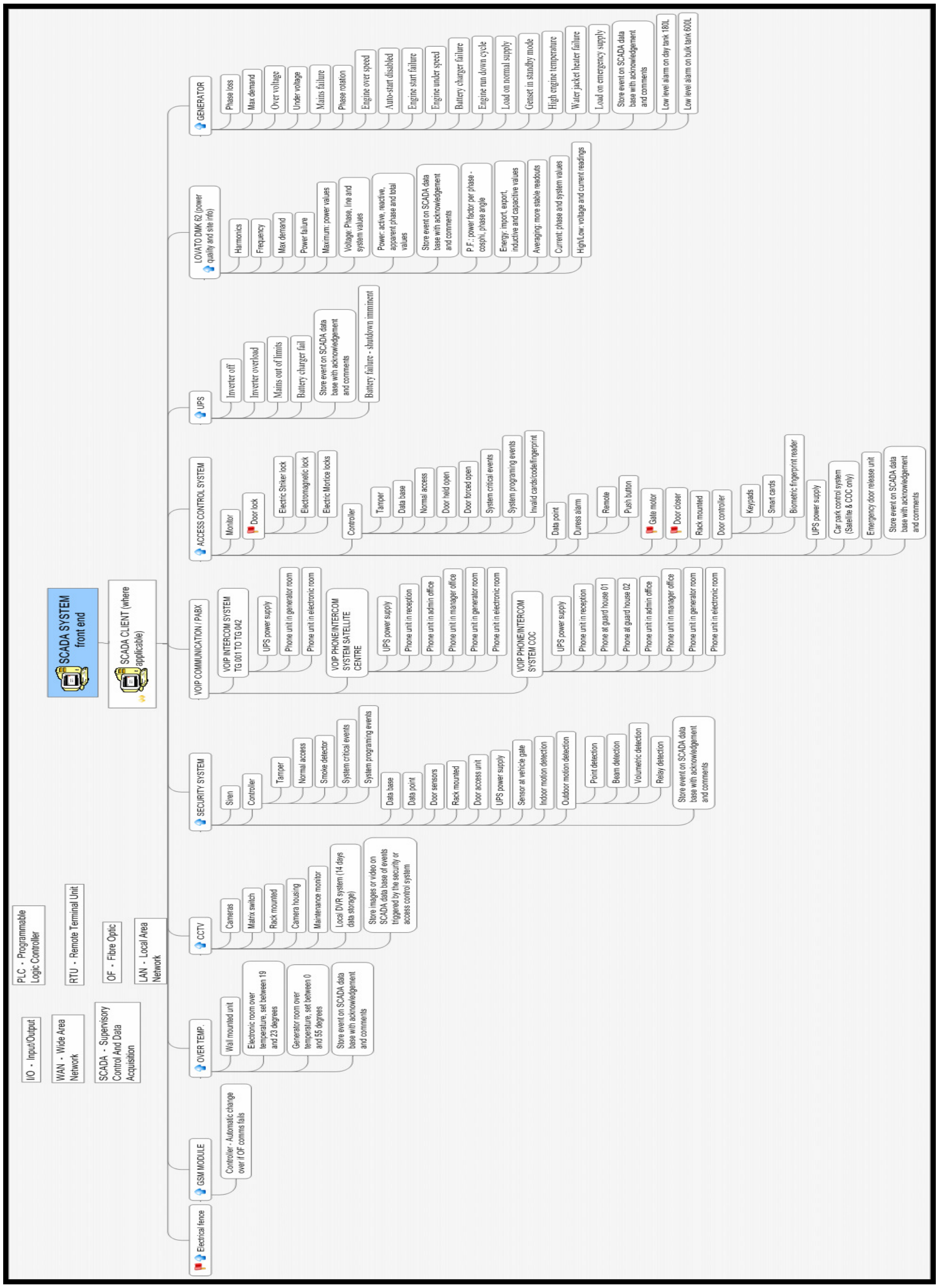


FIGURE 18-3: SCADA SYSTEM BASIC PERIPHERAL LAYOUT

18.2.27.3 The SCADA proposed systems and subsystems including alarms, based on the above layout drawing are summarized below:

18.3 ELECTRICAL FENCE

18.3.1 Electrical fence: Event shall be captured if system is not working and Alarm when triggered. Event/Alarm (Green/Amber) indication on screen with acknowledgment.

18.4 GSM MODULE

18.4.1 Controller: Automatic changeover to GSM if Fibre Optic (OF) communication fails or primary communication fails. Event shall be captured in database. Alarm (Amber) indication on screen with acknowledgment.

18.5 OVER TEMP

18.5.1 Wall mounted control unit

18.5.2 Server and UPS room: Alarm - Over temperature, set between 19 and 23 degrees. Temperature indication in real time with Alarm (Red) indication on screen and alarm captured in database.

18.5.3 Generator room: Alarm - Over temperature, set between 0 and 55 degrees. Temperature indication in real time with Alarm (Red) indication on screen and alarm captured in database.

18.5.4 Events: Event - Store alarm, minimum, maximum and average temperature in SCADA database with acknowledgement and comments.

18.6 CCTV

18.6.1 CCTV: The CCTV system shall be integrated with the access control or SCADA system to provide continuous video on site and images of events and alarms as per the project specification.

18.7 SECURITY SYSTEM

18.7.1 Security system: The security system shall be integrated with the access control system or SCADA system with all the features as per the project specification.

18.8 VOIP COMMUNICATION REMOTE SITES

18.8.1 VOIP intercom System The VOIP shall form an integral part of the SCADA system and it shall be possible to access any VOIP intercom through the system.

18.8.2	UPS power supply	The VOIP controller shall have a backup battery that is supplied with power through the main UPS system.
18.8.3	Phone unit in generator room	VOIP phones shall be available in the Generator room.
18.8.4	Phone unit in electronic room	VOIP phones shall be available in the electronic/UPS room.

18.9 VOIP COMMUNICATION SYSTEM SATELLITE CENTRE

18.9.1	UPS power supply	The VOIP controller shall have a backup battery that is supplied with power by the main UPS system.
18.9.2	Phone unit in reception	VOIP phones shall be available in the reception office.
18.9.3	Phone unit in admin office	VOIP phones shall be available in the admin office.
18.9.4	Phone unit in manager office	VOIP phones shall be available in the manager office.
18.9.5	Phone unit in generator room	VOIP phones shall be available in the generator room.
18.9.6	Phone unit in electronic room	VOIP phones shall be available in the electronic room.

18.10 VOIP COMMUNICATION SYSTEM TOLL PLAZA

18.10.1	UPS power supply	The VOIP controller shall have a backup battery that is supplied with power by the main UPS system.
18.10.2	Phone unit in reception	VOIP phones shall be available in the reception office.
18.10.3	Phone at guard house 01	VOIP phones shall be available in the guard house 01
18.10.4	Phone at guard house 02	VOIP phones shall be available in the guard house 02
18.10.5	Phone unit in admin office	VOIP phones shall be available in the admin office
18.10.6	Phone unit in manager office	VOIP phones shall be available in the manager office
18.10.7	Phone unit in generator room	VOIP phones shall be available in the generator room
18.10.8	Phone unit in UPS room	VOIP phones shall be available in the UPS room
18.10.9	Phone unit in electronic room	VOIP phones shall be available in the electronic room

18.11 ACCESS CONTROL SYSTEM

18.11.1	Door lock:	Each security door shall have an electronic door lock mechanism operated via the access control that is linked to the SCADA system.
18.11.2	Electric Striker lock	Specific locking device to be used.
18.11.3	Electromagnetic lock:	Specific locking device to be used
18.11.4	Electric Mortice locks:	Specific locking device to be used
18.11.5	Controller:	All access control devices shall report to the control, the controller providing the SCADA system with all events and alarms. Events and alarms shall be stored on the controller or local RTU/PLC until uploaded to the SCADA database. The SCADA system shall be able to control each individual device or peripheral through the controller.
18.11.6	Tamper:	All tamper alarms shall be sent to the controller.
18.11.7	Database:	The controller shall have a database to store all events until uploaded to the SCADA system.
18.11.8	Normal access:	Access to the facility shall be via a valid process as approved by the SCADA system and verified by the Contractor.
18.11.9	Door held open:	Alarm shall be generated if a door is kept open for 30 seconds.
18.11.10	Door forced open:	Alarm shall be generated when a door is opened without any valid confirmation by the controller and SCADA system.
18.11.11	System critical events:	Peripherals not communicating with the controller or any alarm form the field devices.
18.11.12	System programming events:	All programming events shall be stored on the database and sent to the SCADA system.
18.11.13	Invalid cards/code/fingerprint:	Alarm shall be generated on the controller and copied to the SCADA system.
18.11.14	Data point:	A USB port shall connect to the controller directly to setup, update or repair the controller onsite.

18.11.15	Duress alarm:	Alarm event shall be stored by the controller.
18.11.16	Remote:	Remotely control the system should the SCADA communication not be available. Manual operation by technical personnel.
18.11.17	Push button:	Used to open a door form the inside. A parallel function shall be available from the SCADA via the controller.
18.11.18	Gate motor:	The motor that operates the vehicle gates. A parallel function shall be available from the SCADA via the controller.
18.11.19	Door closer:	Mechanical device to keep all security doors closed.
18.11.20	Rack mounted:	Controller - Shall be installed in existing cabinet in computer room.
18.11.21	Door controller:	Controls the access through the door and sense data to the controller.
18.11.22	Keypads:	Access field device.
18.11.23	Smart cards:	Access field device.
18.11.24	Biometric fingerprint reader:	Access field device capable to accurate scan identification against 1000 persons under one second. The device shall be waterproof, fixed, dust and shock resistant. Provision shall be made to bypass the biometric fingerprint reader via keypad or key should the biometric reader fail.
18.11.25	UPS power supply:	Controller and all peripherals shall be powered form a backup battery with a power supply from the main UPS.
18.11.26	Car park control system (Satellite & COC only):	System controlling the entering and exiting of vehicles into and out of the car park.
18.11.27	Emergency door release unit:	Break-glass device with key or push button to open a security door during an emergency.
18.11.28	Store event:	Controller and SCADA database with acknowledgement and comments
18.11.29	Access control:	The access control system shall be a standalone system complete with its own database server and interface with the SCADA system.

18.12 UPS

18.12.1	UPS healthy:	The UPS shall have a healthy indication when in normal operation.
18.12.2	UPS on battery:	Alarm (Amber) – The UPS shall have a on battery indication during a power failure or switch over to emergence power.
18.12.3	UPS on Mains:	Event (Blue) – The UPS shall report a UPS on mains after the power was restored.
18.12.4	Inverter off:	Report critical alarm (Red) to the SCADA system with acknowledgment.
18.12.5	Inverter overload:	Report critical alarm (Red) to the SCADA system with acknowledgment.
18.12.6	Mains out of limits:	Report critical alarm (Red) to the SCADA system with acknowledgment.
18.12.7	Battery charger failed:	Report critical alarm (Red) to the SCADA system with acknowledgment.
18.12.8	Store event:	SCADA database with acknowledgement and comments
18.12.9	Battery failure:	shutdown imminent Report critical alarm (Red) to the SCADA system with acknowledgment.

18.13 POWER QUALITY AND SITE INFORMATION

18.13.1	Harmonics:	Record minimum, maximum and average harmonics to the 3rd, 9th, 12th and 15th to the SCADA system with date and time. Real-time monitoring shall be available.
18.13.2	Frequency:	Record minimum, maximum and average frequency with date and time. Real-time monitoring shall be available.
18.13.3	Max demand:	Record maximum demand with date and time.
18.13.4	Power failure:	Record all power failures with date, time and duration with acknowledgement and comments.
18.13.5	Voltage: Phase, line and system values:	Record minimum, maximum and average values with date and time. Real time monitoring shall be available.

18.13.6 Power: active, reactive, apparent phase and total values: Record minimum, maximum and average values with date and time. Real time monitoring shall be available.

18.13.7 Store all event: SCADA database with acknowledgement and comments

18.13.8 PF: power factor per phase: Record minimum, maximum and average values with date and time. Real time monitoring shall be available.

18.13.9 Energy: import, export, inductive and capacitive values: Record minimum, maximum and average values with date and time. Real time monitoring shall be available.

18.13.10 Current: phase and system values: Record minimum, maximum and average values with date and time. Real time monitoring shall be available.

18.13.11 High/Low: voltage and current readings: Record minimum, maximum and average values with date and time. Real time monitoring shall be available.

18.14 GENERATOR

18.14.1 Phase loss - Critical alarm (red) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.2 Max demand - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.3 Over voltage - Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.4 Under voltage - Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.5 Mains failure - Critical alarm (red) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.6 Phase rotation - Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.7 Engine over speed - Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.8 Auto-start disabled - Critical alarm (red) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.9 Engine start failure - Critical alarm (red) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.10 Engine under speed - Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.11 Battery charger failure - Critical alarm (red) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.12 Engine run down cycle - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.13 Mains restored/

18.14.14 Load on normal supply - Event (blue) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.15 Generator set in standby mode - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.16 High engine temperature - Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.17 Water jacket heater failure - Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.18 Load on emergency supply - Event (green) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.19 Store event on SCADA database

18.14.20 With acknowledgement and comments: Report to SCADA with acknowledgement and comments as per figure 3.

18.14.21 Low level alarm on day tank 180 L: Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.14.22 Low level alarm on bulk tank 600 L

18.14.23 To 48 000 L (site dependent): Alarm (amber) - Report to SCADA with acknowledgement and comments as per figure 3.

18.15 EQUIPMENT RECORD SYSTEM (ERS)

18.15.1 The SCADA shall have an integrated ERS that will be updated and electronically stored in the SQL database. Each peripheral shall have a unique number as labelled in the field. The ERS will be updated every time maintenance is done or when equipment is replaced. The SCADA system shall be able to generate a trend report to indicate the movement or status of peripherals. The unique number shall identify the site, location and equipment.

18.15.2 The SCADA system shall allocate unique numbers automatically to the asset, based on the following:

18.15.2.1 Drop down menu – SITE (Toll Plaza name).

18.15.2.2 Drop down menu – LOCATION (Generator or control room)

18.15.2.3 Drop down menu – EQUIPMENT (UPS, Battery, Camera, PLC, etc)

18.15.2.4 Drop down menu – AUTO NUMBER (The number to be complied based on the above selection and as specified in the project specification)

18.15.2.5 Edit number – only authorized personnel shall have access to this option.

18.15.3 Other detail to follow after the number has been allocated i.e.

18.15.3.1 Equipment serial number to be loaded

18.15.3.2 Model number

18.15.3.3 Make

18.15.3.4 Supplier details including contact numbers

18.15.3.5 Future replacement date

18.15.3.6 Installation date.

18.16 COMPUTERISED MAINTENANCE MANAGEMENT SYSTEM (CMMS)

18.16.1 A complete CMMS shall be provided for the electrical and mechanical equipment including any other type of asset. The system shall make use of the ERS data on the system and keep track of maintenance and status of equipment and software.

18.16.2 The CMMS shall keep track of but is not limited to the items below:

18.16.2.1 Maintenance;

18.16.2.2 Breakdowns;

18.16.2.3 Response and repair times;

18.16.2.4 Inventory control;

18.16.2.5 Guarantee periods;

18.16.2.6 Reports;

18.16.2.7 Personnel;

18.16.2.8 Hours operational;

18.16.2.9 Hours down;

18.16.2.10 Work orders;

18.16.2.11 Final repair or maintenance cost

18.16.3 Additional functionality shall be allowed for without the need to update the software.

18.17 WORKSTATION

18.17.1 One or more workstations shall be provided in the control room or any other control area with the Human Machine Interface (HMI) software. The workstation shall have sufficient storage capacity or be linked to any other large storage facility i.e. Network Storage Manager or Server as required, and teh workstations shall be adequately sized for its intended application.

18.18 SERVER

18.18.1 One or more servers shall be provided in a master slave configuration to allow for redundancy. The redundant servers shall synchronize both real-time and historical data on failure restoration.

18.18.2 The redundant servers shall offer full shadowing or parallel scanning to external drives. This will be a configurable attribute. Either of the servers shall be able to act as master.

18.18.3 The switchover to the standby system shall be bumpless and continuous control shall be possible.

18.19 SOFTWARE REQUIREMENTS

18.19.1 The Supervisory control and data Acquisition software package shall be standardised and have a wide and well established user base in the South African and international markets. The software shall be a native 32-bit or 64-bit application and must run on the latest available Operating System recommended by the SCADA supplier including the .NET framework. Preference shall be given to a locally developed and supported SCADA package. A software support service with optional updates shall be available. Software shall be fully supplemented by easily understandable user manuals and documentation.

18.19.2 Any other operating system may be provided if approved by SANRAL or the Independent Engineer.

18.19.3 Tenderers shall indicate the location and level of software support available.

18.19.4 The editing of mimic displays and database tag configuration shall be possible on-line without compromising the availability of the installation. No compilation of the database shall be required.

18.19.5 The system shall be upgradeable to all new versions as they become available. Should this be an annual agreement please include all relevant documentation.

18.20 CONFIGURATION

18.20.1 On-line monitoring, control, configuration and engineering functions must be provided on all client and server stations on the SCADA network. Built in tools must exist to do bulk configuration of the database. SCADA packages that require off-line compilation of configuration changes will not be considered. The system must provide the ability to add Cards on-the-fly from within the graphics editor, turned viewer, or anywhere in the system that calls for a Card. The software shall provide the user with the ability to monitor, fault find and configure a server from a remote LAN or WAN based workstation. The SCADA server must be able to run as a Windows service so that users can log off and log on without interrupting the scanning task. Scripting will be done with VB or JAVA. Viewing of multiple SCADA databases shall be possible from any client on the network. The view shall be in a logical tree structure.

18.20.2 Complex custom objects should be able to be created for reuse on larger application without additional licence costs. The Cards shall be grouped for logical items e.g. VSD's, PID's and any other group of Cards for a control system object. Once the object is created only one reference name shall be required for every instance of the object. These objects shall allow embedded scripting to add specialised functions. Configuration tools will seamlessly integrated within the operator interface. This means that users have on-line access to the engineering facilities while still maintaining full operability on any open document windows. To assist users, built-in, context-sensitive Help and a comprehensive demonstration of all the features of SCADA shall be available.

18.20.3 At any point in time, when a client component such as a UI (user interface) instance is connected to a single server somewhere on the network, the client component references a Card that does not exist in this server, but does exist in anther server connected in a peer-to-peer fashion with the first server, then a special proxy Card shall be automatically and transparently created that for all intents and purpose act son behalf of the remote Card.

18.21 SQL DATABASE

18.21.1 All data shall be stored on an SQL database with easy and unrestricted access to the data for compiling reports or to import into other database facilities.

18.22 SOFTWARE LICENCE

18.22.1 The Operator shall purchase perpetual, unrestricted licences, where any is required, for all software i.e.: operating systems, databases, application software, firmware, etc. for any new equipment and/or systems in the name of SANRAL so that any proprietary rights in respect of such software and/or hardware

18.22.2 Licences vest in the name of SANRAL. There shall be no time or period-related restrictions on any such licences or system functionality

18.22.3 The following minimum licences shall be provided but not limited to:

18.22.3.1 Windows OS – Individual licences.

18.22.3.2 OS client access licence (Microsoft CALs) – Minimum of 10 (Site dependent)

18.22.3.3 OS remote connection licences – Minimum of 4 (Site dependent)

18.22.3.4 Application licence – MS Office, MS SQL server, third party licences, and other.

18.22.3.5 SCADA – Licences.

18.22.3.6 Proof of validity of all compiling and third party licences shall be required and handed over during the final handover.

18.22.3.7 All licence information shall be stored on the SCADA system under the drop down menu.

18.23 DATA COMMUNICATION

18.23.1 Data communication shall be Ethernet through a Wide Area Network (WAN) and Local Area Network (LAN) by means of TCP/IP. All communication hardware shall be industrial type to SANRAL or the Independent Engineer’s approval.

18.24 NETWORKING

18.24.1 The package shall be capable of transparently supporting distributed multi-client, multi-server configurations. In this configuration, the database shall be distributed among the server stations with each one scanning its front-end device(s) and updating its own database. Server stations must have the ability of being able to communicate simultaneously, to equipment from various hardware suppliers, on a single station

18.24.2 All database items shall be transparently available on all operator stations via a dedicated network. This includes mimic displays, trending, reporting and alarms. There shall be no appreciable degradation in response time between subscriptions to local database items, and subscriptions to database items in another server station.

18.24.3 The SCADA system must allow client stations to connect to server stations via a remote link.

18.25 NETWORK SECURITY

18.25.1 The highest possible network security shall be implemented for data transmission, data storage and human interface security. The security shall be comprehensive, complete and integrated with the operating system's security system.

18.25.2 The software shall provide a comprehensive security system. The security system must integrate smoothly with the operating system's security system. It must be possible to completely disable all Windows controls like Title Bar, Sizing Border, Menu, status bar, etc., and thereby create a totally tamper-proof operator interface. Remote user interfaces shall have the ability to be downgraded to view only capability, whereas their default capability should be viewed and controlled. The package will allow the use of dynamic security descriptors, i.e. the security of any operator action may be dynamically changed based on certain conditions.

18.25.3 Security should be Windows profile dependent and shall conform to the windows security policies. Should any other OS be implemented other than Windows, the same security requirements shall apply. Logging into the system from any terminal shall apply the necessary security from the domain controller.

18.25.4 Transfer of data between SCADA client and server must be encrypted and compresses using a proven security standard.

18.26 REDUNDANCY

18.26.1 The package shall be capable of supporting a distributed active fault tolerant cluster model. This must provide the following:

- A true fault tolerant system – providing the basis for continuous availability of the system.

a) System integrity – the system's permanent and cached data must be duplicated so that any component failure will not result in the loss of data for the remaining components.

b) Clustering of the fault tolerant server nodes – the duplicate server nodes should appear as one logical unit from any client's perspective.

c) Continuous availability – the system should detect a node failure and quickly take appropriate action so that the remaining components can continue uninterrupted thereby providing clients with continuous live data and operation.

d) Active fault tolerant clustered nodes – duplicate nodes are actively involved in useful work thereby providing increased throughput of the system.

e) Easy-to-maintain, centralized management providing a single virtual system.

f) The redundant servers shall synchronize both real-time and historical data on failure restoration.

g) The switch over to the standby systems hall be bump less and continuous control shall be possible.

h) The redundant servers shall offer full shadowing or parallel scanning to external devises. This will be a configurable attribute.

i) Either of the servers shall be able to act as master.

j) On clustered servers the functionality for both load balancing and redundancy must be available. Any number of servers can belong to the same cluster; all the servers within a cluster should be able to handle their combined workload evenly and to provide continued operation in the event that one or more fail.

18.27 .NET FRAMEWORK

18.27.1 The software should be able to consume WEB services and to embed .NET controls. This functionality should be native to the application and make full use of the .NET framework. The application should be developed on the .NET framework and no additional software should be required to allow the full framework functionality.

18.28 NOTIFICATION

18.28.1 The SCADA system shall have an SMS and email facility that can be set up to send alarms, reports, equipment statuses, etc. manually or automatically as required. A minimum of 10 SMS and e-mail accounts shall be possible.

18.29 REMOTE ACCESS

18.29.1 Remote access shall be available through the WAN, LAN or GSM/GPRS network. Other communication may also be implemented if approved by SANRAL or the Independent Engineer.

18.29.2 The clients should be able to run on a LAN/WAN or as a WEB client on the Internet or Internet without deploying multiple front ends.

18.30 OTHER CONNECTIVITY

18.30.1 The SCADA shall allow for additional data types to be connected. This should include databases as well as WEB services, OPC and others. Connectivity should allow data types to be used within the SCADA client. This might include being able to query data from data tables for use in the SCADA. Data connectors shall be able to be added without affecting the installation.

18.31 INTEGRATION AND INTEROPERABILITY

18.31.1 The system shall support all the current de facto industry standards for open system interfaces – OLE, DDE, CSV. The Software shall easily and seamlessly connect to other third party applications such as Excel, Lotus, Access, SQL Server, Oracle, Delphi, PowerBuilder, Visual Basic, etc. SCADA systems that 'lock' the user into one programming language/environment will not be considered for this project. All properties or attributes of all tags must be accessible this way, i.e. no artificial restriction to value only attributes will be acceptable. An ODBC, ADO and OLEDB native interface should be supported without the requirement for additional software or extra coding. The interfaces shall allow the SCADA to log any attribute of any tag into a log file or into a database at the same time with different sample resolutions.

18.31.2 The SCADA shall be able to interact with a database bi-directionally and a specific field in a specific table should be able to be browsed form within the SCADA.

18.32 EXPANDABILITY

18.32.1 The software and hardware shall be able to be expanded to allow for any future additions or modification to the installation.

18.33 HUMAN MACHINE INTERFACE (HMI)

18.33.1 The HMI shall allow the user to interact with the SCADA system in an easy to understand and user friendly way. The HMI shall have the following functions on the main screen (depending on the size of the installation, more than one screen may be used):

18.33.1.1 Overview of the electrical equipment under supervision.

18.33.1.2 Background drawing of the facility with interactive symbols overlay.

18.33.1.3 Photo or graphical image of the electrical or any other device being supervised by the system.

18.33.1.4 Main drop down menu with authorization to other information as listed on the drop down menu or as specified in the project specification.

18.33.1.5 Drop down menu with predefined selections to best describe the problem.

18.33.1.6 Login or logout selection or biometrics login or logout.

18.33.1.7 Auto logout by the system.

18.33.1.8 Acknowledgement of alarm area or pop-up screen.

18.33.1.9 All electrical information to be stored and easily available.

18.33.1.10 Facility to upload data onto the database.

18.33.1.11 Screen to change to display relevant data of the event or alarm.

18.33.1.12 Display status on all communication protocols available.

18.33.1.13 The security to be set for each type of user by an administrator or master user.

18.33.1.14 The security levels shall be set up in accordance to the security levels as required by the client. The system shall be fully flexible in this regard.

18.33.1.15 No Internet or any Windows application shall be available when the SCADA system GUI is running. Only an approved user shall have the authority to shut down the application and only by logout.

18.33.1.16 All events shall be logged in the database.

18.33.1.17 Any peripheral that can be switched, started, stopped, opened, closed or powered up or down or whatever the case may be, shall be fully interfaced with the HMI.

18.33.2 The Contractor shall note that the items listed in the standard specification are the minimum requirements of the system and additional functionality may be required.

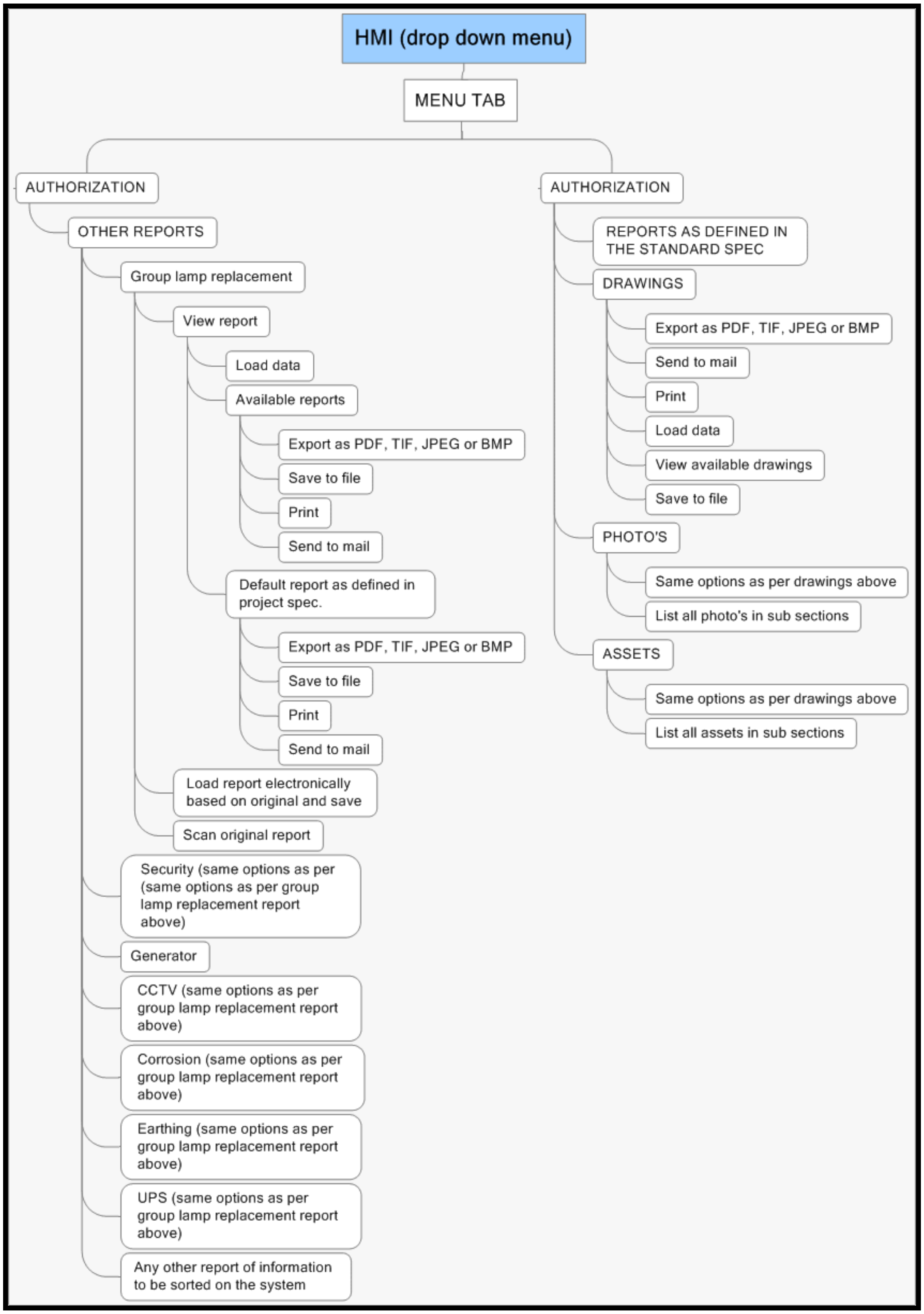


FIGURE 18-4: HMI (DROP DOWN MENU)

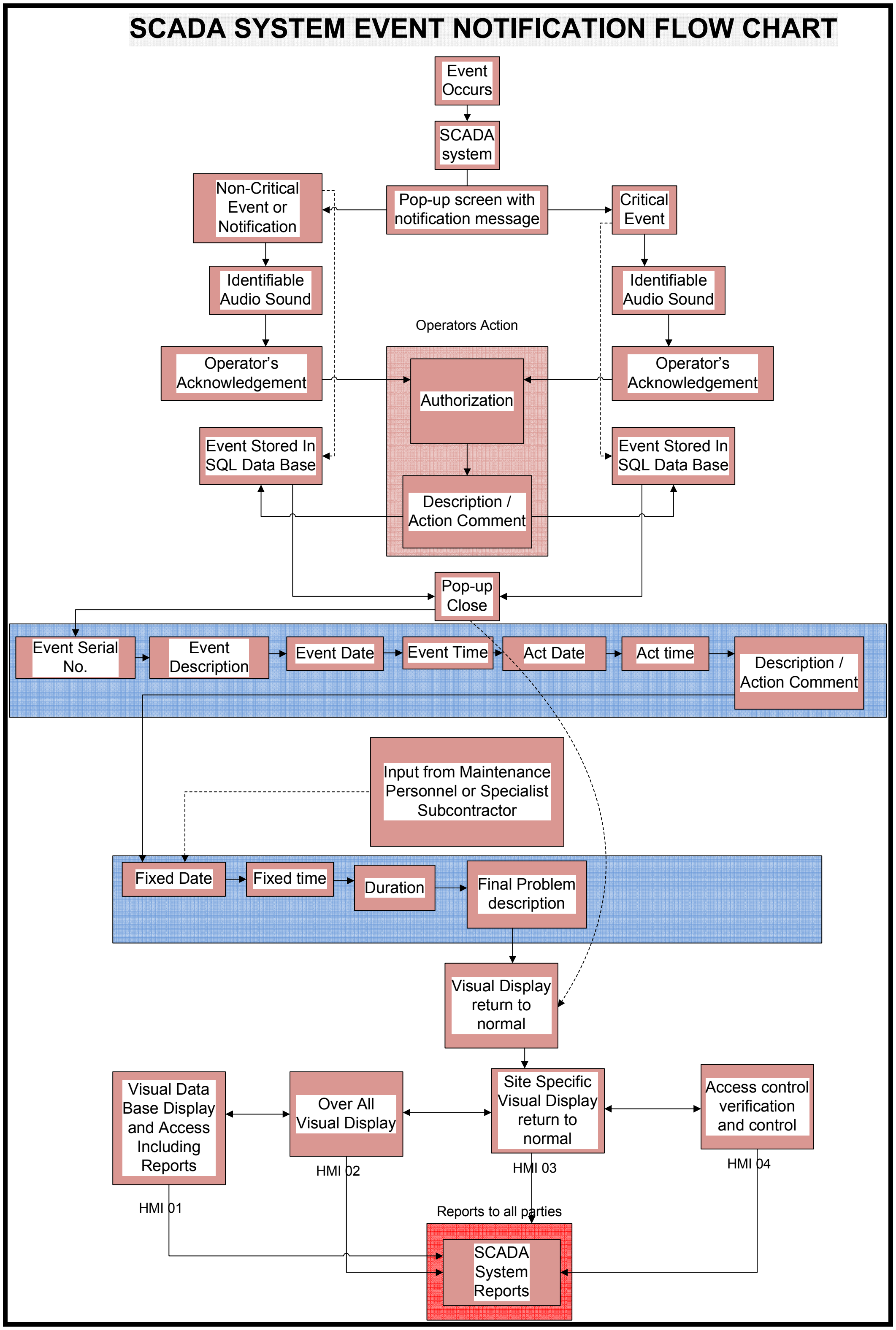


FIGURE 18-5: SCADA SYSTEM EVENT NOTIFICATION FLOW CHART

18.34 REPORTING

18.34.1 Detail, complete and user-friendly reports shall be easily available to the user for the operation and maintenance of the installation and equipment as detailed under Annexure E and D. The reports shall include but not be limited to the following:

18.34.2 Operational and Maintenance reports (See Annexure D):

k) Comprehensive report.

l) Event notification report.

m) Alarm notification report.

n) Critical Alarm notification report.

o) Maintenance report.

p) Outstanding items report.

q) Remote operation report.

r) Exception report – The software shall report any exceptions on any control or monitor field devices in the system. The system shall compile averages of each field device for a day, week, month or year and report any abnormalities above the average, e.g. a security door that is opened on a Sunday with no previous record of this operation on a Sunday will generate an exception report. The SCADA system shall implement this report after the first calendar month.

s) CMMS report.

t) ORT BOS interface and Traffic reports, this report can be tested and implemented during milestone 6 if approved by the Engineer.

18.34.3 Equipment reports (See Annexure E):

a) Equipment failure report.

b) Generator report.

c) UPS report.

d) Temperature report.

e) Power Quality report.

f) Access control system report.

g) Alarm system report.

h) CCTV system report.

i) SCADA overall status report – report system status on data stored, storage space remaining, server maintenance, server usage, software information i.e. all licenses information, latest updates and antivirus/antispyware update status with renewal dates, etc.

j) Trend report.

18.34.4 Pro forma Operational reporting on general and scheduled maintenance:

a) Generator maintenance report (6 monthly) (See Annexure F for report pro forma)

b) UPS maintenance report (Bi-monthly) (See Annexure G for report pro forma)

c) Earthing site test report (6 monthly) (See Annexure H for report pro forma)

d) SCADA system maintenance (See Annexure I for report pro forma)

e) Corrosion report every three years (pro-forma original to be scanned and stored or new to be developed with ORT contractor in future)

f) Road and area lighting report (See Annexure J for report pro forma)

g) General day-to-day maintenance report (no pro forma original to be scanned and stored or new to be developed with ORT contractor in future). The report shall be designed and laid out during the implementation and commissioning of the system with the ORT contractor.

18.34.5 The pro forma reports shall be printable with empty fields to be completed by maintenance contractor onsite. The data shall be uploaded after the maintenance work has been completed and the original report scanned and filed on the SCADA system. It shall be possible to extract trend reports on the field data.

18.34.6 The reports shall be divided into sub-reports with dedicated serial numbers that can be audited and verified that they are complete and correct.

18.34.7 All logged data are automatically summarised each night for historical reports. Users have the option to print the standard reports included with the SCADA System or create their own reports by requesting the SI to implement a new report type. All logged data can also be imported into Microsoft Excel.

18.34.8 There are four report types in the Report Module that an operator can select and each report type displays data from a different viewpoint over a specified period selected by the user.

Daily - prints and displays a report of hourly averages and totals for the date selected. The user may select Month, Day, Year and Starting and Ending Hour in military time for the report.

Weekly - prints and displays a report of daily averages and totals for seven days from a beginning date. The user may select Month, Day and Year. The date is the first day of the reported week.

Monthly - prints or displays a report of the daily averages and totals for a selected month and day range. The user may select Month, Year and Starting and Ending days for the report.

Yearly - prints or displays a report of the monthly averages and totals for a selected year and month range. User may select Year and Starting and Ending months for the report.

18.34.9 Each Report Style (Period and Instance) is used differently according to the selected Report Type (Daily, Weekly, Monthly and Yearly).

18.34.10 Period Reports are intended to show totals and averages for a time frame. Instance Reports are intended to show the actual values at an instant in time.

18.34.11 Reports are:

Detail Reports	-	using up to 10 variables per report, these reports break down one site in hourly format for daily reports, daily format for weekly and monthly reports, and monthly format for yearly reports. Also, Detail Reports can be set up for one variable over several sites. These reports are usually used to troubleshoot a site or sites at 24-hour intervals.
Summary Reports	-	give the totals or averages for all sites at once. These reports are the best for typical system reports and helpful in locating a site that needs watching more closely.
Combination Reports	-	allow several daily reports to be printed at once. The best use for this report style is for monitoring several sites over several days. It saves the user time printing several daily reports at one time instead of each report being selected and printed one by one.
Graphs	-	allow trends to be seen quickly and can be viewed in several formats. The trends can be set up to display the system's averages or one site's averages. The graphs can be viewed in 2-D or 3-D with bars, lines, curves, etc. The graph data can be copied to the clipboard, titles can be changed, and the scale can be changed.

18.34.12 Instance Reports are:

History Reports	-	show every variable logged by the system with a timestamp and can be set up for all sites at once in a group or one site at a time. The number of data types is selectable from all to one. Though this is a great debugging tool, it is recommended to print one site at a time because this report can become very long.
Last Instance Reports	-	show the last polled value for all sites at once or in a group or for the specific selected item e.g. fuel level of a specific generator. This report is the best way to see the system's current state.

18.34.13 The SCADA shall have the function to export any report or graphs to PDF or excel format.

18.35 OBJECT ORIENTED GRAPHICS

18.35.1 Mimic screens shall be graphically based on dynamic and static objects (where possible, real images of the equipment shall be used). The system shall support true vector based graphics and allow unlimited panning and zooming without any degradation in mimic resolution and sharpness. There shall be no limitation to the screen resolution and/or number of colours supported. A comprehensive standard graphics symbol library shall be provided that will allow modification and/or adding of custom symbols to the library easily without requiring additional software. All library symbols shall support unlimited panning, zooming and sizing. It shall be possible to dynamically move, size and rotate all graphic objects linked to changes of state in the online database.

18.35.2 The package shall have conventional CAD type editing facilities to ensure that the mimics are easy to build and modify. It shall be possible to launch third party applications from within a graphic page, by operator action or on process event, as well as configure user-specified, process-triggered, hypertext help pages for display.

18.35.3 The SCADA system shall allow mimics to be “replayed” from historically logged data as well as live real-time data. The Operator must have the ability to simply toggle a real-time mimic into historical mode. The replay feature shall be in-built and should not require additional configuration. The SCADA shall support dynamic toll tips allowing multiple tags to be configured and updated in the toll tip.

18.35.4 User Interface adaptability will allow for the creation of new presentation layer objects such as pictures trends, wizards, templates, animation behaviours, alarm and event views, etc. Templates shall be supported for trends and graphic pages. The tag assignment shall depend on the selection of the common plant areas.

18.35.5 The mimics must support the concept of levels and layers.

18.35.6 The minimum must support ActiveX and Windows controls.

18.35.7 The mimics must support VB.NET and/or C# scripting.

18.35.8 The mimics must support real-time multi-language translation according to the logged on

18.36 FAULT TOLERANT

18.36.1.1 The package shall be capable of supporting a distributed active fault tolerant cluster model. This must provide the following:

18.36.1.2 A true fault tolerant system – providing the basis for continuous availability of the system.

18.36.1.3 System integrity – the system's permanent and cached data shall be duplicated so that any component failure will not result in the loss of data for the remaining components.

18.36.1.4 Clustering of the fault tolerant server nodes – the duplicate server nodes should appear as one logical unit from any client's perspective.

18.36.1.5 Continuous availability – the system shall detect a node failure and quickly take appropriate action so that the remaining components can continue uninterrupted thereby providing clients with continuous live data and operation.

18.36.1.6 Active fault tolerant clustered nodes – duplicate nodes are actively involved in useful work thereby providing increased throughput of the system.

18.37 INTERFACE

18.37.1 The system shall support all the current de facto industry standards for open system interfaces – OLE, DDE, CSV. The Software shall easily and seamlessly connect to other third party applications such as Excel, Lotus, Access, SQL Server, Oracle, Delphi, PowerBuilder, Visual Basic, etc. SCADA systems that 'lock' the user into one programming language/environment will not be considered for this project. All properties or attributes of all tags must be accessible this way, i.e. no artificial restriction to value only attributes will be acceptable. An ODBC, ADO and OLEDB native interface should be supported without the requirement for additional software or extra coding. The interfaces shall allow the SCADA to log any attribute of any tag into a log file or into a database at the same time with different sample resolutions.

18.37.2 The SCADA shall be able to interact with a database bi-directionally and a specific field in a specific table should be able to be browsed form within the SCADA.

18.38 REMOTE OPERATION

18.38.1 The SCADA system shall have the functionality to switch or start equipment or peripherals as may be needed for access or to test equipment e.g. open locks for maintenance personnel or start a generator to test the unit, etc.

18.38.2 All remote tests shall be stored in the database with the required authorisation and a short description on the test details. The maximum average and minimum values of the test shall be automatically stored in separate fields that are specific to the test. Any out of specification values shall be reported by the SCADA system. All fields populated automatically shall not be editable.

18.38.3 The Subcontractor shall supply and install RS232 or RS485 to Ethernet converters with the following minimum specification:

a) FEATURES: RS232 to ETHRENET CONVERTER

- Local or Worldwide Ethernet 10/100M or Internet Connection

- Serial baud rates (300, 600, 1200, 2400, 4800, 9600, 19.2k, 38.4k, 115.2K,...921.6K)
- Ethernet activity, Power LED's
- Web Server, configuration and user pages
- DB9 12" molded cable DCE (female), male adapter included
- Included AC Power adapter, 500mA @ 9VDC (Terminal Block available)
- Plastic housing,
- OEM versions available for small minimum quantity
- CD with Manuals, PC Setup and Virtual COM Port Redirector Software to be provided.

b) Features: RS485 to ETHERNET CONVERSION

- Local or Worldwide Internet Connection
- 10/100Mbit Ethernet - Auto-Sensing
- Serial baud rates (2400, 4800, 9600, 19.2k, 38.4k, 115.2K,...921K)
- Ethernet activity, Power LED's
- Web Server, configuration and user pages
- RS485 or RS485 Multi-Drop network support
- RS422 Support (half-duplex only)
- 7-pole terminal block for power and data lines
- Jumpers to enable optional Tx/Rx Termination Resistors
- DIN Rail and Surface Mount clips to be provided
- CD with PC Setup and Virtual COM Port Software to be provided

18.39 MINIMUM SPECIFICATION FOR THE OVER TEMPERATURE DEVICE

18.39.1 The Temperature Alarm is a microprocessor-based dual-setpoint temperature alarm suitable for environmental and industrial applications. It sounds an alarm and controls the operation of two electrical circuits whenever the temperature reaches either of two independently set limits. The temperature range is-40° to 80°C and the alarm range is the same. The alarms can be selected to operate either greater than or less than the selected temperature output. A liquid crystal display provides readout of the measured temperatures and is also used to display maximum and minimum temperatures as well as the values of the various alarm parameters using a series of setup menus.

18.39.2 Self-contained relays for each alarm point can be used to trigger an alarm on the SCADA system. These internal relays may be used to control external power relays if high current loads are to be switched. An audible alarm, which may be silenced if desired, shall also included. To eliminate erratic or premature operation of controlled devices, the controller shall have a delay or conformation interval prior to the initiation of an alarm and also a delay time prior to negating an alarm.

18.39.3 All setpoints and maximum and minimum temperature values are stored in non-volatile memory so that these values are not lost if there is a power failure. The circuits are designed to have high electrical noise immunity to transient spikes generated by loads being switched with the alarm relays. The unit restarts in the running mode after a power failure.

18.39.4 The temperature specifications shall be as follows:

a) Temperature sensor: Precision thermistor

b) Measurement range -40° to +80°C

c) Alarm range -40° to +80°C

d) Resolution 0.1°

e) Accuracy ± 0.2°C)

f) Alarm ON and OFF delay range 0-99 seconds

g) Controls Protected push buttons that select
Run or set variables
Select menu item
Increment alarm setting
Decrement alarm setting
Clear stored max and min values

h) Indicators LEDs for alarm point 1 and 2
2 line x 16 character LCD
Display character size 3x8 mm

i) Operating temperature Control module only -20° to +50° C

j) Input power 12 Vac or dc

k) Output Analogue (4 to 20 mA for -20° to 80°C) to Ethernet (TCP/IP)

l) Current 50 mA maximum

m) Alarm Contacts rated 3A @ 24 Vdc/230 Vac

18.40 RTU/PLC MINIMUM SPECIFICATION

18.40.1 Small platform, 32-bit processing, high speed LAN and USB communication, advanced power-saving features, plus data logging to USB mass storage devices.

18.40.2 The RTU/PLC shall take power conservation in mind.

18.40.3 The RTU/PLC shall uses industry-standard Modbus and DNP3 serial protocols as well as Modbus TCP and UDP-based Ethernet protocols. Two USB ports provide an additional PC communication link as well as support for a USB memory stick when data logging.

18.40.4 Minimum specifications:

a) Processors: CPU: 32-bit ARM7 microcontroller, 32 MHz clock, integrated watchdog timer. Microcontroller co-processor, 20 MHz clock

- Memory: 4 MB SRAM, 16MB flash ROM
- Non Volatile: CMOS SRAM with lithium battery retains contents for 2 years with no power
- Datalog Capacity: 465k words
- Analog Inputs: 8, 0-20/4-20mA / 0-5/0-10V (15-bit) software configurable
- Analog Outputs: Standard: None. 2, 0-20/4-20mA (12-bit) with optional 5305 on 5607 I/O board
- Digital I/O: 16, 12/24V, 48V, 115/125V, 240V digital inputs. 10, relay outputs (dry contact or DC solid state)
- Counter Inputs: 1, 0-10Hz or 0-5kHz (dry contact); 2, 0-10kHz (turbine or dry contact)
- Serial Port COM1: RS-232 port, 8-pin modular RJ45 jack, full or half duplex, or RS-485 port, 2-wire, half duplex
- Serial Port COM2: RS-232 port, 8-pin modular RJ45 jack, full or half duplex, or RS-485 port, 2-wire, half duplex
- Serial Port COM3: RS-232 port, 8-pin modular RJ45 jack, full or half duplex with RTS/CTS control and Vision OIT power control
- Baud Rates: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200
- Serial Protocols: Modbus RTU, Modbus ASCII, DNP3, DF1
- Serial Protocol Modes: Slave, Master, Master/Slave, Store and Forward
- Ethernet Port: RJ45, 10/100BaseT
- Ethernet Protocols: Modbus TCP, Modbus RTU in UDP, Modbus ASCII in UDP, DNP in TCP, DNP in UDP
- Network Protocols: IP, ARP, TCP, TFTP, UDP and ICMP
- USB Host Port: USB 2.0 compliant “A”-type receptacle, provides up to 100mA at 5V
- USB Peripheral Port: USB 2.0 compliant “B”-type receptacle
- Wireless 1: Spread spectrum radio at 900MHz2 and 2.4GHz2
- I/O Terminations: 5, 6 and 9-pole removable terminal blocks, 12 to 22AWG, 15A contacts
- Dimensions: 5.65 inch (144mm) wide, 6.50 inch (165mm) high, 2.80 inch (72mm) deep
- Packaging: Corrosion resistant zinc-plated steel with black enamel paint

- Environment: 5% RH to 95%, non-condensing, – 40°C to 70°C
- Power: 11 - 30VDC, 12mW at 12V during Sleep. 510mW at 12V during normal operation. 32MHz, LEDs off, no expansion, LAN and USB disabled 320mW at 12V during reduced power mode operation. 12MHz, LEDs off, no expansion, LAN and USB disabled 1.2W at 12V during normal operation. 32MHz, LEDs off, no expansion, LAN enabled and USB disabled. Add 25 to 100mW when enabling the LEDs. 8.5W at 24V maximum, 5V supply fully loaded. 11 - 30VDC, 10.3mA plus analog outputs
- DNP and IEC 60870-5 Compliance: For your convenience, Control Microsystems provides a series of DNP3 Device Profile and IEC60870-5 Interoperability documents that detail the level of implementation of both these protocols within our products. This information, coupled with other third-party device profile and interoperability documents, provides a set of commonly supported protocol functionality.

18.40.5 All RTU Digital outputs shall be wired to individual 24 DC Interposing relays with Normally Open and Normally closed contacts.

18.41 RECOVERY PACK & CLONING/GHOSTING

18.41.1 The SCADA system shall have a full recovery pack with all data and software to reinstall on a server when required.

18.41.2 Cloning of the server shall also be done after the commissioning of the SCADA system to further reduce recovery time. A copy of the cloning HDD shall be stored at the redundant site.

18.42 AUDIT AND VERIFICATION

18.42.1 The software shall provide a complete audit and verification facility.

18.42.2 The SCADA system shall at least comply with the generally accepted practices for auditing as specified herein.

18.42.3 Each and every alarm, event and data entry shall have a uniquely identifiable and traceable number stored by the SCADA system.

18.42.4 The SCADA system shall ensure that each Entity shall store those data that are collected on and/or reside on its system. Audit trails shall be required of all updates to data in the system.

18.42.5 The SCADA system shall incorporate automated verification procedures to verify that all the required data elements were successfully communicated from one system to the other. Data integrity verification and request of missing data shall be performed at pre-defined intervals.

18.42.6 All reports submitted to the Employer in electronic or any other format shall reflect the data integrity status, e.g. whether the day/month is closed, of the data or statistics reflected in any such report.

18.42.7 The SCADA system shall be auditable in terms of System User access to the system.

18.42.8 The Server hard disk shall be used to record all system activity for archiving purposes. It shall not be possible to alter archived data.

18.42.9 Every system activity event along with all details, including but not limited to the following list, shall be time stamped with the time of occurrence to the nearest second and shall be recorded in the system activity log for archiving.

a) All access attempts (allowed and disallowed).
b) Alarm events.
c) System events.
d) Operator activity.

18.42.10 The central control shall provide an on-line facility to archive system data and event records to an archive file to free hard disk space for further activity logging.

18.42.11 The archive process shall be initiated by either manual operation or automatically by time.

18.42.12 It shall be possible to nominate the number of days of data that shall remain on the server subsequent to an archive process.

18.43 SUPPORT

18.43.1 Sufficient local support shall be available for the hardware and software. The contractor shall provide sufficient proof of local support for the hardware and software.

18.44 GUARANTEE

18.44.1 A minimum of 12 months guarantee shall be provided for the hardware and software on workmanship and system failure.

18.45 INDUSTRIAL STANDARDS

18.45.1 The following industrial standards shall apply.

18.46 LABELLING

18.46.1 All hardware and cabling shall be labelled and be easily traceable in the schematic drawings to be provided. The Contractor shall get approval from SANRAL for the proposed labelling to be used. It may be necessary to do one site for approval should it be required by SANRAL, prior to manufacture.

18.46.2 All labelling and schematics shall be stored electronically on the SCADA system.

18.47 OPERATION

18.47.1 The SCADA system shall be a user-friendly Windows based or similar approved operating system that can easily be modified to comply with changing environments and operational requirements.

18.47.2 One or more personnel shall monitor and operate the SCADA system to ensure all alarms and events are attended to in the shortest possible time. The Contractor shall provide additional personnel should it be required by the system.

18.48 COMMISSIONING

18.48.1 Commissioning is a quality-orientated process for achieving and documenting that the performance of systems, facilities and assemblies meets pre-defined objectives and criteria. Commissioning ensures that quality, performance and functionality meet the demands of a specification, as it was formulated from the needs and requirements of the client.

18.48.2 Because the process of Commissioning is so comprehensive, it provides the opportunity to evaluate, or formulate the preventive, predictive and corrective actions of operational and maintenance procedures and manuals.

18.48.3 The benefits of proper Commissioning include:

18.48.3.1 Improved workplace performance

18.48.3.2 Reduced risk factors and threats

18.48.3.3 Prevention of business losses

18.48.3.4 Identifying weaknesses

18.48.3.5 Quality documentation for maintenance and operations

18.48.3.6 Cost control

18.48.3.7 Less downtime

18.49 COMMISSIONING GOALS

18.49.1 Throughout the entirety of this document, the specification of this project is defined. The purpose of commissioning this project is to ensure that functionality, quality, safety and efficiency in terms of the specification are met.

18.49.2 The Contractor shall provide a Commissioning matrix if not supplied by SANRAL or the Independent Engineer. Each site shall have some or all of the listed equipment and may even have additional equipment. This matrix may be used or incorporated as a test procedure when Commissioning starts. Note that columns under Commissioning are called Operational functionality, Quality, Risks and Efficiency. The test procedure must be defined in each of these columns to verify the compliance of each of the items in terms of the specification. Use the current comments as a minimum test, but feel free to elaborate in order to ensure comprehensive checking and testing.

18.49.3 SCADA GUI (Operational Functionality): Use this field to describe the scenarios that need to be tested from an "Operator" point of view (What functionalities this item requires).

18.49.4 DB Management: Use this field to clarify what records need to be inserted into the database for the different states or scenarios.

18.49.5 Risks: Use this field to list possible risks. These risks can be physical or system related.

18.49.6 Test Procedure: Use this field to describe a test procedure that will ensure that all functionalities and scenarios are covered.

18.49.7 You may choose to have one sheet where the test procedures are listed and a separate sheet where the results are recorded, or you may want to incorporate the test procedure and the results into one document.

18.50 COMMISSIONING STAGES AND TIMING

18.50.1 Due to the fact that irreversible problems or enormous financial burdens can occur when problems are not identified early enough during implementation, it is important to identify various staged for commissioning during the process of building/installing/implementing in order to prevent snowballing effects of problems. These commissioning phases or stages should be established early, even before implementation start and should be determined in co-operation with, or by the system supplier-/-installer who has most experience and knows where the risk areas are in the process.

18.50.2 Commissioning should be planned carefully in advance, taking into account the timing constraints that may be crucial for implementation, depending on the situation.

18.51 SPECIFIC STANDARDS

18.51.1 Although the client will produce a specification, it is important that all other standards and specifications applicable by South African laws and standards are met and it is the Tenderer's responsibility to point out any conflicts or grey areas between the client's specification and applicable laws and standards.

18.52 DEFINE THREATS, RISKS AND CONSEQUENCES

18.52.1 It is important to note that a part of the purpose of Commissioning is to ensure that functions and procedures etc. are working safely and properly. Before testing commences, it is important to understand that certain procedures may fail, causing damage to equipment or endangering lives. These types of risks need to be identified beforehand and listed in the Risks column. Before each test commences, anticipated risks must be isolated or eliminated as best possible and where not possible, disaster recovery procedures must be in place in the event of malfunction to minimize the effect.

18.53 SPECIAL TESTING NEEDS

18.53.1 It is important to note that in order to facilitate a Commissioning test, there may be specific needs for different equipment. There will almost always be a requirement for teams of people on the operator’s side and on the plant side with proper communication equipment to successfully conduct these tests. Other specialized Contractors and pre-arranged conditions may also be required for testing.

18.54 DOCUMENT COMPLIANCE

18.54.1 During and after Commissioning, the documentation used for testing serves as a historical record of the owner’s expectations and performance delivered.

18.54.2 Testing and Maintenance documentation must be provided and verified with the process of Commissioning.

18.54.3 Operating and Training Manuals must also be provided and verified during the process of Commissioning.

18.55 INSPECTIONS & TESTING

18.55.1 The Tenderer shall carry out the following factory acceptance testing in order that the Engineer may witness compliance of the SCADA client layout and operation, reporting and functionality to the specified requirements:

a) Layout shall be approved including functionality. A functional layout may be proposed for the Engineer to approve.

b) Database shall be approved including functionality. A functional layout may be proposed for Engineer to approve.

c) Reports shall be approved. Report layout shall be approved by the Engineer.

d) Each alarm condition shall be simulated, acknowledged, captured in database and reported in any of the required reports as selected.

e) Each visual alarm shall be tested.

f) Each audible alarm shall be tested.

g) Alarm sequencing verification.

h) Each peripheral shall be tested for responsiveness. Peripheral to open/close, stop/ tart, etc. when selected.

i) Test e-mail and SMS functionality.

j) Test recovery pack. The recovery test will be one on a separate server with only an OS loaded. The server that replaces the existing and the SCADA system shall function without any changes or set-up changes. Only contact details may be changed. The software must be able to generate a recovery disk when requested and once every year.

k) Check drawings and single line diagrams proposed including descriptions and labelling. Original layout drawings of the infrastructure shall be used where possible.

18.55.2 The Tenderer shall carry out the following site acceptance testing in order that SANRAL may witness compliance of the SCADA system to the specified requirements:

a) Test all alarm functionality as per the factory acceptance testing.

b) Test database functionality as approved during the factory acceptance testing.

c) Audit reports based on site testing.

d) Each visual alarm shall be tested.

e) Each audible alarm shall be tested.

f) Test fibre optic and GSM communication.

g) Test e-mail and SMS functionality.

h) Check drawings and single line diagrams proposed including descriptions and labelling.

18.56 DRAWINGS AND INFORMATION

18.56.1 The Tenderer shall submit full details of the SCADA system, including the following:

a) Complete hardware and software list.

b) List of software licences.

c) Drawing indicating all dimensions of the alarm panel and equipment layout.

d) Drawing indicating typical mounting and fixing details. These drawings shall clearly indicate all dimensions of the component items, electrical fixing details and electrical connections.

18.56.2 The Tenderer shall provide one set (1 x hard, 1 x PDF, 1 x Word) of operating manuals for the alarm system as installed, prior to final Commissioning for approval.

18.56.3 The manuals shall contain comprehensive technical data catalogues, operating instructions and detailed wiring diagrams complete with cable wire and core numbering as well as terminal block numbering.

18.56.4 The Tenderer shall provide full details of spares sourcing at the time of handover.

18.56.5 All relevant information e.g. drawing commissioning documentation, licences, etc shall be stored on the SCADA system in PDF file format.

18.57 SCADA DATA AND COMPLIANCE SHEET

TABLE 18-1: SCADA DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
N/A						
SCADA						
	CLAUSE					
18.51.1	18.2	ELECTRICAL FENCE				
18.51.2	18.3	GSM MODULE				
18.51.3	18.4	OVER TEMP				
18.51.4	18.5	CCTV				
18.51.5	18.6	SECURITY SYSTEM				
18.51.6	18.7	VOIP COMMUNICATION/ PABX				
18.51.7	18.8	VOIP PHONE/INTERCOM SYSTEM SATELLITE CENTRE				
18.51.8	18.9	VOIP PHONE/INTERCOM SYSTEM COC				
18.51.9	18.10	ACCESS CONTROL SYSTEM				
18.51.10	18.11	UPS				
18.51.11	18.12	POWER QUALITY AND SITE INFORMATION				
18.51.12	18.13	GENERATOR				
18.51.13	18.14	General				
18.51.14	18.15	Workstation				
18.51.15	18.16	Server				
18.51.16	18.17	Software requirements				
18.51.17	18.18	SQL database				
18.51.18	18.19	Software licence				
18.51.19	18.2	Data communication				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
18.51.20	18.21	Networking				
18.51.21	18.22	Network security				
18.51.22	18.23	.Net framework				
18.51.23	18.24	Notification				
18.51.24	18.25	Remote access				
18.51.25	18.26	Other CONNECTIVITY				
18.51.26	18.27	Integration and interoperability				
18.51.27	18.28	Expandability				
18.51.28	18.29	Reporting				
18.51.29	18.3	Object oriented graphics				
18.51.30	18.31	Fault tolerant				
18.51.31	18.32	INTERFACE				
18.51.32	18.33	REMOTE Operation				
18.51.33	18.34	RECOVERY PACK				
18.51.34	18.35	Audit and verification				
18.51.35	18.36	Support				
18.51.36	18.37	Guarantee				
18.51.37	18.38	Industrial standards				
18.51.38	18.39	Labelling				
18.51.39	18.4	Operation				
18.51.40	18.41	Commissioning				
18.51.41	18.42	COMMISSIONING GOALS				
18.51.42	18.43	DEFINE THREATS, RISKS AND CONSEQUENCES				
18.51.43	18.44	SPECIAL TESTING NEEDS				
18.51.44	18.48	DOCUMENT COMPLIANCE				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
18.51.45	18.49	Inspections & Testing				
18.51.46	18.50	DRAWINGS AND INFORMATION				

19. SECURITY AND ACCESS CONTROL REQUIREMENTS

19.1 INTRODUCTION

19.1.1 Security Elements

19.1.1.1 All elements of security can only achieve one of more of the following five basic functions:

(a) Deterrence

(b) Detection

(c) Assessment

(d) Reaction (delay and response)

(e) Evidence gathering

(f) Electronic security systems can act as a deterrent, perform detection, assist in the assessment of the event with regard to its severity, assist in reaction, and gather evidence.

(g) The minimum functions applicable to the security and access control system are:

(h) Deterrent (e.g. fencing, access control with guardhouse, visible CCTV cameras)

(i) Detection (e.g. alarm sensors, CCTV)

(j) Assessment (e.g. CCTV verification of alarm sensors)

(k) Reaction (e.g. audio communication with intruder)

(l) Evidence gathering (e.g. logging of alarms and recording of CCTV images)

19.1.1.2 The Command Centre will be housed in the Central Operations Centre from where operators will monitor all the security activities.

19.1.2 Typical security levels

19.1.2.1 The security will be divided into five (5) levels with the following specifications:

(a) Level 0: This level will enforce access control with security fencing and security gates with manual locks.

(b) Level 1: This level will enforce access control with security doors and gates with magnetic and/or electric locks.

(c) Level 2: This level will enforce access control with security doors and gates with magnetic and/or electric locks in conjunction with smart card readers and cards.

(d) Level 3: This level will enforce access control with security doors and gates with magnetic and/or electric locks in conjunction with biometric readers with incorporated keypads.

(e) Level 4: This level will enforce access control with security doors and gates with magnetic and/or electric locks in conjunction with biometric readers with incorporated keypads and CCTV.

(f) Level 5: This level will enforce access control with security doors and gates with magnetic and/or electric locks in conjunction with smart card readers and cards, biometric readers with incorporated keypads and CCTV in conjunction with CAT 4 safe doors.

19.1.2.2 In general, the facility design should be such that movement to and from a certain level of security should be through the next higher or lower security level.

19.1.3 Toll Plaza levels

19.1.3.1 The Central Operations Centre will be divided into the following areas with associated security levels:

(a) Level 0: The area within the fenced area (the total external site)

(b) Level 1: The public access area inside the COC building

(c) Level 2: Restricted staff area (beyond first set of doors and stairs)

(d) Level 3: Command Centre and Management area

(e) Level 4: Server room

(f) Level 5: Vault

19.1.4 Satellite or remote sites Security Levels

19.1.4.1 The Satellite or Remote sites will be divided into the following areas with associated security levels:

(a) Level 0: The area within the fenced area (the total external site)

(b) Level 1: The public access area inside the Satellite Centre building

(c) Level 2: The area beyond the first set of doors and stairs

(d) Level 3: Management area and area where desks are to serve the public

(e) Level 4: Server room

(f) Level 5: Vault

19.1.5 Other smaller facilities

19.1.5.1 The Technical Shelters will be divided into the following areas with associated security levels:

(a) Level 0: The area within the fenced area (total external site)

(b) Level 1: Not applicable

(c) Level 2: Not applicable

(d) Level 3: Restricted staff area including gantries

(e) Level 4: Equipment room

(f) Level 5: Not applicable

19.2 FACILITY SECURITY REQUIREMENTS

19.2.1 Toll Plaza centre

19.2.1.1 The Toll Plaza centre shall have the following minimum security requirements:

(a) Separate maintenance and warehousing structure

(b) Associated parking/carports with reserved spaces for Toll Plaza centre vehicles

(c) Toll Plaza centre building will not serve the purpose of a face-to-face customer service facility

(d) Single entrance point to the building complex with associated site guardhouse

(e) Single entrance into main building for desired access control

(f) Emergency doors to be strictly monitored

(g) No direct access to each of the entities available from the outside

(h) General access will be through the central foyer area

(i) Controlled staff access permitted between the various entities

(j) Specific access to each of the entities should be from the central entrance foyer area or from a separate internal entrance for each entity

(k) Provision may need to be made in the operations rooms for the near future when the expansion is required

19.2.1.2 In addition to offices/workstations, provision needs to be made for other necessary building space as follows:

(a) Departmental meeting spaces;

(b) Ablutions;

(c) Recreational space such as rest rooms and canteen facilities or restaurant;

(d) Kitchenettes;

(e) Archives and store rooms;

(f) Safes;

(g) Printing rooms and Paper stores;

(h) Warehousing for tags;

(i) Server rooms;

(j) Plant and generator rooms;

(k) Central operations/control rooms;

(l) Maintenance facilities for electronic equipment and facilities (it is assumed that maintenance of vehicles will be outsourced);

19.2.2 Parking areas and associated roadways

19.2.2.1 Other facilities that may be housed in the COC building that may include Transaction Clearing House (TCH) or other operations and maintenance facilities

19.2.3 Satellite or Remote facilities

19.2.3.1 The Satellite facilities shall be based on the following security requirements:

(a) The assets shall be protected against theft and vandalism (high availability, protection of state/semi-state assets). The facility shall be secure.

(b) Camera surveillance of the platform is required.

(c) Access control back end equipment will be housed in toll equipment cabinets.

(d) The Satellite or Remote facilities will house equipment that a system supplier must be able to install and maintain. The maintenance can be periodic preventative maintenance or urgent corrective repairs. It is therefore a requirement that the maintenance people have the applicable access to the Satellite or Remote facilities at the applicable times. It is assumed that the maintenance people should always have access to the Satellite or Remote facilities. In other words, the access to the facilities should not be time or otherwise restricted.

(e) The access entry point shall be secure so that unauthorized access is minimized.

19.3 SECURITY PHILOSOPHY

This section has been included to indicate the philosophy that was used to determine the security requirements.

19.3.1 Access Control Elements

19.3.1.1 One of the basic concepts of security is to limit access to people who share a common interest with the organisation. Criminals, who will harm the organisation's people, take or misuse its physical property or intellectual property, or harm its good name, will not be allowed to enter. Access control systems use something that the person:

(a) is (biometric comparison),

(b) has (a token or smart card) or

(c) knows (a password),

(d) to make judgements as to whether the person should be allowed into a secure area.

(e) Systems commonly use a credential to identify the subject as a person who is authorized to be in a certain area at a certain time. Most credentials are in the form of an identification badge that the subject can wear.

19.3.1.2 Identification badges contain the following:

(a) Person's image

(b) Person's name

(c) Colour or pattern scheme

(d) Electronic coding used with card readers: allows security system to determine whether the bearer is permitted through a door, gate or portal at a specific time of day

(e) Keypads can be used instead of cards.

19.3.1.3 More secure systems use a biometric credential to determine that a person is authorized:

(a) fingerprint,

(b) hand geometry,

(c) retinal scan,

(d) iris scan,

(e) voice comparator,

(f) facial recognition,

(g) finger blood vessel scan or other measure.

(h) Often biometric readers simply confirm that the person is who he or she claims to be, by having presented a card or key code. In the most sophisticated variant, the biometric system actually identifies the user by matching the biometric sample against a vast database of other previously taken samples.

(i) Minimum Requirements for Access Control Elements per site

The following are the minimum requirements for the Security System:

i. Smart Cards

ii. Biometric Fingerprint Readers

iii. Keypads.

19.3.2 Detection Elements

19.3.2.1 If deterrence is the ultimate goal of security countermeasures, then detection is where deterrence begins. The ability to detect is at the heart of eliminating the probability of success of the criminal mission. Detection is a process that includes sensing, processing, transmitting the detection and reporting it to someone who can act.

19.3.2.2 There are many types of alarm sensors, including the following:

(a) Point detection: door, window, duress (panic switch) and floor-pad switches

(b) Beam detection: photoelectric or laser beams

(c) Volumetric: sensing of unwanted motion in a defined area

(d) Relay detection: sensing the condition of another process or system

(e) Capacitance detection: commonly includes numerous perimeter detection systems which detect the presence of a person in an area he or she should not be in

(f) Intelligent detection: utilisation of microprocessors and software to cause detection of a specific behaviour or condition in specific circumstances

19.3.3 Minimum Requirements for Alarm Sensors per site

19.3.3.1 The following are the minimum requirements for the alarm sensors for the Security System:

(a) Point detection

(b) Beam detection

(c) Volumetric detection

(d) Relay detection

(e) Alarm Processors

19.3.3.2 In most cases involving sophisticated security systems (including all enterprise security systems), the detection is processed locally before it is transmitted. Processing may involve simple decisions such as whether or not the detection is occurring during an appropriate time period (e.g. volumetric alarms in an office building lobby during normal working hours). The processing may be more extensive such as checking to determine whether a group of conditions is satisfied before triggering the alarm. The processing typically occurs in an alarm and access control system controller. The processor will usually also perform a check to ensure that the detection was received correctly.

19.3.4 Alarm Transmission

19.3.4.1 As soon as the alarm is processed, it must be transmitted to someone who can take action on the detection. Almost all integrated alarm system today use TCP/IP Ethernet connections and are sometimes converted to fibre optic or wireless (802.11 or other) mediums.

19.3.4.2 Minimum Requirements for alarm transmission per site

19.3.4.3 The following are the minimum requirements for alarm transmission for the Security System:

(a) TCP/IP Ethernet connections

(b) Converted to fibre optic for the backbone transmission

(c) Fibre Optic backbone between remote locations and the Command Centre at the Central Operation Centre.

19.3.5 Alarm Reporting

19.3.5.1 The detection is received by a monitoring device and is acknowledged by a person who can act on it. In enterprise security systems, the detection is almost always displayed on a computer with specialized software that is also capable of integrating access control, CCTV, voice communications and ancillary systems e.g. two-way radio, private automatic branch exchange (PABX), elevators, building automation and information technology.

19.3.6 Follow-on Action

19.3.6.1 Following detection and assessment, the security system should assist in preventing an adversary from successful completion of a malevolent action against a facility. Follow-on action is that integrated element which allows the enterprise security system to do some interesting things e.g. based on detection of an intrusion into a highly restricted area, the system can implement delaying barriers which might include dispatching personnel, activating vehicle or pedestrian barriers (rising bollards or roll-down doors), switching off all lights and disorientating audio signals (sounding alarms within the structure which raises the anxiety level of the intruder) to disrupt the progress of the intruder. Follow-on actions can also facilitate access for a legitimate user, such as turning on lights from a parking garage through lobbies, corridors and to the exact office of a card holder.

19.3.7 Assessment and Verification Elements

19.3.7.1 Some alarm notifications are nuisance conditions and not a real alarm and it is therefore important to vet all alarms so as not to respond to a tree branch falling against a perimeter fence. There are several ways that assessment can be achieved:

(a) Guard response assessment: dispatch a guard to check the alarm condition. This takes time and is costly. The delay before assessment is not desirable and it is possible that by the time the guard arrives at the alarm site, the person who caused it may be gone and therefore no verification is possible even though the alarm notification was real. Guard response assessment is not ideal.

(b) Second alarm sensor assessment: an alarm can also be verified by the activation of a second alarm. Although it is possible for a single nuisance alarm to occur, it is less likely that two nuisance alarms could occur in rapid succession. Alarms can therefore be linked to confirm each other.

(c) Audio assessment: in parking structures and other remote areas, audio alarms that respond to specific sounds such as a person screaming in alarm or fear are often used. The same microphone that caused the alarm can then be used to confirm it. By listening to the area where the alarm occurred, a console guard can confirm that the noise that activated the alarm was a real event.

(d) Video assessment: one of the most common forms of assessment is with video cameras. A guard can observe the condition at the scene of the alarm very quickly and this is a precise way of verifying alarms.

19.3.8 Minimum Requirements for Assessment and Verification Elements per site

19.3.8.1 The following are the minimum requirements for the assessment and verification elements for the Security System:

(a) Second alarm sensor assessment

(b) Video assessment.

19.3.9 Reaction Elements

19.3.9.1 After an alarm is verified, the organisation may choose to act on it. Options include deterring the intruder, delaying him or her or disrupting the intrusion. This requires reactive electronic automated protection systems (REAPS). There are three common types of REAPS:

(a) Communication elements: the most basic and least expensive method is to communicate with the intruder. Only the most determined intruder will continue after he or she is interrupted in the act. Security intercoms are often an effective and economical tool, which can be used to stop intruders in their tracks.

(b) Deployable barriers: more sophisticated systems utilise deployable barriers including rising bollards and wedges to stop vehicles, and electrified locks, roll-down doors and deployable operable walls to delay pedestrians. Environment disruption devices can be used to delay an intruder until a more formidable response force can arrive and take control of the offender.

(c) Attack disruption: in high security environments, it may be necessary to actually disrupt the intrusion or attack. This can include deployable smoke, fast setting and sticky foam dispensing systems, drop chains, explosive air bags, automated weaponry, deluge water systems, acoustic weapons etc. All of these have the common element of making it much more difficult for an attack or intrusion to continue and can result in the capture of the attacker or intruder. There are two types of attack disruption systems, non-lethal and lethal. Even some non-lethal systems can cause injury. In either case, it is important to implement safety measures in the activation mechanism to ensure that accidental activation does not occur and injure innocent people.

(d) Evidence gathering, storage and retrieval: one of the key elements of enterprise security systems is their ability to log alarms and events and to record video and audio which can serve as the evidence required to build a case against a criminal offender.

(e) Policy enforcement: one of the key capabilities of enterprise security systems is the ability to support safety, business ethics and security policy enforcement. The ability to detect improper behaviour, assess it as a real event and use the evidence to support additional training or enforcement is of tremendous value to any organisation. The systems can also help to determine chronic or determined policy abusers and provide the evidence necessary to weed out employees or contractors who are working against the best interests of the organisation. On the most basic level, access control systems do a wonderful job of controlling who goes where, helping to ensure that sensitive areas are limited to those with clearance and that visitors do not walk in the area un-escorted.

19.4 TECHNICAL SPECIFICATION

The following is the minimum specification to provide a fit-for-purpose security system for the infrastructure.

19.4.1 Access Control System

19.4.1.1 The access control system shall provide, but is not limited to the following functionality:

(a) Be able to integrate with other electronic security sub-systems (duress, CCTV etc.)

(b) Utilise both access levels and time zones to determine whether access is to be granted.

19.4.1.2 All access control panels shall be located in a secured room.

19.4.1.3 The System shall be capable of providing a means of controlling access through nominated doors, gates, barriers, etc. by checking the access privileges stored in memory for access credentials presented at each access control reader.

19.4.1.4 The System shall also be capable of monitoring the condition of inputs connected to the access control readers and control panels forming part of the System. The System shall be able to be programmed to apply a variety of conditions to the way in which these inputs are monitored, and annunciate the condition of each input in accordance with its programming.

19.4.1.5 The System shall produce and maintain a log of all events that include but are not limited to:

(a) Normal access transactions

(b) Tampers

(c) System critical events, failures and malfunctions

(d) System programming events.

19.4.1.6 The System shall provide an operator with a means of searching and extracting information relative to particular events, door operations, cardholder events and the production of printed reports detailing such information.

19.4.2 Access Controlled Doors

19.4.2.1 Electric devices used in securing access controlled doors shall be controlled by the associated card reader, time and/or event program, via the operator terminal or door release panels. Whenever access controlled doors are opened on presentation of valid credentials, the associated door alarm shall be suppressed.

19.4.2.2 Access controlled doors shall provide indication of the status of the door (open or closed) to the operator through the User Interface (e.g. reed switch).

19.4.2.3 Forced Door Alarm functionality shall be provided on ALL access controlled doors and are to be monitored by the operator through the User Interface.

19.4.3 Car Park Control System (if applicable).

19.4.3.1 A controlled access system shall be provided to restrict unauthorized vehicular access to the secure vehicle parking area.

19.4.3.2 The system shall be configured as follows:

(a) Allow operation of the gate through the Access Control System via the presentation of a valid proximity access card or other valid access credential;

(b) Weatherproof readers mounted onto a steel pedestal;

(c) Steel pedestals to accommodate an intercom;

(d) Face plate of each pedestal to be non-ferrous to maintain maximum card reader range;

(e) Pedestal to be designed to the approval of the Architect and Project Manager;

(f) Secure face plate of each pedestal with tamperproof screws;

(g) Provide all necessary security control equipment and logic interfaces to the Command Centre.

19.4.4 Access Control Alarms

19.4.4.1 A separate alarm message shall be transmitted to the Toll Plaza for each of the following alarm conditions but is not limited to:

(a) Door forced open

(b) Door held open too long

(c) Invalid card

19.4.4.2 The alarm messages shall be displayed in plain English text.

19.4.4.3 Each alarm shall clearly identify the time, location and type of alarm.

19.4.4.4 Access Control Panels (ACP) shall comply with the following:

(a) Facilitate the connection of access readers.

(b) Validation data and alarm status data will be maintained locally.

(c) ACP will be capable of being updated via the operator terminal and fully configured (control data, time schedules, etc) from the Command Centre Software.

(d) ACP will operate in a completely stand-alone mode for a minimum of twenty-four hours in the event of communication loss with the Command Centre Software.

(e) Be fitted with output control facilities, to enable activation of field equipment either by automatic reaction to events, or by operator intervention via the keyboard.

(f) Be housed in a secure cabinet equipped with an anti-tamper device.

(g) Check each access card presented against authorized database information.

(h) Be continuously polled by the Command Centre. When all access card data are valid, the reader terminal shall grant access. Invalid data shall be logged and recorded on systems data storage facility.

(i) ACPs will include a timer, adjustable from 0 to 3 minutes, which is to shunt the door alarm contact on the associated door for the period of the timer, whenever access is granted. The timer is to be set to allow sufficient time for the door to be used and closed again. If the door remains open for a period exceeding this time, only then is an alarm to be displayed on the operator terminal as the normal security alarm for that door and logged and recorded.

(j) Provide mains fail and low battery condition alarms (separate alarm inputs) to the operator terminal with the appropriate alarm text.

(k) Provide a minimum of 30% spare door control input on each APC to enable future connections.

19.4.5 Access Cards

19.4.5.1 Access Cards shall comply with, but not be limited to, the following:

(a) Contactless card or

(b) Contactless/smart card

(c) Biometric reader

(d) Key pads

19.4.6 Access Reader

19.4.6.1 Access control readers shall be proximity type readers operating with passive proximity cards.

19.4.6.2 Card reading is required to be both rapid and consistent, regardless of the orientation of the card and further enclosure of the card.

19.4.6.3 Access readers shall comply with, but not be limited to, the following:

19.4.6.4 Card readers shall be surface wall mounted and shall be vandal proof.

19.4.6.5 Standard readers shall have a minimum read range of 100mm.

19.4.6.6 Audible and visual indication of a valid, invalid and faulty card read.

19.4.6.7 Mounted on the lock side of the door where practical, 100mm from the frame of the door.

19.4.7 Sonalerts

19.4.7.1 Sonalerts shall comply with, but not be limited to, the following:

(a) Locate above each access-controlled door.

(b) Sound if the door remains open longer than a predetermined period. Should the door continue to remain open longer than a second predetermined period, only then shall an alarm be generated at the operator terminal.

(c) Capable of being isolated via the operator terminal and be disabled when the associated door is in access mode.

(d) Flush ceiling mounted, complete with sound selection and level adjustment.

19.4.8 Door Release Buttons (if required)

19.4.8.1 Door release buttons shall comply with, but not be limited to, the following:

(a) Install on the secured side of selected access controlled doors.

(b) On activation, the associated door alarm will be deactivated for a period and the power interrupted, to allow travel through the door and door to close, while sending a door exit signal to the Command Centre User Interface

(c) Compatible with the requirements of the access control system and door locks (i.e. the device will signal a valid egress to the ACP before releasing the electronic lock).

19.4.9 Emergency Door Release Unit (Break Glass)

19.4.9.1 Emergency door release unit shall comply with, but not be limited to, the following:

(a) Install on the egress side of selected access controlled doors.

(b) On activation, power will be directly interrupted to the door. Simultaneously, the associated door alarm will be activated and can only be reset from the operator terminal. An alarm signal will be sent to the Command Centre and logged.

(c) Compatible with the requirements of the access control system and door locks (i.e. the device will directly cut power to the lock (fail-safe) and signal break glass activation to the Command Centre.

19.4.10 Electric Door Locking System

19.4.10.1 Electric Mortise Locks

Electric mortise locks shall comply with, but not be limited to, the following:

(a) Shall be configured for power to unlock (fail secure) with dead latch, unless otherwise specified.

(b) Shall be capable of Key Manual Override

(c) Shall monitor key override function.

(d) Shall monitor door handle operation.

(e) Shall monitor dead latch and door closed status (in series with reed switch).

(f) Shall have door forced alarm monitoring.

(g) Fit with internal door release switch and be free handle exit (Do not use standalone door release buttons).

(h) Operation of a free handle shall suppress the associated access control door alarm.

19.4.10.2 Electric Strikes

Electric strikes shall comply with, but not be limited to, the following:

(a) Shall monitor dead latch pin and electric tongue sensor.

(b) Shall have door forced alarm monitoring.

(c) Request to exit buttons fitted on secure side of nominated doors

(d) Shall be configured for power to unlock (fail-secure) with dead latch, unless otherwise specified.

(e) Tongue sensor wired in series with reed switch.

19.4.10.3 Electromagnetic Locks

Electromagnetic Locks shall comply with, but not be limited to, the following:

(a) Provide Hall Effect sensor to detect that the door has closed and the magnetic field has bonded to the lock.

(b) Securely fasten to the head or top frame of the door.

19.4.10.4 Cable Transfer Unit

Cable transfer units shall comply with, but not be limited to, the following:

(a) Shall conceal all cabling.

(b) Shall be installed to all electric mortise lock doors so that cabling can transfer from the doorframe to the door leaf.

19.5 SECURITY ALARM SYSTEM

19.5.1 Overview

19.5.1.1 The Security Alarm System shall provide, but not be limited to, the following functionality:

(a) Provide indication of the condition of detection devices connected to the inputs of the Security Alarm panels forming part of the System.

(b) The System shall be able to be programmed to apply a variety of conditions to the way in which these inputs are monitored and annunciate the condition of each input in accordance with its programming.

19.5.1.2 Field alarm devices, e.g. Detectors, Reed Switches and Duress Buttons etc., shall be separately and independently connected to a separate and individual alarm input. All security panels shall be located in a secured room (preferably in the same space as the access control panels) and the door to that space shall be electronically monitored.

19.5.1.3 Naming conventions for all equipment shall be in a format approved by SANRAL or the Independent Engineer. No variation will be allowed unless written approval is obtained from SANRAL or the Independent Engineer.

19.5.2 Alarm Monitoring

19.5.2.1 The system shall be monitored in the Central Operation Centre Command Centre.

19.5.2.2 The following alarms shall be reported to Central Operation Centre Command Centre but shall not be limited to the following:

(a) Tamper alarms of all system components including detection devices on a 24 hour basis;

(b) Duress alarms on a 24 hour basis;

(c) Intruder alarms outside normal business hours;

(d) System seal and unseal events, including times and users;

(e) Partial system seals;

(f) Alarm restoration;

(g) Zone isolations;

(h) Low battery;

(i) AC fail;

(j) Fuse failures;

(k) Daily communications test and test results;

(l) System lockout after a preset number of unsuccessful code attempts.

19.5.2.3 The Contractor shall liaise with the Central Operation Centre Command Centre during the test and Commissioning phase to ensure that all alarms are reporting properly.

19.5.3 Alarm Monitoring Panel

19.5.3.1 Alarm Monitoring Panels (AMP) shall comply with, but not be limited to the following:

(a) Facilitate the connection of security field devices.

(b) Be fully intelligent devices capable of processing, transmitting and receiving alarm and control data from the security communications network.

(c) Control data and alarm status data will be maintained locally.

(d) AMPs will be capable of being updated (control data, time schedules, etc.).

(e) AMPs will operate in a completely stand-alone mode for a minimum of twenty-four hours in the event of communication and power loss.

(f) Be fitted with output control facilities, to enable activation of field equipment either by automatic reaction to events, or by operator intervention via the keyboard.

(g) Be housed in a secure cabinet equipped with an anti-tamper device.

(h) Provide mains fail and low battery condition alarms (separate alarm inputs) to the Command Centre with the appropriate alarm text.

(i) Ensure a minimum of 30% spare inputs are available on AMPs to enable connection of additional security devices.

19.5.4 Alarmed Doors

19.5.4.1 Access Control and alarmed doors shall comply, but not be limited to the following:

(a) Fit with flush magnetic reed door contacts.

(b) Unauthorized access shall cause an alarm to be generated at each Operator console.

(c) The alarms associated with emergency exit doors shall be active and instantaneous twenty-four (24) hours per day.

19.5.5 Alarm Inputs

19.5.5.1 Alarm inputs shall comply with, but not be limited to the following:

(a) Connect to an individual alarm input.

(b) The only exception is double sets of doors, where each leaf is to be alarmed, but connected to a single input.

19.5.6 Detectors

19.5.6.1 The maximum number of detectors per zone shall be one (1).

19.5.6.2 Each individual detector shall be reported as an individual alarm.

19.5.6.3 All cable entries into the detector shall be sealed to prevent the ingress of dirt, insects and the like that may cause environmental false alarms.

19.5.7 Wall Mounted Volumetric Detectors

(a) Shall be mounted at a height and orientation in accordance with the manufacturer's recommendations.

(b) The detector when mounted flat on the wall shall be fixed through the rear of the detector (behind the printed circuit board) or by means of a metal or other suitably secure manufactured bracket if mounted in a corner, to ensure that the active field of view does not encroach onto adjacent external windows.

(c) The configuration shall be such that both technologies must detect motion before an alarm is signalled (using AND logic).

(d) Sensitivity shall be set to give maximum detection capability with NIL false alarms.

(e) The detector cover is to be tamper switched.

(f) The detector shall be installed so the active field of view provides protection to all possible access points to the area e.g. windows, doors, trapdoors etc.

19.5.8 Ceiling Mounted Volumetric Detectors

(a) Shall be mounted in accordance with the manufacturer's recommendations.

(b) The configuration shall be such that both technologies must detect motion before an alarm is signalled (using AND logic).

(c) Sensitivity shall be set to give maximum detection capability with NIL false alarms.

(d) The detector cover is to be tamper switched.

(e) The detector shall be installed so the active fields of view provide protection to all possible access points to the area e.g. windows, doors, trapdoors etc.

19.5.9 Magnetic Reed Switches

19.5.9.1 Flush Type

(a) Flush magnetic reed switches shall comply with, but not be limited to, the following:

(b) Install on nominated internal and perimeter doors.

(c) Installed on the top of the door 100mm from the edge.

(d) Installed opposite hinge or pivot.

19.5.9.2 Surface Type

(a) Surface magnetic reed switches shall comply with, but not be limited to, the following:

(b) Install on nominated internal and perimeter doors as indicated on the drawings.

(c) Installed on the top of the door 100mm from the edge.

(d) Installed opposite hinge or pivot.

19.5.9.3 Surface Type (Heavy Duty)

(a) Surface magnetic reed switches shall comply with, but not be limited to the following:

(b) Install on roller doors, gates etc.

(c) Provide tamperproof junction box for cable terminations and end of line resistors.

(d) Position so as not to be damaged by vehicles or other traffic.

(e) Stainless steel armoured cable.

19.5.10 End of Line Resistors

19.5.10.1 All End-of-Line resistors must be located at the peripheral device connected to the system.

19.5.11 Anti-Tamper Circuits

19.5.11.1 All field equipment shall comply with, but not be limited to the following:

(a) Fit with an anti-tamper device.

(b) Circuit shall not be suppressed when the system is in access mode.

19.5.12 Duress Alarm System

19.5.12.1 Overview

(a) The Duress Alarm System shall provide, but is not limited to the following functionality:

(b) Be able to be integrated with the other electronic security systems installed on site.

(c) Provide indication of the condition of duress devices connected to the inputs of the Duress Alarm panels forming part of the System.

(d) The System shall be able to be programmed to apply a variety of conditions to the way in which these inputs are monitored, and annunciate the condition of each input in accordance with its programming.

(e) Each duress point shall be reported as an individual alarm. Individual portable radio duress activators (if applicable) shall be treated as individual alarm points, and shall be reported as individual alarms.

(f) Duress alarm signals shall also be transmitted on a 24-hour basis to the Command Centre and must be afforded the highest priority alarm status.

(g) Naming conventions for all equipment shall be in a format approved by SANRAL or the Independent Engineer. No variation will be allowed unless written approval is obtained from SANRAL or the Independent Engineer.

19.5.12.2 Duress Buttons

Under bench and desk buttons shall comply with the following:

(a) Surface mounted on the underside of the bench or desk and fixed with 6-gauge counter-sunk screws.

(b) Set back from the edge of the bench or desk by 25mm.

(c) Shrouded to reduce the risk of false activation.

Wall mounted duress buttons in all other areas shall comply with the following:

(a) Mount at 1100mm from the finished floor level.

(b) Device shall be installed with pushbutton facing downwards and fixed to wall with 6-gauge counter-sunk screws.

19.6 CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

19.6.1 Overview

19.6.1.1 The Closed Circuit Television (CCTV) System also referred to as a surveillance system shall provide, but is not limited to the following functionality:

(a) Be able to be integrated with the other electronic security systems installed on site.

(b) Provide an extensive CCTV surveillance system to permit overall visual surveillance of Public, Staff, Secure and External areas of the Site;

(c) Master control and recording facilities shall be located within the Security Equipment Rack/Room at the Toll Plaza centre;

(d) Operator control, recording and download facilities shall be provided at the Command Centre.

19.6.1.2 All necessary system design, programming (i.e. videotext, point descriptors, display maps, alarm message text) shall be included.

19.6.2 System Function

19.6.2.1 The purpose of any CCTV system shall be to act as a deterrent and to provide general surveillance of the nominated area.

19.6.2.2 The CCTV System shall be programmed so that any duress or alarm situation shall cause the closest camera to the alarm/duress location be switched to an “Alarm Mode” which shall increase the recording rate and display the image on a nominated monitor.

19.6.3 Digital Video Recorder

19.6.3.1 A digital recording system shall be provided to enable local recording, review, management and archiving of all camera images as well as remote reviewing and management.

19.6.3.2 The local system operators shall be able to easily copy, or back up an image or sequence of images (tracks) onto CD type media.

19.6.4 Video Output Display

19.6.4.1 This shall be taken into account prior to locating, installing and Commissioning cameras. Approval shall be sought from SANRAL or the Independent Engineer before final camera placement is undertaken.

19.6.5 Programming

19.6.5.1 Programming of the system shall be such that it shall be possible for an authorized operator to easily change any or all of the system programming parameters with minimal training.

19.6.5.2 Specific details on how the video control and management system shall be programmed shall be provided to SANRAL or the Independent Engineer for approval prior to the commencement of installation.

19.6.5.3 Naming conventions for all equipment shall be in a format approved by SANRAL or the Independent Engineer. No variation will be allowed unless written approval is obtained from SANRAL or the Independent Engineer.

19.6.6 Alarm Handling

19.6.6.1 The system shall include a comprehensive suite of alarm handling routines. Upon receipt of an alarm the associated video input(s) shall be switched to the programmed monitor output for display along with a pre-programmed alarm enunciated message.

19.6.6.2 The video management system shall detect video signal failure and initiate an alarm for the user.

19.6.7 Monitors

19.6.7.1 All operator monitors shall be minimum 17" LCD Flat Panel in size. The monitors may not be required if a SCADA system is provided and the security system interfaced with the SCADA system.

19.6.7.2 Video monitors shall include one or more of the following:

(a) Set-up monitor located with the DVR (17" LCD Flat Panel);

(b) Working monitor (17" LCD Flat Panel);

(c) Alarm Monitor (17" LCD Flat Panel);

19.6.8 Monitor Brackets

19.6.8.1 High-level monitor brackets shall conform, but not be limited to the following:

(a) Appropriate bracket shall be provided to accommodate monitor size and weight.

(b) Suspended from the ceiling or wall as agreed on-site.

(c) Underside of the monitor mount to be a minimum of 2150 mm above finished floor level.

(d) Securely mounted.

(e) Allow monitor angle adjustment for optimum viewing.

19.6.8.2 The Contractor shall install all necessary devices to prevent damage to equipment and wiring.

19.6.9 CCTV Interface

19.6.9.1 The Contractor shall provide an interface between the security and surveillance systems to automatically activate the video surveillance system on activation of the appropriate alarm. The appropriate alarms that trigger the video surveillance system will include but not be limited to:

(a) Use of an intercom station,

(b) Monitored points,

(c) Door open too long,

(d) Door forced alarms and

(e) Duress alarms, etc., associated in the general vicinity of a video surveillance camera.

19.6.9.2 Each security alarm shall be transmitted to the surveillance system as an individual signal. The video surveillance system shall be configured to activate the appropriate camera, monitor, etc.

19.6.10 CCTV Management Software

19.6.10.1 The software shall provide, but not be limited to the following functionality:

(a) The ability to view images as full-screen or multi-screen displays;

(b) Ability to network multiple PCs together and view any or all camera images simultaneously;

(c) Individual user and password for system management and remote site access at each PC.

19.6.11 Digital Video Recorder

19.6.11.1 Each Digital Video Recorder shall conform but not be limited to the following minimum requirements:

(a) Provide a sufficient number of Digital Video Recorders to enable the connection and recording of all cameras and a spare camera input capacity for the connection of an additional 30%.

19.6.11.2 Provide sufficient hard disk storage capacity for the continuous recording of all inputs as follows:

(a) Minimum period of 14 days' operation in the Site environment.

(b) Minimum 6 full frames per second.

(c) Minimum Colour recording utilising PAL.

(d) All images shall incorporate watermarking.

(e) Recording capacity of all DVRs is distributed evenly, so that all DVRs record approximately the same amount of days.

(f) The DVRs shall work in "loop" mode, i.e. over-write the earliest recording once the capacity is filled up.

19.6.11.3 Cameras shall be recorded as follows:

(a) Minimum 16 full frames per second in Alarm State.

(b) Minimum 6 full frames per second otherwise.

(c) Minimum Colour recording utilising PAL.

(d) All images shall incorporate watermarking.

(e) Camera identification shall be programmed for each input.

19.6.11.4 Image Authentication and System Protection

(a) Time and data text shall be permanently embedded within the recorded image;

(b) Images shall be individually watermarked;

(c) The system shall provide extensive, user definable password protection (entered via keyboard) for access to playback, record and system set-up functions.

19.6.12 Matrix Switch

19.6.12.1 The matrix switch required to manage the camera system shall conform, but is not limited to the following:

(a) The video matrix switch shall have a capacity to connect all cameras, monitors and keyboards with a spare capacity of at least 30%.

(b) Provide sufficient alarm inputs (make contact or open collector input) for all functions with an additional 30% spare capacity.

(c) Provide sufficient relay outputs (make contact or open collector input) for all functions with an additional 30% spare capacity.

(d) All video inputs of the matrix switch shall include down frame looping cards (DFL), the looping output of the down frame looping cards shall be connected to an input of a DVR.

(e) All video signals shall be looped through a Patch Panel before being routed through to the matrix switcher.

(f) Shall automatically switch a camera image to the console monitor on an alarm.

(g) Shall be password protected with least two access levels.

19.6.13 Control Keyboard

19.6.13.1 Provide a camera control keyboard on each Operator Console at the Command Centre, to enable control of all cameras and functions. Programming of camera sequences, alarm response, ID, time/date and any other program functions will be carried out via the keyboard.

19.6.13.2 Provide a key switch or password to prevent unauthorized access and modifications to programmed functions.

19.6.14 Cameras

19.6.14.1 Cameras shall conform, but not be limited to the following:

(a) Shall be mounted in appropriate, approved housings and supported by appropriate, approved brackets.

(b) Shall be phase locked and synchronized to ensure clean, roll-free switching and image stability.

(c) Shall be installed and Commissioned to ensure focus, clarity and brightness of image at each Operator Console.

(d) Shall be powered from a centralized distributed power supply. Plug packs are not acceptable.

19.6.15 Lenses

19.6.15.1 Lenses shall conform, but not be limited to the following:

(a) Shall be Vari-focal, video driven auto-iris type.

(b) The specific focal length required for each camera position will be determined on site. Lens focal length will typically range from 4 mm to 16 mm.

19.6.16 Camera Housings and Mounts

19.6.16.1 Internal Housings

Internal housings shall conform, but not be limited to the following:

(a) Fitted with screw fixings to prevent unauthorized access.

(b) Sealed and secured.

19.6.16.2 External Housings

External housings shall conform, but not be limited to the following:

(a) Fitted with screw fixings to prevent unauthorized access.

(b) Sealed and secured.

(c) Provide external housings with a sunshield.

19.6.16.3 Camera Mounting

Camera mounting shall conform, but not be limited to the following:

(a) Utilise wall or ceiling mounted brackets.

(b) Provide manual adjustment of position of 0 degrees to 90 degrees tilt and 360 degrees pan.

(c) Be firmly locked into the desired position and be rigidly supported to prevent any vibration and movement.

19.6.16.4 Mounting Poles

External cameras shall typically be wall mounted. In the absence of a suitable wall, cameras shall be mounted on mounting poles.

Camera mounting poles shall conform, but not be limited to the following:

(a) Preferably, purpose-made concrete mounting poles or other material proven to be corrosion and vibration resistant (to be approved by SANRAL or the Independent Engineer) shall be used.

(b) Various heights shall be utilised to ensure clear/unobstructed view of the areas to be monitored.

(c) Have a weatherproof and tamper-proof compartment at the base, for the enclosure of wiring and connectors.

19.7 INTERCOMMUNICATIONS SYSTEM

19.7.1 Overview

19.7.1.1 The Intercommunications System shall provide but is not limited to the following functionality:

(a) Be capable of being integrated with other electronic security systems installed on site.

(b) Provide audio communication facility to the master station from all sub master and field stations.

19.7.1.2 Provide Field stations to each of the nominated locations. Each field station may separately or severally call one (1), some, or all master and sub master stations.

19.7.1.3 To receive an incoming call at a master station, a call initiated from a field station shall illuminate at the master station and a tone shall sound. The operator at the master station can elect to receive the call by selecting the relevant field station button.

19.7.1.4 The master station speaker and microphone shall then be activated allowing connection to the field station. The field stations shall be hands free in operation once a master station accepts or initiates a call. The master station shall have the ability to terminate the call.

19.7.1.5 Each additional incoming call shall sound a tone and the relevant field station indicator shall be displayed until the call is accepted at the receiving master station.

19.7.1.6 The master station shall be capable of initiating a call to any field, master or sub master station such that a tone is sounded at the recipient station. It shall be possible for field stations to call master stations but not other field stations.

19.7.1.7 The Contractor shall provide details of the proposed programming of the intercommunications system to SANRAL or the Independent Engineer prior to installation.

19.7.2 Intercom Exchange

19.7.2.1 The Intercom Exchange shall conform as a minimum but is not limited to the following:

(a) Located as defined on drawings or in the Scope of Works.

(b) Provide sufficient number of inputs to allow connection of all field stations.

(c) Provide spare capacity for the connection of an additional 30% field stations.

(d) Provide a regulated power supply and cabling terminal block at the Station.

(e) Enclosed in an enclosure of approved manufacture that is monitored for tamper protection.

19.7.3 Master Station

19.7.3.1 Intercoms shall conform as a minimum but not be limited to the following:

(a) Label each button (with suitably printed text) to identify each field station.

(b) All incoming calls shall be indicated with an illuminated light and a corresponding tone.

(c) No hum or interference shall be detectable.

19.7.4 Sub Master

19.7.4.1 Intercoms shall conform as a minimum, but not be limited to the following:

(a) Label each button (with suitably printed text) to identify each field station.

(b) All incoming calls will be indicated with an illuminated light and a corresponding tone.

(c) No hum or interference shall be detectable.

19.7.5 Field Station

19.7.5.1 Intercoms shall conform as a minimum, but not be limited to the following:

(a) Flush mounted and centred at 1300 mm from the finished floor level, with the exact location for installation to be determined on site to the approval of SANRAL or the Independent Engineer.

(b) Face plate to have engraved operating instructions.

(c) No hum or interference shall be detectable.

19.7.6 CCTV System Alarm Outputs

19.7.6.1 An output signal for each field station in the form of a normally closed voltage free relay contact shall be provided which is to activate/open on the operation of a call button on a field station.

19.7.6.2 The output shall be configured to display an appropriate camera view on a monitor located at each Operator console.

19.8 SYSTEM POWER SUPPLIES

19.8.1 Plug Packs and power boards shall not be used in any instance.

19.8.2 All power supplies installed for the provision of Low Voltage power to any part of the equipment installed at the Site shall conform but not be limited to the following:

19.8.2.1 Individual power supplies shall be provided for the supply of power to locks and shall be segregated from power supplies provided for other electronic equipment;

19.8.2.2 Shall be installed in accordance with the manufacturers recommendations;

19.8.2.3 Shall be provided with a minimum allowance of 30% spare capacity.

19.8.3 Standby Power

19.8.3.1 Standby power supplies shall be provided by others.

19.9 RACKS

19.9.1 Where specified on drawings or in the Scope of Works the system equipment, with the exception of field panels and devices, operator consoles, monitors etc. shall be housed in a 19-inch type rack to be provided and installed as part of these works.

19.9.2 Racks shall be enclosed on all sides with lockable doors front and rear including vertical power distribution rails, cable management (with separation between power and signal cables in accordance with the relevant Cabling Regulations), ventilation (if necessary fans shall be installed), cable termination panels etc.

19.9.3 The rack enclosure shall be constructed with ample manufactured ventilation slots or pores.

19.9.4 The rack shall be positioned such that equipment can be readily accessed, front and rear for maintenance and servicing purposes.

19.9.5 The rack shall be designed to accommodate all nominated equipment allowing for a 1RU space between equipment components.

19.9.6 Patch panel(s) shall be provided for all incoming and outgoing video and data cabling.

19.9.7 Cable management shall be provided for all internal and external cabling.

19.9.8 The rack shall be securely fixed to the floor or wall and equipment securely mounted inside it.

19.10 SECURITY DATA AND COMPLIANCE SHEET

TABLE 19-1: SECURITY DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
N/A						
SECURITY						
	CLAUSE					
19.10.1	19.4.1	Access Control System				
19.10.2	19.4.2	Access Controlled Doors				
19.10.3	19.4.3	Car park control (if applicable)				
19.10.4	19.4.4	Access control areas				
19.10.5	19.4.5	Access Cards				
19.10.6	19.4.6	Access Reader				
19.10.7	19.4.7	Sonalerts				
19.10.8	19.4.10	Electric Door Locking System				
19.10.9	19.4.10.2	Electric Strikes				
19.10.10	19.4.10.3	Electromagnetic Locks				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
19.10.11	19.4.10.4	Cable Transfer Unit				
19.10.12	19.5	Security Alarm System				
19.10.13	19.5.2	Alarm Monitoring				
19.10.14	19.5.3	Alarm Monitoring Panel				
19.10.15	19.5.4	Alarmed Doors				
19.10.16	19.5.5	Alarm Inputs				
19.10.17	19.5.6	Detectors				
19.10.18	19.5.7	Magnetic Reed Switches				
19.10.19	19.5.8	End of Line Resistors				
19.10.20	19.5.9	Anti-Tamper Circuits				
19.10.21	19.5.10	Duress Alarm System				
19.10.22	19.6	Closed Circuit Television (CCTV) System				
19.10.23	19.6.2	System Function				
19.10.24	19.6.3	Digital Video Recorder				
19.10.25	19.6.4	Video Output Display				
19.10.26	19.6.5	Programming				
19.10.27	19.6.6	Alarm Handling				
19.10.28	19.6.7	Monitors				
19.10.29	19.6.8	Monitor Brackets				
19.10.30	19.6.9	CCTV Interface				
19.10.31	19.6.10	CCTV Management Software				
19.10.32	19.6.11	Digital Video Recorder				
19.10.33	19.6.12	Matrix Switch				
19.10.34	19.6.13	Control Keyboard				
19.10.35	19.6.14	Cameras				
19.10.36	19.6.15	Lenses				
19.10.37	19.7	Intercommunications				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		System				
19.10.38	19.8	System Power Supplies				
19.10.39	19.9	Racks				

20. TOLL PLAZA WARNING BEACON

20.1 SCOPE

20.1.1 This specification covers the requirements for the Toll Plaza warning beacon.

20.2 GENERAL

20.2.1 The warning beacon shall be a fully contained, low voltage weatherproof type comprising clustered high-flux LEDs as light source or similar approved, Fresnel lens and a tinted front lens.

20.2.2 The housing shall be robustly constructed of die cast aluminium alloy or other corrosion proof and UV resistant material and be effectively sealed against ingress of moisture and dust to IP 66.

20.2.3 The light assembly shall comply with the requirements of SANS 1459 and be provided in red, amber or green colour.

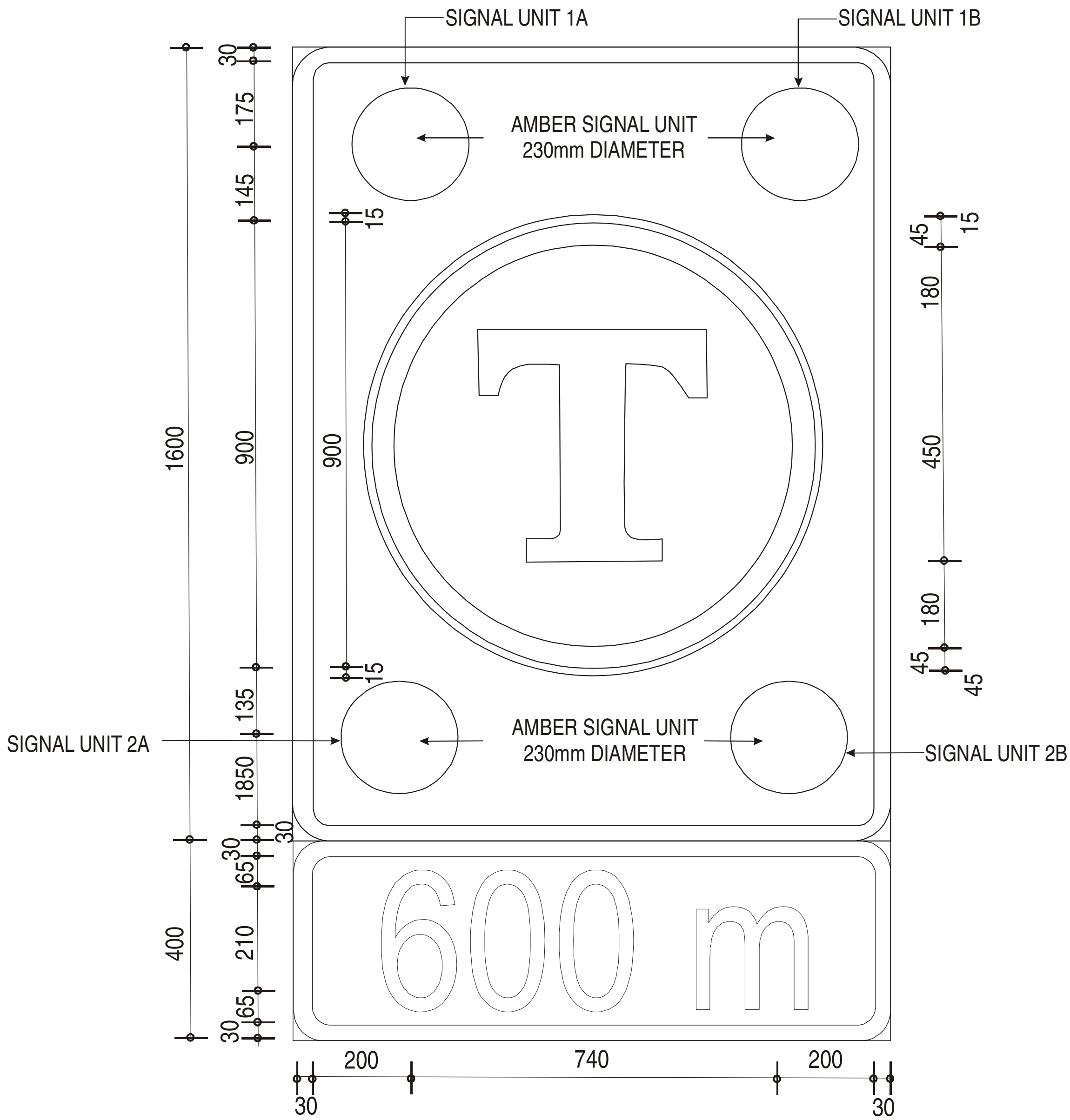
20.2.4 The optics and the LED wiring shall be designed such that with proper drive electronics, the failure of a single LED will not create a dark spot nor will it reduce the signal intensity.

20.2.5 The beacon shall be similar or approved equal to the 200 mm diameter “Lumiled” traffic light as distributed by WACO Industries.

20.3 WARNING BEACON DATA AND COMPLIANCE SHEET

TABLE 20-1: WARNING BEACON DATA AND COMPLIANCE SHEET

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
20.3.1	SANS 1459:2004 (SABS 1459)	Traffic lights				
WARNING BEACON						
	CLAUSE					
20.3.1	20.3.1	General				



NOTES:

1. SIGNAL UNITS SHALL COMPLY WITH SANRAL STANDARD SPECIFICATION.
2. FOR ELECTRICAL PURPOSES ONLY - THIS DRAWING MUST BE READ IN CONJUNCTION WITH SA ROAD SIGN MANUAL
3. ALL AMBER SIGNAL UNITS TO BE SUPPLIED MUST USE THE LATEST LED TECHNOLOGY
4. SIGNAL UNITS 1A & 2B & 1B & 2A TO BE ILLUMINATED TOGETHER
5. THE SIGNAL UNITS SHALL COMPLETE ONE ILLUMINATION CYCLE (FLIP FLOP) EVERY 1 SECOND

FIGURE 20-1: TOLL PLAZA HAZARD SIGN

21. INSPECTIONS, TESTING, COMMISSIONING AND HANDING OVER

21.1 PHYSICAL INSPECTION PROCEDURE-

21.1.1 On completion of the Installation or before any inspection or testing is required, the Contractor shall carry out his own inspections to ensure that the installation and equipment comply with the Specifications and that the quality of workmanship and materials are to the specified standards.

21.1.2 SANRAL or the Independent Engineer will not act as the Contractor's inspector or quality control official.

21.1.3 Once the Contractor has completed the installation, written notice shall be given to SANRAL or the Independent Engineer in order that a mutually acceptable date can be arranged for a joint inspection.

21.1.4 During the course of the inspection, the representative of SANRAL or the Independent Engineer will compile a list of items (if any) requiring further attention. A copy of this list will be provided to the Contractor who will have a period of 7 days in which to rectify the listed items.

21.1.5 The Contractor shall then provide written notice that he is ready for an inspection of the remedial work to the offending items.

21.1.6 This procedure will continue until the entire installation has been correctly completed in accordance with the specifications.

21.1.7 After the First inspection, all time and travelling costs incurred by SANRAL or the Independent Engineer for further inspections or re-inspections will be payable by the Contractor.

21.2 FACTORY INSPECTIONS AND TESTS

21.2.1 The Contractor shall advise SANRAL or the Independent Engineer in writing of any routine, type or specific tests to be carried out on equipment during the course of manufacture in the manufacturer's factory or works or of any stage of completion in the manufacturing process which requires inspections in terms of the Contract and Specifications.

21.2.2 Such notice shall be given at least 7 days prior to the testing or inspection being required. The Contractor will dispatch equipment from the factory at his own risk if tests have not been witnessed and inspections not been carried out by SANRAL or the Independent Engineer or his authorized representative and approval given by SANRAL or the Independent Engineer for dispatch.

21.2.3 The Contractor's Project Engineer shall in all instances do his own inspections and ascertain that equipment will be ready for inspection or testing before SANRAL or the Independent Engineer's attendance is requested. SANRAL or the Independent Engineer also reserves the right to inspect any equipment at the manufacturer's works at any stage during the manufacture.

21.2.4 The Contractors Project Engineer will also be required to attend all inspections and tests with SANRAL or the Independent Engineer or his authorized representative.

21.3 TESTING AND OPERATIONAL INSPECTION PROCEDURE OF INSTALLATIONS

21.3.1 The Contractor shall have the complete installation tested and approved by the local authorities where applicable.

21.3.2 Subsequent to the above testing and approval, the Contractor shall in the presence of SANRAL or the Independent Engineer test all circuits with respect to:

21.3.2.1 Polarity

21.3.2.2 Phase balance

21.3.2.3 Insulation level

21.3.2.4 Earth Continuity

21.3.2.5 Earth leakage relay sensitivity

21.3.2.6 Trip testing and proving of all protection equipment .

21.3.2.7 A certified schedule of all measured values shall be submitted to SANRAL or the Independent Engineer.

21.3.3 Upon completion of the installation and within 3 months of the handover date, the Contractor shall provide a recording voltmeter to record the voltage at three locations in the complex over a period of 48 hours each. These locations will be nominated by SANRAL or the Independent Engineer.

21.4 TYPE TESTS, TEST CERTIFICATES AND SPECIALIZED TESTS

21.4.1 The Tenderer shall submit with his tender one copy of each of all the type test certificates called for in the Specifications.

21.4.2 All tests shall be carried out in accordance with the requirements of the specified and recognized standards. Where tests have not been detailed in the documents, the Contractor shall provide comprehensive documentation of the standards and procedures he intends using in testing.

21.4.3 Such additional tests in the manufacturer's works, on site or elsewhere as in the opinion of SANRAL or the Independent Engineer are necessary to determine that the contract works comply with the specifications may be called for. The general principle regarding payment of such tests shall apply i.e. the tests will be paid for if they are additional to those specified however, payment will in all cases only be made for tests with positive results. Retest will in no circumstances be paid for.

21.4.4 The Contractor will be required to submit certified copies of all type, routine and rating test certificates to SANRAL or the Independent Engineer.

21.5 "AS BUILT" DRAWINGS, MAINTENANCE AND OPERATING MANUALS

21.5.1 As each portion of the work is completed, the Contractor shall provide SANRAL or the Independent Engineer with “as built” drawings, maintenance and operating manuals and other documents which are called for in the Standard Technical Specification, the Detail Technical Specification or any other specification or documentation forming part of this contract or as agreed to.

21.5.2 Where “as built” layout drawings are required and where such electrical layouts are drawn on Architectural drawings, SANRAL or the Independent Engineer will supply cad drawings of the Architectural drawings on request at the current market costs to enable the Contractor to accurately detail the completed installation. The Contractor shall obtain his own "base'” material and information for all workshop, design, schematic and wiring diagrams or other drawing which must be provided as built.

21.5.3 In addition, a complete reticulation and schematic diagram showing all supply cables and switchboards or other equipment shall be provided in an electronic cad or PDF file version behind a clean plastic cover in the substation or adjacent to the Main Switchboard if not located in a substation.

21.5.4 The Contractor shall, before the works are taken over by SANRAL provide two complete sets of Operating and Maintenance Manuals together with drawings and technical data sheets of the works as completed in sufficient detail to enable SANRAL to maintain, dismantle, re-assemble and adjust all parts of the works. A copy of the manuals and drawings shall also be available in PDF format.

21.5.5 The installation will not be regarded as complete until all of the requirements of this section have been met.

21.6 COMMISSIONING

21.6.1 The installation shall be comprehensively Commissioned as individual and integrated systems as may be required by the configuration after the works are substantially complete.

21.6.2 The Contractor shall provide adequate and competent personnel for Commissioning of every particular installation and for the full duration of the Commissioning process.

21.6.3 The Commissioning shall include interaction between other services and Contractors where interdependence of installations is encountered.

21.6.4 The Commissioning process shall, after all testing has been completed be the final proving ground of the systems and during this procedure the installations shall be subjected to all possible inputs and actions which way be encountered under operational conditions. The Contractor shall prove the full operation, working and compliance of the installation in accordance with the specifications.

21.6.5 A programme of the planned Commissioning procedures shall be submitted to SANRAL or the Independent Engineer at least days before Commissioning commences to enable SANRAL or the Independent Engineer to witness the Commissioning.

21.7 DOCUMENTATION

21.7.1 All documentation on the testing, Operational, Maintenance test certificates, “as built” drawings, etc shall be available in electronic (PDF file format) and stored on the SCADA system.

22. CODE OF PRACTICE FOR THE LIGHTING OF NATIONAL ROADS

22.1 ADOPTION OF RELEVANT SANS CODES OF PRACTICE

22.1.1 Adoption of SANS 10098-1:2007 as amended – The Lighting of Public Thoroughfares.

22.1.1.1 The South African Bureau of Standards has issued a Code of Practice for Public Lighting, Part 1 and Part 2. These publications should be adopted, where applicable, for the design of lighting installations of all national roads. The SANS 10098 Part 1 Code lays down lighting design standards for major roads, covering minimum average road surface luminance values, overall luminance uniformity. Longitudinal luminance uniformity and the maximum threshold increment (applicable to the control of flare from the street lighting luminaires). The standards set in this code relate to the lighting requirements on roads (with or without a median) for maximum traffic volume during the hours of darkness (motor vehicles per hour per lane). These standards form the basis for the lighting of national roads. Special cases and areas of national roads are given below

22.1.2 Adoption of SANS 10098-2:2005 as amended – The Lighting of Certain Specific Areas of Streets and Highways.

22.1.2.1 The SANS 10098 Part 2 Code deals with the lighting of road crossings, including pedestrian crossings and the lighting requirements for road tunnels. Special cases are given below.

22.1.3 Adoption of SANS ARP 035: 2002 “Guidelines for the Installation and Maintenance of Street Lighting”.

22.1.3.1 ARP 035: 2002 shall apply to all street lighting installations and to the maintenance thereof.

22.2 SPECIAL CASES

22.2.1 Toll Roads

22.2.1.1 Conventional Toll Plazas lighting may be divided into four categories:

(a) Category 1 - High volume Conventional Toll Plazas in urban and rural areas

(b) Category 2 - Low volume Conventional Toll Plazas in mainly rural areas

(c) Category 3 - Low volume Conventional Toll Plazas in ecologically sensitive environments

(d) Category 4 - Conventional Toll Plazas associated with predominantly electronic toll collection.

22.2.1.2 ORT Toll plazas lighting may be divided into the following:

(a) ORT toll plazas with existing road lighting infrastructure.

- The Contractor shall position the ORT toll gantries midway between the existing road lighting masts.

- See drawing below with the two gantries midway between the existing road lighting masts indicating a dark shadow between the two gantries. The Contractor shall provide additional lighting on the gantry to provide sufficient illumination according to the road lighting levels.

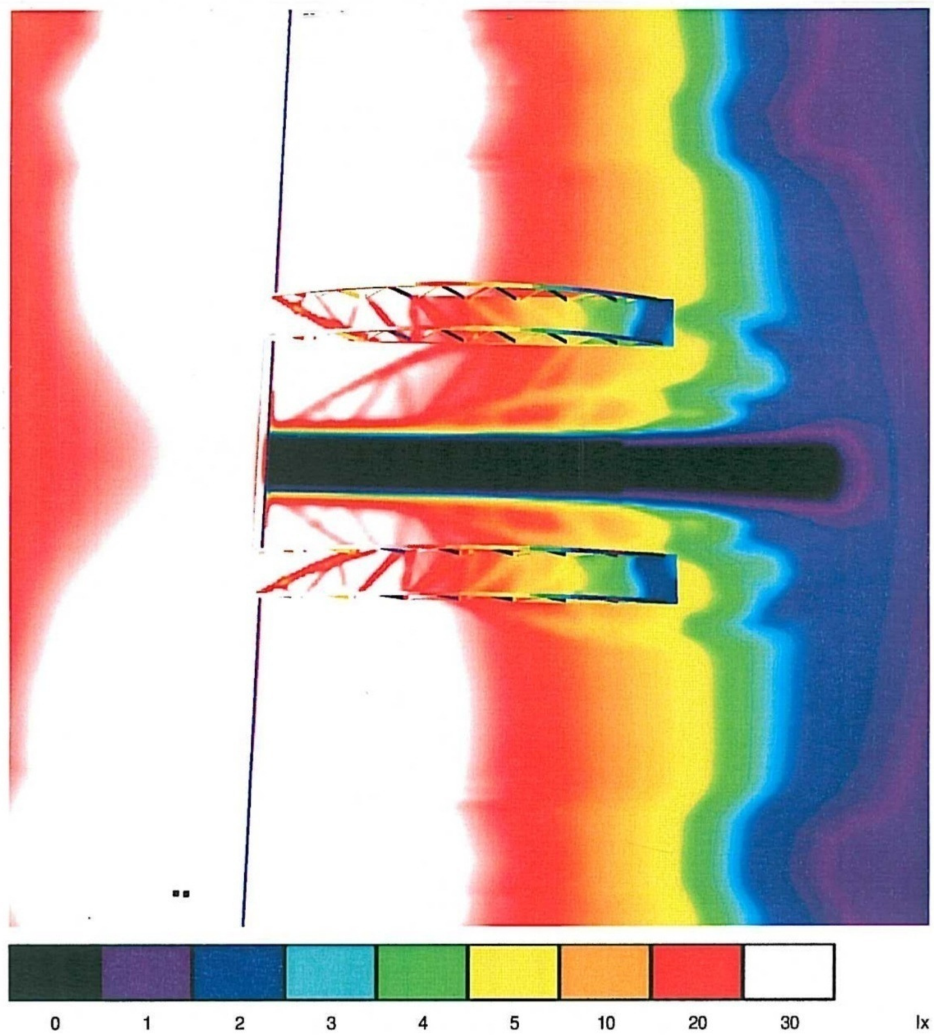


FIGURE 22-1: TOLL GANTRY MIDWAY BETWEEN ROAD LIGHTING MASTS - COLOUR PENDING LAYOUT

(b) ORT Toll Plazas without existing road lighting infrastructure.

- The Contractor shall position the new road lighting masts so that the ORT toll gantries are midway between the mast positions.
- The Contractor shall provide adaptation lighting on the exit side of the gantry as per SANS 10098-2 should the toll system required additional lighting for the toll system i.e. number plate recognition, however preference shall be given to infrared image capturing systems.

22.2.2 Apron areas

22.2.2.1 Where the Toll Plaza apron is situated in an unlit section of a national road an independent electrical supply will have to be installed. It is also essential that a backup supply be provided in and near the Toll Plaza for the security of personnel and money as well as to enable the operator to identify the type of vehicle entering, verify the money and change being given, and for the continued operation of the installation

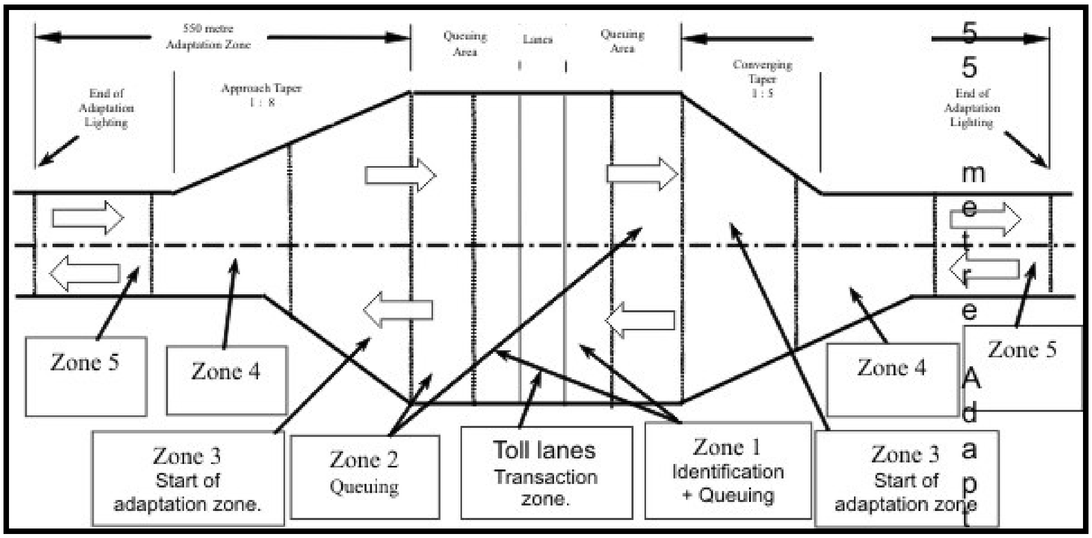


FIGURE 22-2: TOLL PLAZA ROAD AND AREA LIGHTING ZONES

22.2.3 Apron areas can be divided into the following zones (starting from the centre):

22.2.3.1 Toll Lanes where the transaction takes place.

(a) Zone 1. This is the queuing zone on the approach side and the identification zone on the departure side.

(b) Zone 2. A queuing zone on the approach side and parallel to traffic flow on the departure side.

(c) Zone 3. Apron diverges on the approach side, allowing driver to select an operational toll lane to pay the toll fee. The apron converges on the departure side and this is the start of the first adaptation zone.

(d) Zone 4. Second adaptation zone.

(e) Zone 5. Third adaptation zone.

TABLE 22-1: LIGHTING REQUIREMENTS FOR THE VARIOUS CATEGORY OF CONVENTIONAL TOLL PLAZAS

Category	Toll Lanes	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
[Posted speed limit-Apron area]	Transaction Zone.	Identification	Queuing	Start of adaptation	Adaptation	End of Adaptation
Category 1 High volume plaza urban/rural [70 km/hr]	≥ 50 lux Vertical and horizontal.	≥ 30 lux Vertical and horizontal. (30 m)	≥ 15 lux Horizontal (50 m)	1.2 cd/m² (150 m)	0.7 cd/m² (200 m)	0.35 m² 200 m)
Category 2 Low volume plaza (rural) [60 km/hr]	≥ 50 lux Vertical and horizontal.	≥ 15 lux Vertical and horizontal. (30 m)	Omit	1.0 cd/m² (100 m)	0.5 cd/m² (150 m)	0.25 cd/m² (175 m)
Category 3 Plaza in ecologically sensitive area [40 km/hr]	≥ 25 to ≤ 40 lux Vertical + horizontal	Street lighting 1cd/m² No glare permitted. (30 m)	Omit	Use dimmable LED road studs or LED bollards for traffic guidance provided safety is not compromised. Innovative lighting solutions are encouraged.		
Category 4 Manual payment lanes next to electronic plazas [60 km/hr]	≥ 25 to ≤ 40 lux Vertical + horizontal.	ETC Same as cat 1 or 2. Manual - street lights 1 cd/m² (30 m)	Same as cat 1	Depends on the road design. Use street lighting to the end of the access lanes where manually tolled vehicles rejoin the highway or arrange for visual guidance by means of LED bollards.		
Lighting Requirements for the Various Classis of Conventional Toll Plazas on unlit National Roads						

22.2.3.2 In order to cater for changes to the drivers' eye adaptation on entering or, more importantly, exiting from the area, the lighting of the road area must be at its highest near the toll booth and taper off towards the unlit areas of the road. The SANS Code 10098-2 recommends that the lighting levels in the transition zones be reduced to half that in the preceding zone, based on the length that would be traversed in 15 seconds when travelling at the posted speed of the road.

22.2.3.3 The minimum overall luminance uniformity ratio in all stages of driver exposure shall not be less than 0.33.

22.2.3.4 Should the Toll Plaza be located on a lighted highway then the toll facility shall be lit to a higher lighting level than that for normal street lighting. Stages 3, 4 and 5 will then be at the street lighting luminance.

22.2.3.5 The required minimum vertical illuminance level as seen from the direction of the tollbooth, to enable the toll collector to identify the number of axles of incoming vehicles, is 30 lux. The average horizontal illuminance at road level in this area should not be less than the 30 lux.

22.2.3.6 When selecting the type of luminaires to be used in this area care shall be taken to ensure that no direct glare is created for incoming motorists and that no waste light is projected above the horizontal in order that atmospheric light pollution is eliminated. Special attention shall be paid to the elimination of obtrusive lighting when a Toll Plaza is located in an urban area.

22.2.4 Areas in and adjacent to tollbooths

22.2.4.1 The general lighting in the tollbooths and at the paying points shall not be of such high a level that it creates a glare source for oncoming traffic. It is therefore recommended that the average vertical illuminance should be 50 lux with local lighting luminaires mounted over the desk to give the required working level illumination.

22.2.4.2 In the lanes area there shall be sufficient lighting for a driver to read details of toll tariff boards and notices and to verify the change received. The lighting shall also provide sufficient illuminance on the vertical face of the vehicle facing the toll attendant in order that the type of vehicle and the driver may be identified. The recommended minimum vertical illuminance should be 50 lux. The positioning of these luminaires and their light distribution shall not create glare to the driver.

22.2.4.3 Should CCTV be utilised to facilitate the identification of small trailers, the toll transaction or number plates of approaching and departing vehicles then uniform vertical illumination of 30 lux shall extend over 30m on approach and departure side either side of the toll booth.

22.2.5 On and off ramps

22.2.5.1 Where tollbooths are located at on and off ramps, it is important that the approach and departure areas be lit to the standards listed above. In order to visually indicate to approaching motorists the existence of the tollbooth, it is recommended that the approach road and the off ramp be illuminated by a different light source e.g. by metal halide lamps where the national road and approach roads are lit with high pressure sodium.

22.2.5.2 If rumble strips are present on the off ramp, and lighting is to be provided to light the off ramp, then these shall be detectable under the lighting. This method should not be employed when the plaza is situated in an urban area.

22.2.6 Signs

22.2.6.1 All signs in the approach area to a toll and within the area shall be adequately lit in order that the motorists will be able to read them and take whatever action is necessary. Internal lighting provides ideal visibility, but the maximum luminance of the sign face shall not exceed 600 candelas per square meter. If exterior floodlights are used, they shall be mounted above the sign to prevent upward stray light that would create atmospheric pollution. Care shall however be taken that the floodlights and their fixtures do not create obtrusive shadows over the face of the sign from sunlight during daylight hours.

22.2.7 Toll roads in dangerous areas

22.2.7.1 Where toll roads are situated near airports, high mast height restrictions and special upward light control from the luminaires may be enforced. If such a situation should occur the airline and airport department of the South African Civil Aviation Authorities should be consulted.

22.2.8 Late night low traffic volume operation

22.2.8.1 Lighting levels Shall be reduced when road usage drops below 100 vehicles/hour during area specific time periods.. Special light output reduction circuitry using dual output ballasts and control wires or wireless control shall be utilised for this energy reduction feature. Also, see timed power switch under Section A Clause 9.6.

22.2.9 Maintenance

22.2.9.1 Maintenance of the lighting of a toll road shall be carefully controlled. The lighting in the area is designed to minimum lighting levels and at no time shall the standard of lighting, for safety reasons, be permitted to fall below these levels. A properly controlled maintenance programme shall be adhered to at all times. Group replacement of lamps shall be undertaken on a regular basis, based on the lamp lumen depreciation and luminaire dirt depreciation factors to which the installation was originally designed.

22.3 URBAN HIGHWAYS

22.3.1 Adjacent to high-density residential areas

22.3.1.1 Where urban highways run adjacent to high-density residential areas, it is important that adequate lighting be provided on the reserves on both sides of the road. This surround illuminance shall be provided over a 2 m wide strip and have a minimum surface illuminance of not less than 50% of that provided over the same area of the adjacent strip of the roadway. In many of these areas, although illegal, pedestrians do cross the roads at night and can create a serious danger to themselves and to the motorists. For this reason, a person approaching the road should be seen by a driver before he steps onto the roadway. Furthermore, where a motorist has some problems with his vehicle and has to stop on or over the edge, it is important that visibility is adequate.

22.3.1.2 Where the off ramps lead onto an unlit roadway it is important that a section of the road on each side of the ramps be illuminated. The road surface luminance at the intersection shall not be less than that of the off ramp. The crossroad lighting should be designed to taper off as it leaves the intersection. The SANS 10098-2, section 3.10 gives details of how this transition lighting shall be achieved.

22.3.2 On and off ramps

22.3.2.1 Where on and off ramps form part of the roadway network it is important that they are clearly visible to the driver on the highway. It is important that the commencement of the slip road can be noted some distance ahead to enable the driver to take the necessary action to divert from the traffic lane. For this reason the Contractor shall utilisation of lamps of a different colour and at a lower mounting height to that used for the highway itself, will provide better visual guidance. Innovative use of LED road studs or bollards shall be used for enhancing visual guidance in areas where the probability of the of mist or fog is high.

22.3.2.2 When the off ramps are inclined upwards to the crossroad it is important that the glare from the luminaires at the intersection shall be strictly controlled, otherwise they could considerably reduce the visual acuity of the oncoming driver.

22.3.2.3 On highways with complex interchanges, the utilisation of high-mast lighting is generally the most practical and economical system to utilise. Depending on the actual design of the interchange, the mounting heights of the masts shall not be less than 30 m. Several luminaires are normally mounted on each mast to give the necessary degree of light coverage. The actual design of the pole positioning and mounting heights will depend on the overall area covered by the interchange and its complexity. Such installations leave the lit area almost free of columns thereby giving the road user an uncluttered view of the road junction and its exits.

22.3.3 Adaptation zones

22.3.3.1 Where the lighting of a highway terminates, it is important that the lighting level gradually decreases in order that a driver’s night vision can adapt to the final unlit conditions. Full details of the recommendations for transition lighting are given in SANS 10098-2, section 3.10.

22.3.4 Pedestrian underpasses and bridges

22.3.4.1 An important consideration when designing lighting for highways is the possible presence of pedestrian tunnels under and bridges over the highway. These are usually provided for the safety of pedestrians who wish to cross the roadway.

22.3.4.2 The Occupational Health and Safety (OHS) Act lays down a minimum average illuminance for indoor passages of 75 lux, which is also be applicable to underpasses. During the day however, the provision of lighting will depend on a number of factors such as the penetration of daylight, which will vary according to the time of day and the position of the sun, as well as possible obstructions to incoming light at the entrances. Such aspects must be considered and appropriate lighting provided. Where possible, light coloured 45 ° sloping structures at each end will serve to reflect light into the pedestrian tunnel thereby reducing the need for artificial lighting during daytime. Where tunnels are long or are curved, they shall be lit 24 hours per day. The lighting quality will depend on the internal finishes and reflection factors of the walls and ceiling. . , No surface conduit or cables shall be used and heavy-duty bulkhead fittings with toughened glass covers and 5 mm galvanised steel mesh guards shall be utilised (70 W HPS Light source).

22.3.4.3 The OHS Act specifies a minimum average lighting at floor level of 20 lux. The Contractor shall install pedestrian bridge lighting where the contribution of existing street lighting is less than the requirement. . Modern practice is to enclose pedestrian bridges and cables shall run in the tubular structure of the canopy to 70W heavy duty bulkhead fittings with toughened glass covers protected by 5mm galvanised steel mesh guards. Spill light onto the highway below and glare shall be limited Special care shall be taken with the lighting design of the highway lighting under these bridges to limit shadows.

22.3.5 Lighting of pedestrian crossings

22.3.5.1 Where these are situated, apart from at road intersections with traffic lights, local lighting with additional luminaires shall be considered. For normal two-way roads, a luminaire shall be installed before the crossing in each direction of the traffic flow, on the side of the road on which the traffic drives. Full cut off luminaires with asymmetric light distribution directed towards the crossing are most suitable, causing less glare to motorists.

22.3.5.2 The illuminance at the road crossing, when measured on a vertical plane, shall be significantly higher than the horizontal illuminance produced by the road lighting on the carriageway. The highest level shall be at the road edge where pedestrians wait to enter the crossing. A recommended minimum vertical illuminance is 40 lux, and glare limitations in the opposite direction to oncoming traffic shall be strictly controlled. See also SANS 10098-1, section 5.3.

22.3.5.3 The Contractor shall submit to SANRAL approval, the method and means for marking pedestrian crossings.

22.3.6 Fill-in lighting for shadow areas under or near bridges over lit roads.

22.3.6.1 Bridges crossing lit roads often create shadow areas; the position of which depends on the width of the bridge and the position and height of the street light poles. It is possible to predict the position of the shadow during the design stage and to place suitable luminaires under the bridge to overcome the problem. Where possible, the luminaires shall be attached to the vertical pillars supporting the bridge deck. Luminaires mounted on the vertical pillars shall be mounted on a swivel outreach arm, with a locking pin to lock the luminaire in the setup position, for easy and safe maintenance. The mounting height shall be as high as possible leaving a clearance of 100mm between bridge deck and top of luminaire.

Attachment of luminaires to the under side of the deck results in the luminaire lamp being subjected to vibration from heavy vehicles using the bridge. This results in premature failure of the lamp. Sometimes it is impossible to mount luminaires other than on the under side of the deck in which case this attachment position should be used.

22.3.6.2 Due to the low mounting height under bridges it may be necessary to light the shadow area from both the median and the outer sides of the road. Rake angles of up to 25^0 may be necessary and fully cut off flat glass luminaires will be required to counter-glare. Should the light pole configuration be such that the shadow falls outside the area covered by the bridge, then the use of swivel out-rigger brackets, with locking pins, attached to the side of the bridge structure may be used.

***Note**, the Contractor shall obtain approval from SANRAL for the road lighting installation on or near bridges.*

22.3.7 Lighting for highway under HV power lines.

22.3.7.1 Due to the low mounting height under the HV power lines it may be necessary to light the highway from both the median and the outer side of the road. Rake angles up to 25° may be necessary and full cut off flat glass luminaires will be required to counter glare.

22.3.7.2 The pole or mast installed under the HV power line must be electrically connected to the earthing system by means of a 70mm² BCEW.

22.4 RURAL HIGHWAYS

22.4.1 Adjacent service stations in dark surroundings

22.4.1.1 All information signs **at or before the service station or other place of business** must have strictly controlled luminance in accordance with Government Notice No. R. 685 The South African National Roads Agency Limited and National Roads Act, 1998 (Act No. 7 of 1998) Regulations on Advertising on or Visible From National Roads. The luminance should not exceed the following levels:

(a)	Illuminated Area	Maximum Luminance
(b)	Less than 0.5 square metres	1000 candelas per square metre
(c)	0.5 to 2.0 square metres	800 candelas per square metre
(d)	2.0 to 10 square metres	600 candelas per square metre
(e)	10 or more square metres in visual zones	350 candelas per square metre
(f)	10 or more square metres in other areas	400 candelas per square metre

22.4.2 T-junctions and cross roads

22.4.2.1 Where lighting is required at T-Junctions and cross roads, recommended lighting layouts are given in section 5 of SANS 10098-1. It is important that transition lighting is also included as detailed in SANS 10098-2 section 3.10.

22.4.3 Roads/bridges adjacent to towns

22.4.3.1 Where national highways are located alongside residential or other built-up areas and are lit, consideration should be given to the possible light intrusion into private property or onto non-lit roads in the area. This is also a factor where the highway is bridged over an urban road, lit or unlit, in built-up areas. Where the National Road is bridged over by a lit urban road, care shall be taken that no obtrusive glare is directed towards National Road users.

22.4.3.2 In order to control spill light, only cut-off or semi cut-off light distribution luminaires should be used. .

22.5 TUNNELS

22.5.1 Short tunnels

22.5.1.1 From the viewpoint of daytime lighting requirements, tunnels which are less than 500 m in length, are considered “short”. Tunnels less than 40 m long usually do not require lighting unless urban or rural topography prevents sufficient light entering from outside or the tunnel is curved. Tunnels within the 40 to 500 m range require daytime lighting to overcome the “black hole” effect. Night time lighting requirements are as for the approach roads to the tunnel. Outside pavement luminance should be maintained throughout the tunnel and for at least 200 m after the exit.

22.5.2 Long tunnels

Long Tunnels are those longer than 500 m. Daytime lighting requirements for long tunnels fall into the following categories:

22.5.2.1 Adaptation Zone lighting

22.5.2.2 Interior Zone lighting

22.5.2.3 Fire emergency lighting

22.5.2.4 Marker lighting

22.5.2.5 Tunnel lighting is further subdivided into unidirectional and bi-directional installations. As for short tunnels, night time lighting maintains the outside pavement luminance in accordance with the relevant street lighting design to SANS 10098 as amended.

22.5.3 Adaptation lighting (only required during day light operation).

22.5.3.1 Outside daylight luminance of the road and portal surrounds can be in excess of 8000 cd/m². Adaptation lighting ensures that the driver's eyes become accustomed to the lower level of illumination of the interior zone in safety by slowly reducing the quantity of lighting over a period of 20 seconds. This obviates the dangerous "black hole effect" experienced if the eyes have not adjusted to the lower interior luminance levels.

22.5.3.2 Adaptation lighting comprises high-pressure sodium luminaires mounted at an inclination of 15 ° towards the incoming driver (counter cast lighting.) Pavement luminance levels of at least 5% of the maximum outside daytime luminance should be present at the start of the adaptation zone and reduce approximately as shown in graph 1. Counter-cast lighting should typically extend for 250m from the tunnel entrance (10 seconds travelling time at 90 kph), thereafter the following 250m (10 seconds) should be lit using the continuous fluorescent strip lighting set at 100% output. After 20 seconds the average driver's eyes will have adapted to the interior low lighting levels and a step chance down to 3 cd/m^2 may be made. This level of pavement luminance is maintained until the exit portal of a uni-directional tunnel or to 500m before the exit portal of a bi-directional tunnel when the adaptation lighting from that side of the tunnel is encountered. Alternative tunnel lighting design can be considered if full documentation is submitted to SANRAL or the Independent Engineer.

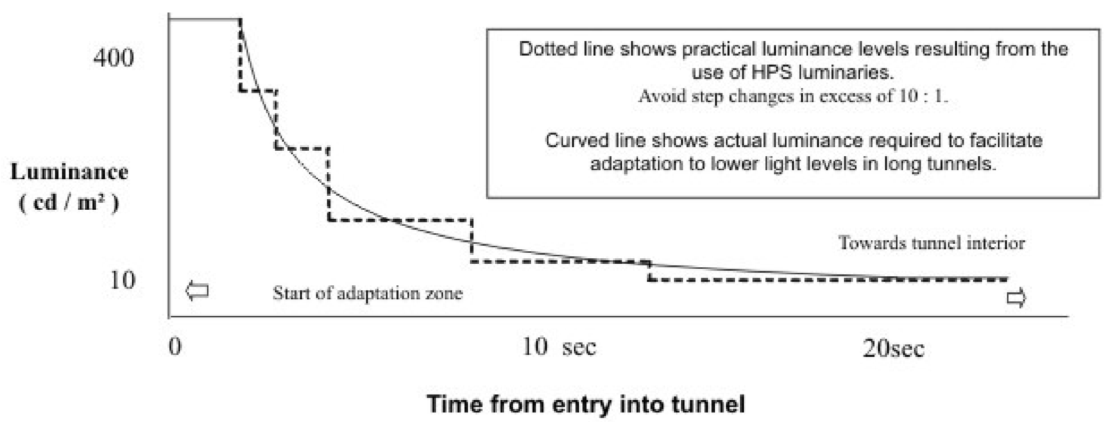


FIGURE 22-3: GRAPH 1 LUMINANCE LEVELS TO ALLOW THE DRIVER'S EYES TO ADAPT TO TUNNEL INTERIOR LIGHTING. (AFTER SCHRAUDER)

22.5.3.3 The Contractor shall incorporating equipment which automatically measures exterior, and interior road luminance and switches luminaires to maintain the 5% starting level, thereby conserving energy. It also serves as the day/night changeover switch. The last 250 m (10 s) of the adaptation lighting is usually fluorescent strip lighting, which forms part of the interior installation and is switched to 100% output. This applies to daytime operation only.

22.5.3.4 The adaptation lighting shall be applicable to Tunnels for national roads. Lighting levels shall be increased or decreased not exceeding a 10:1 ratio.

22.5.4 Interior lighting

22.5.4.1 The interior zone comprises that part of the tunnel greater than 500 m away from a portal. Interior lighting must take account of luminaire spacing, which could cause observable flicker in the dangerous range of 2½ to 14 pulses/second. Sensitive drivers experience symptoms ranging from mild nausea through migraine to epileptic fits.

22.5.4.2 Interior lighting can be designed as either a continuous fluorescent installation (in which case there will be no obtrusive flicker) or as a spaced high pressure sodium installation where the flicker frequency falls outside the dangerous range for the design speed limits. Drivers who disregard the speed limit would then run the risk of being subjected to flicker in the dangerous range.

22.5.4.3 Where continuous strips of fluorescent lighting are installed throughout and are used the following shall be adhered to:

(a) Emergency lighting (100% output),

(b) Day-time operation (100% from where HPS luminaires end to the end of the adaptation zone, giving a luminance level of 10 cd/m² from the road surface,

(c) Interior zone dimmed to 30% output yielding an interior road surface luminance of 3 cd/m²)

(d) Night-time operation where only one strip of fluorescent lighting need be utilised, this being dimmed to 30% output to provide 1,5 cd/m² road surface luminance throughout the tunnel, seamlessly joining up with the street lighting luminance of 1.5 cd/m² outside on the approach roads.

22.5.5 Fire emergency lighting

22.5.5.1 In the event of fire, smoke rises to the tunnel ceiling and “builds down” to obscure any conventional lighting. Fire emergency luminaires shall comprise either tungsten filament incandescent lights or white LEDs mounted behind glass domed covers so that the filament or LED point source is proud of the tunnel wall, at a height of 750 mm above the pavement. Spacing is at 40 m. These point source lights shall be seen through smoke and are used for guidance in fire conditions. They illuminate signs (pictograms) showing persons which way to proceed to a place of safety.

22.5.6 Marker lighting

22.5.6.1 Long tunnels are usually equipped with stopping bays at 1 km intervals to assist drivers of vehicles experiencing mechanical problems to stop safely and summon assistance. Marker lighting provides strong yellow low pressure sodium light to indicate the presence of a stopping bay while still a distance away. A 50 m long stopping bay shall be lit by 10 x 40W fluorescent fittings and 20 x 90W LPS fittings.

22.5.7 Emergency lighting

22.5.7.1 10% of the interior zone lighting should be fed from an uninterruptible power supply. In the case of continuous fluorescent strip lighting, 3 luminaires will be fed from Red phase., 3 from White phase and 3 from Blue phase and the 10th luminaire would be fed from the UPS.

22.6 ADDITIONAL CONSIDERATIONS FOR THE LIGHTING OF NATIONAL ROADS

22.6.1 Glare Control

22.6.1.1 The control of glare shall be considered for every situation. Glare control in the form of threshold increment (TI) shall be calculated by computer software complying with CIE 140. . The final results shall be submitted to SANRAL or the Independent Engineer for approval. Details of this form of glare are given in section D-1.3.2 of SANS 10098 and the maxima TI (%) permitted are given in Table 1 in Amendment 1 of SANS 10098-1.

22.6.2 Light Sources

The choice of the light sources to be used for the lighting of national roads will be dependent on a number of factors. These include the efficacy of the lamp, the operating life and the lumen depreciation over life, the colour rendering properties and the costs of purchase and operation of the lamps.

22.6.2.1 Efficacy: The average lumens per watt (efficacy) of a lamp vary considerably depending on its type, wattage and age. These also vary between manufacturers but a general guide is as follows:

(a) Low pressure sodium lamps: 140 to 200 lumens per watt

(b) High-pressure sodium lamps: 100 to 125 lumens per watt

(c) Light-emitting Diodes (LEDs) 100 to 110 lumens per watt

(d) Metal halide lamps: 70 to 90 lumens per watt

(e) High-pressure mercury lamps: 50 to 60 lumens per watt

These figures exclude losses in associated control gear.

22.6.2.2 From the above, it would appear advantageous to utilise Low Pressure Sodium lamps but these have a monochromatic light output which does not allow adequate colour rendering and therefore this light source has fallen from favour for street lighting but it is used for marker lighting i.e. tunnels.

22.6.2.3 Life: The definition of this aspect of lamp usage varies between countries and manufacturers. It can be related to average lamp failure rate or lumen depreciation down to a specifically defined percentage of initial output. When designing a lighting installation the minimum luminance/illuminance level must be determined, at which time the lamps will need to be replaced. In order to obtain these data, the lamp manufacturers must supply this information in the form of lumen depreciation curves for their specific lamps. A recent development in High Pressure Sodium lamps is the introduction of the 4Y Super lamp which not only produces a greater flux, but has a 4 year lamp life, therefore 4Y lamps shall be used. Colour rendering properties: These vary considerably between the different types of lamps. For road lighting only, there is no specific colour rendering recommendation. However, where enhancement of visual guidance provided by the road environment, driver navigation or pedestrian orientation and recognition of traffic signs or of geometric measurers is important, the colour rendering properties of the lamps chosen should be considered. The colour rendering properties (Ra) are rated from 0 to 100, where 100 rates as excellent. As these vary considerably between lamp types, details should be obtained from the manufacturer's published data.

22.6.2.4 The costs of the lamps will vary considerably between manufacturers and distributors. The operating costs will also depend on the type of control gear utilised in operating the lamps. These data shall be determined from suppliers.

22.6.3 Pole Types

22.6.3.1 Three different materials are used for the manufacture of street lighting poles. These are spun concrete, galvanized steel and fibreglass. These poles shall be manufactured in accordance with SANS 470:2007, SANS 1225/763 and SANS 1749:2006 respectively. The actual choice of pole material to be used will depend on many factors such as local availability, corrosion resistance, ease of erection, maintenance and costs, and scrap value, which might promote theft. The method of mounting will also depend on the material used and the height of the pole. In general terms, poles up to 15 m mounting height (i.e. height of luminaire above ground level) can be installed directly into the ground provided that the length to be installed below ground level and the thickness of the material will give adequate support (with a planting dept of 2m). Masts of greater mounting height will require concrete bases onto which the masts will be anchored by means of bolts. In such cases, at least two PVC duct shall be incorporated into the foundation to provide for the installation of the electricity supply cables.

22.6.3.2 When specifying the designs and types of poles required, special attention shall be paid to the wind loading on the poles and their positions in the area. Poles of 10 m and higher are subject to resonant frequencies of the complete column/bracket/luminaire system. Harmonics as well as the resonant frequency that can lead to premature lamp failures have been identified. Columns that are mechanically strong enough to withstand the vibration levels that will be encountered in service conditions shall therefore be specified. Luminaires utilising GES lamp holders must incorporate sprung inserts in the holder to prevent the lamp unscrewing under the effects of wind vibration.

22.6.3.3 All glass fibre poles shall be reinforced with steel mesh extending round the pole and for 250 mm above and below the inspection hole. Reinforced poles shall be capable of supporting double outreach arms of 3 m each and single outreach arms of 2 m. The pole shall not bend noticeably when carrying a luminaire on the 2 m outreach arm.

22.6.3.4 All steel poles, base plates and mounting bolts shall be hot dip galvanised to SABS Standards. The minimum wall thickness of steel poles is dependent on the height of the pole and shall not be less than 4 mm. At least a 3 mm thick sheath shall be welded to the lower part of the pole to extend 500 above and below the normal ground level of a planted pole. A tar coating shall be applied inside and outside this sheath.

22.6.3.5 When calling for quotations for poles for new installations, manufacturers shall provide proof that the pole design has satisfied a competent professional structural engineer and that it will withstand the expected wind loading pertaining to the area of installation. Subsequent orders for replacement poles shall be manufactured to the same specification.

22.6.4 Mounting Heights/Outreach

22.6.4.1 When specifying mounting heights of poles for highway lighting, it is preferable to standardise in order that designs, maintenance and replacements will be identical. The recommended standard mounting heights, i.e. above ground level, are 8 m, 10 m, 12 m, 15 m, 18 m and 20 m. The High mast lighting lengths will depend on spacing and interchange layout, but again, standardisation is recommended. Consideration Shall be given to the availability of maintenance equipment before deciding on pole height.

22.6.4.2 For the same reasons outreach arm lengths shall also be standard at either 500 mm, 2 m or 3 m outreach. In extreme cases 4 m double outreach arms may be used for median mounted poles.

22.6.4.3 For general highway lighting design, the mounting height of the luminaires on the poles shall be related to, the width of the carriageway including a minimum 2 m setback of the pole from the road edge. The overhang of the luminaire from the pole shall not be more than 25% of the pole mounting height. If a negative overhang is used (i.e. the luminaires are behind the kerb line) the luminaire light distribution shall be carefully selected in order to obtain the maximum luminaire utilisation factor on the roadway. The angle of tilt (rake angle) of the luminaire also has a major effect on the utilisation factor and the luminance uniformity on the roadway. Depending on the light distribution, the higher the angle of tilt the greater the possibility of an unacceptable waste light factor and atmospheric pollution. All these factors shall be considered in the design of the lighting installation.

22.6.4.4 In certain circumstances such as beneath overhead power transmission lines or adjacent to the end of airport runways or airfields, it may be necessary to utilise poles with a mounting height of 5 metres in order to satisfy the OHS Act. for free space to power lines and/or Civil Aviation Authority regulations. Luminaires under power-lines may be inclined at rake angles above zero degrees and need not necessarily be of the fully cut-off variety unless glare problems are encountered. Great care must be exercised when working on equipment below power lines due to the high voltages which may be induced. Adequate earthing is therefore vital. Luminaires mounted adjacent to the ends of airport runways or airfields will be required to be set at zero rake angle and to be of the fully cut-off flat glass type. Due to the difficulty of obtaining sufficient luminance coverage across multi-lane carriageways when using short 5 m mounting height poles and luminaires at zero rake angle, it may be necessary to mount poles both in the median and on the sides of the road. It may not be possible to achieve the minimum luminance level and overall uniformity required in SANS 10098: Part 1 as amended. In these circumstances, apart from the street lighting, lanes shall be marked with reflective road studs for the length of the road where the required SANS parameters cannot be met. Installations adjacent to airport runways or air fields must be fitted with Aviation Red Warning Lights to the satisfaction of the Civil Aviation Authority and must be supplied from an uninterruptible power source. Street light poles shall be of glass fibre construction and shall be frangible if struck by an aircraft.

22.6.5 Inspection Holes and Covers.

22.6.5.1 Inspection holes shall normally be positioned above the reinforcing sheath, 500 mm above ground level, except in areas where vandalism and theft of electrical power are commonplace. In this case, the inspection holes shall be positioned at a height of 1,5 metres above ground level. Cover plates shall be securely attached by means of bolts having a vandal proof head requiring a special key to unscrew the bolt.

22.6.6 Positioning of Poles

22.6.6.1 The lighting pole positioning for major highways, with at least two lanes in each direction can be installed in the following configuration:

(a) opposite each other; or

(b) in a staggered arrangement.

22.6.6.2 Where an island exists between the carriageways, double outreach poles can be installed in the median.

Note, the Contractor shall choose the lighting design most suitable for the prevailing road conditions.

22.6.7 Luminance Measurements

22.6.7.1 As the SANS 10098-1 specifies road luminance as the design factor for major roads, this is the factor that shall be measured to test design and installation compliance. It shall also be used at regular intervals for maintenance checking. All measurements shall be taken with a calibrated luminance meter that is designed for this specific task and recorded on a pre-determined grid.

22.6.7.2 For measurement at a grid point, the meter shall be capable of restricting the total angle of the measuring cone to 2 minutes of arc in the vertical plane and 20 minutes of arc in the horizontal plane. The size of the measurement area on the road shall not be greater than 0,5 m transversely and 2,5 m longitudinally.

22.6.7.3 For measurement of average luminance by means of a single reading, the meter shall have a masking facility by which only light from the relevant area of the road surface is included in the measurement.

22.6.7.4 The angle of view of the meter shall be at 89 degrees, plus or minus 0,5 degrees normal to the road surface.

22.6.7.5 If a luminance meter is not available, luminance values shall be obtained by multiplying the illuminance reading by a conversion factor depending on the road surface reflecting characteristics. A typical conversion factor for normal asphalt is R3 = 0.08. For "porous asphalt" , a figure of 0.05 shall be taken for the conversion factor. The method of calculation of average illuminance is given in Subsection 4.1.4 of Amendment No 2 (1998) of SANS 10098. However new luminance metres are now becoming available which can be installed in a moving vehicle and via a computer, measure and calculate spot and average luminance values along the roadway.

22.6.7.6 Only Computer programs that comply with the CIE 140 standard shall be used.

22.6.7.7 The lighting design shall be submitted in electronic and hard copy format to SANRAL and the Independent Engineer for their comments and approval.

22.6.8 Road Surfaces

22.6.8.1 As stated in SANS 10098-1 and many other international Codes of Practice, road lighting designs are based on road surface luminance i.e. the light reflection properties of the surface. As it is not practical to light a road at night to the same levels as daytime, the alternative method of visibility is used i.e. silhouette vision. This is achieved by lighting the road surface to a certain brightness level, against which objects on the roadway will be seen in silhouette. This will then provide adequate visual performance and visual comfort at the low general lighting levels experienced at night. The illuminance on a road surface, which refers only to the amount of light reaching that surface per unit area, will not give any indication of how effective the visual sensation will be, nor how bright the surface of the road will appear. The brightness depends on the amount of light radiated by the surface per unit of bright area and per unit of solid angle in the direction of the observer. Therefore, it is the luminance and not the illuminance that will determine the visual performance of the roadway lighting.

22.6.8.2 In order to obtain the required lighting levels to provide better visual performance on our roads at night, it is important that the road reflection qualities are taken into account when designing the lighting installation and in its maintenance.

22.6.9 Maintenance

22.6.9.1 Maintenance shall be conducted strictly in accordance with ARP 035:2002 “Guidelines for the Installation and Maintenance of Street Lighting.”

22.6.9.2 Lamp replacement shall be carried out on a group basis, i.e. all lamps in a particular section shall be replaced at the same time at pre-determined intervals. These intervals will depend on the type of lamp used and its rate of lumen depreciation. It will also depend on the IP Rating (resistance to ingress of water and dust) of the luminaires chosen and the amount of atmospheric pollution in the area. As the lighting would originally have been designed for a specific luminance value, the group replacement shall take place when the measured lighting level falls below that level. Details of lamp lumen depreciation will have to be provided by the manufacturer (see 4.2b above) and luminaire maintenance factors are given in SANS 10098 Appendix B.

22.6.9.3 Individual lamp failures shall also be noted and lamps replaced as soon as possible. Failure of control equipment can also occur due to a number of factors and this will affect lamp life.

22.6.9.4 Lighting maintenance including lamp replacement shall be carried out by properly trained personnel who shall report control gear failure or other problems to the relevant maintenance technician. It is also important that specifically designed maintenance vehicles, with all the required equipment be utilised. Lighting maintenance personnel shall provide adequate signage and coning off for the safe accommodation of traffic.

22.7 STANDARDISED LIGHTING INSTALLATION MEDIAN LIGHTS ON FREEWAYS

22.7.1 Concept

22.7.1.1 This standardised design was conceived in order to create a standardised street lighting design that will cater for present needs of the South African National Roads Agency Limited and future expansion to a maximum of 5 lanes per carriageway. This standard design only applies to major city freeways where the existing number of lanes per carriageway is already 3 with traffic volumes indicating the probability of early extension to 4 and a growth pattern which indicates likely extension to 5 within the forecast period.

Note, the in the event that medium lighting can not be provided, due to the presence of existing infrastructure, an opposite arrangement of singe outreach masts shall be used. Transition from median to opposite arrangement shall only be carried out at interchanges.

22.7.2 Standard Lighting Design

22.7.2.1 The number of lanes per carriageway for design purposes shall be 5 x 3.5m wide lanes.

22.7.2.2 Where a median barrier is provided, the standard spacing shall be 58m to conform to the standard median barrier design.

22.7.2.3 Two luminaires per pole fitted with 600W HPS Super T 4Y Lamps shall be used.

22.7.2.4 Road luminance shall be 2 cd/m^2 minimum with Overall Uniformity (Uo), Longitudinal Uniformity (Ul) and Threshold Increment (TI) in accordance with the parameters set down in SANS 10098-Part 1 .

22.7.2.5 Where the presence of ‘off’ and ‘on’ ramps dictate a temporary widening of the freeway to 6 lanes for a short distance, the additional lighting shall be supplemented by outside light poles which are for ramp lighting.

22.7.2.6 Overhead sign gantries and ORT gantries shall be placed midway between light poles as far as possible.

22.7.3 Electrical Design

22.7.3.1 Bulk power supplies shall be at 11 kV.

22.7.3.2 Only paper-insulated lead-covered steel tape armoured copper cables shall be used.

22.7.3.3 11 kV switch gear and ring main units shall be SF 6 insulated.

22.7.3.4 Secondary contactors on the 11 kV switchgear shall close when the main switch is open. A signal indicating that the secondary contactor is open, shall be fed back to the main control room. This method shall be used if a tele-management system has not been provided.

22.7.3.5 Cables shall be buried at a depth of at least 1 m and shall be fitted with “Cable Guard” or similar approved units at 50 m intervals. Where cables are run in ducts, “Cable Guard” or similar approved units shall be fitted in manholes to prevent long lengths of cable being easily removed.

22.7.3.6 The twin cable system of supplying the poles shall be used in which odd numbered poles are connected to one cable and even numbered poles are connected to the second cable. This system facilitates the use of smaller sized cables and, in the event of one cable being faulty, every second street light will still be operational.

22.7.3.7 Passive radio frequency identity tags similar or equal to those supplied by 3M shall be used to mark the cable routes and positions of cable joints.

22.7.3.8 Separate 10A MCBs shall be provided in each pole for supplying individual luminaires.

22.7.3.9 Where overhead bridges or ORT gantries are located along the route, provision shall be made for a sleeve in the concrete median barrier from the nearest pole position so that any additional lighting may be supplied with power.

22.7.3.10 Provision of conduits built into bridges shall be made to facilitate the supply of power to supplementary under-bridge lighting.

22.7.3.11 Ideally, sleeved road crossings for cables shall be installed during the construction phase of the project but should additional ducts be required, then directional drilling techniques shall be employed.

22.7.3.12 Where pedestrian bridges require lighting, the power supply conduit shall be run in the tubular steel structure of the bridge to heavy duty bulk head fittings with thick glass covers protected by 5mm galvanised steel mesh guards. It is vital for the bridge designer and consulting electrical engineer to liaise on this matter.

22.7.3.13 The provision of fully marked up "As-Built" drawings shall be a PC Sum in the Bill of Quantities. Pole positions, kiosks, cable joints and cable run direction changes shall be given GPS co-ordinates and recorded on the "As-Built" drawings.

22.7.4 Luminaires

22.7.4.1 The luminaire chosen mounting on the 20m poles is the Beka-Schréder Onyx 33 fitted with a 600 W HPS Super T 4Y lamp. The lamp position shall be selected to project the beam over the 5 lanes.

22.7.4.2 Twin ballasts shall be fitted along with switches to reduce the light output during off-peak hours. Switching may be effected in one of three ways:

(a) A self-contained power switch with built-in timer mounted in the luminaire. Note that this is effective where the off-peak period is predictable and also if the power supply is not interrupted. The system resets itself to zero after a 15-second power outage and the cycle restarts at the incorrect time. The system has a fail-safe feature which switches the luminaire to full brightness in the event of malfunction.

(b) A pilot wire controlled relay mounted in the luminaire. The pilot wire is in turn switched from the supply kiosk by way of a fibre optic controlled interface. A central control centre allows dimming to be activated either or automatically or overridden manually, should local conditions require this.

(c) A full tele-management installation based on open standard wireless mesh technology. An example of this technology is the Owlet Nightshift. Switching equipment may be positioned in the luminaire for single installations or in the pole if two luminaires are carried on a double outreach arrangement. This system lends itself to keeping supply cables energised at all times, thereby reducing the problem of cable theft. Control signals are transmitted via GSM or internet. The system gathers data from each luminaire and assembles this for further processing and use by the maintenance team. The system shall form part of a SCADA solution if implemented.

22.7.4.3 Retrofitting of installations not provided with off-peak dimming control is best effected by applying the tele-management system, as providing pilot wires will be difficult.

22.7.4.4 A rake angle of zero shall be applied.

22.7.5 Street Light Poles

22.7.5.1 Street light poles shall be 20 m mounting height. Poles shall be mid-hinge masts or scissor masts. Prior to submission of the tender, the manufacturer shall certify in writing that the pole has been designed by a Professional Structural Engineer and that is suitable for the altitude, terrain and wind speeds likely to be encountered at the intended place of installation.

22.7.5.2 Where no median barrier is specified, poles shall be flange-mounted on concrete plinths incorporating the bolt cage. Where a median barrier is specified, the bolt cage shall be built into the median and the flanged poles shall be bolted to the cage. A space of 30mm shall be arranged between the bottom of the flange and the concrete plinth to allow for positioning the pole vertically. Once the pole has been erected to the satisfaction of the Engineer, then the space between the flange and concrete shall be grouted with a strong cement/sand mix.

22.7.5.3 The pole manufacturer shall specify the maximum wind speeds permissible when lowering the mid-hinge/scissor pole.

22.7.5.4 Each median-mounted pole shall be fitted with short double outreach arms of 500mm length.

22.7.5.5 Pole numbering shall incorporate the chainage along national roads as part of the coding to facilitate location. The pole number shall comprise yellow 50mm high letters and numerals on a black background. The number shall be placed at a height of 2 metres above the flange in a position easily visible from a maintenance vehicle.

22.7.5.6 Lightning finials shall be attached to the topmost part of the pole and connected to the pole earthing system.

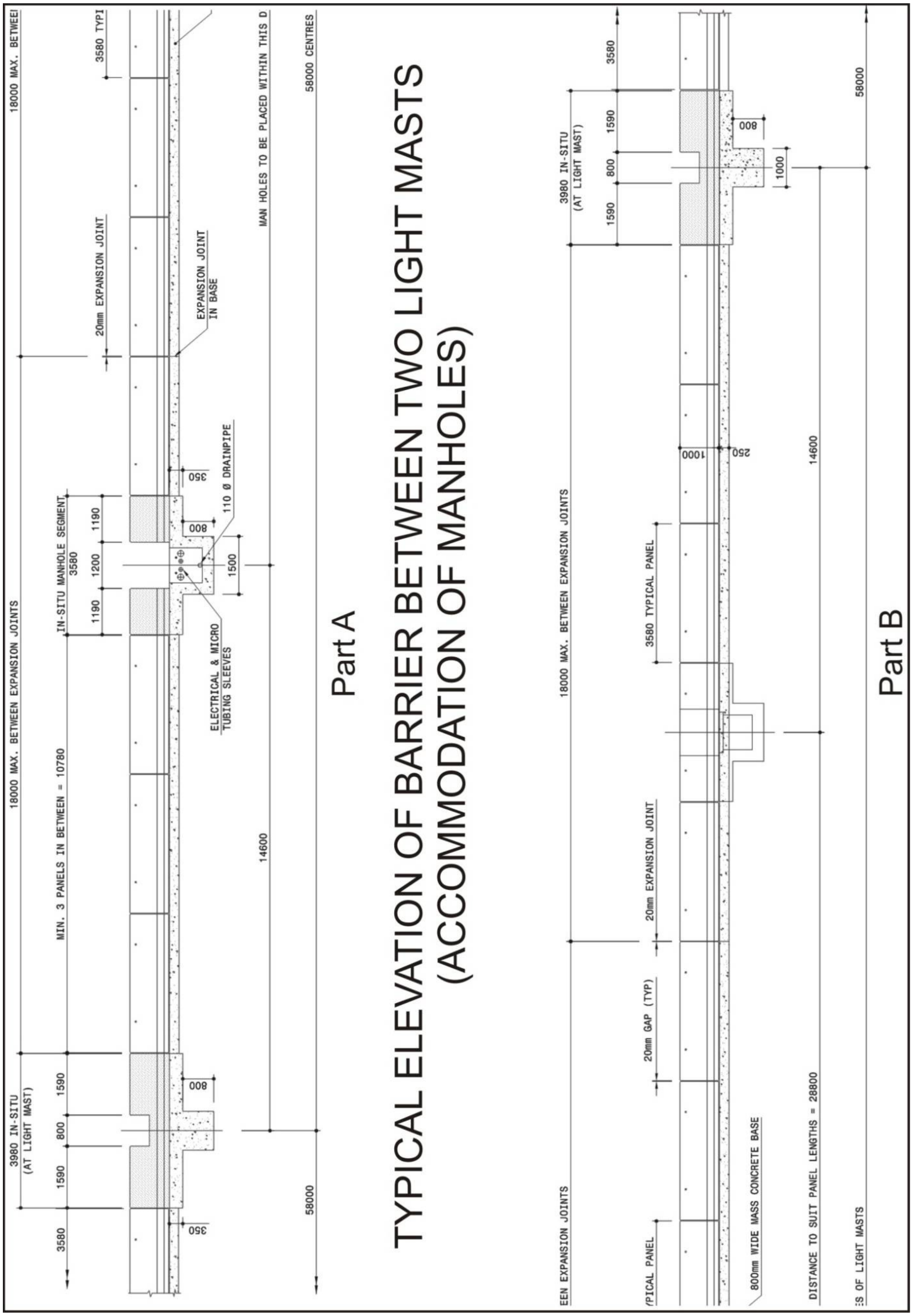


FIGURE 22-4: TYPICAL ELEVATION OF BARRIER BETWEEN TWO LIGHT MASTS

22.7.6 Maintenance

22.7.6.1 Group lamp replacement should be carried out towards the end of the fourth year of operation for 4Y lamps for installations which do not incorporate a tele-management system. Tele-management allows the gathering of maintenance data for each luminaire and therefore lamp replacement records are readily available.

22.7.6.2 Routine cleaning of the outside of the curved glass covers must be carried out at intervals determined by the pollution present in the area.

22.7.6.3 Prior to glass cover cleaning, the current drawn by each individual luminaire should be measured by tong tester. If the expected current drawn by the lamp type is exceeded, it is probable that the power factor correction capacitor has failed. This should therefore be replaced during the cover cleaning exercise when the pole has been lowered.

22.7.6.4 The maintenance contractor shall only lower poles if the weather conditions are suitable - the manufacturer shall specify the maximum wind speed for the safe lowering of the mast.

22.7.6.5 The maintenance team shall respond immediately in the case of collision damage to poles where the structure is obstructing traffic flow on the freeway. Other involuntary maintenance shall be attended to on a sliding time scale depending on the importance thereof. Routine maintenance shall be planned well in advance. All maintenance, repair and accident damage shall be captured on a SCADA or similar data base software to be able to extract reports manually or automatically on a monthly basis. The Contractor shall capture the following minimum information listed below:

(a) Date and time of event.

(b) Event category (if required)

(c) Event description.

(d) Event status.

(e) Date and time acknowledge by Contractor.

(f) Event repair time and date.

(g) Action taken to resolve event.

(h) Total repair time

22.7.6.6 In the event of vehicle damage to any pole requiring the replacement of the pole, the hinge shall be examined for abnormal wear and attachment of outreach arms to the pole checked for corrosion and metal fatigue cracks.

22.7.6.7 Three-monthly reports shall be issued to SANRAL detailing the percentage availability of street lighting during the previous three-month period, the number of inspections carried out, the types of faults encountered, the stores stock holding of spare parts and any other relevant information.

22.8 CODE OF PRACTICE FOR THE LIGHTING OF NATIONAL ROADS DATA AND COMPLIANCE SHEET

TABLE 22-2: CODE OF PRACTICE FOR THE LIGHTING OF NATIONAL ROADS DATA AND COMPLIANCE SHEET.

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
22.9.1	SANS 10098-1:2007 (SABS 098-1)	Public lighting Part 1: The lighting of public thoroughfares				
22.9.2	SANS 10098-2:2005 (SABS 098-2)	Public lighting Part 2: The lighting of certain specific areas of streets and highways				
22.9.3	ARP 035:2007 (ARP 035)	Guidelines for the installation and maintenance of street lighting				
22.9.4	SANS 470:2003 (SABS 470)	Concrete poles for telephone, power and lighting purposes				
22.9.5	SANS 1225:1985 (SABS 1225)	Ammoniated liquid detergent cleaner				
22.9.6	SANS 1749:2006 (SABS 1749)	Glass-reinforced polyester (GRP) poles				
LIGHTING						
	CLAUSE					
22.9.7	22.3	SPECIAL CASES				
22.9.8	22.3.1	Toll Roads				
22.9.9	22.3.2	Apron areas				
22.9.10	22.3.3	Areas in and adjacent to toll booths				
22.9.11	22.3.4	On and off ramps				
22.9.12	22.3.5	Signs				
22.9.13	22.3.6	Toll roads in dangerous areas				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
22.9.14	22.3.7	Late night low traffic volume operation.				
22.9.15	22.3.8	Maintenance				
22.9.16	22.4	Urban Highways				
22.9.17	22.4.1	Adjacent to high-density residential areas				
22.9.18	22.4.2	On and off ramps				
22.9.19	22.4.3	Adaptation zones				
22.9.20	22.4.4	Pedestrian underpasses and bridges				
22.9.21	22.4.5	Lighting of pedestrian crossings				
22.9.22	22.5	Rural Highways				
22.9.23	22.5.1	Adjacent service stations in dark surroundings				
22.9.24	22.5.2	T-junctions and cross roads				
22.9.25	22.5.3	Roads/bridges adjacent to towns				
22.9.26	22.6	Tunnels				
22.9.27	22.6.1	Short tunnels				
22.9.28	22.6.2	Long tunnels				
22.9.29	22.6.3	Adaptation lighting				
22.9.30	22.6.4	Interior lighting				
22.9.31	22.6.5	Fire emergency lighting				
22.9.32	22.6.6	Marker lighting				
22.9.33	22.6.7	Emergency lighting				
22.9.34	22.7	ADDITIONAL CONSIDERATIONS FOR THE LIGHTING OF NATIONAL ROADS				
22.9.35	22.7.1	Glare Control				
22.9.36	22.7.2	Light Sources				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
22.9.37	22.7.3	Pole Types				
22.9.38	22.7.4	Mounting Heights/Outreach				
22.9.39	22.7.5	Inspection Holes and Covers.				
22.9.40	22.7.6	Positioning of Poles				
22.9.41	22.7.7	Luminance Measurements				
22.9.42	22.7.8	Road Surfaces				
22.9.43	22.7.9	Maintenance				
22.9.44	22.7.10	Waste Light				
22.9.45	22.8	STANDARDISED LIGHTING INSTALLATION MEDIAN LIGHTS ON FREEWAYS				
22.9.46	22.8.2	Standard lighting design				
22.9.47	22.8.3	Electrical Design				
22.9.48	22.8.4	Luminaires				
22.9.49	22.8.5	Street light pole				

23. GENERAL MECHANICAL EQUIPMENT

23.1 GENERAL

23.1.1 The warranty of all Equipment both bought out and of in-house supply, shall be carried by the Contractor. All machinery shall conform to OHS Act requirements.

23.1.2 All machinery shall be of non-combustible material, as far as is practical.

23.1.3 All floor mounted machinery shall be mounted at least 200 mm above the floor to allow access for cleaning, unless such machinery is constructed with a tight base preventing material from reaching inaccessible areas beneath the machine.

23.1.4 Mild steel seam welded hollow section is to be used on all fabricated support work. Ends must be made off. This includes support steelwork.

23.1.5 The design and installation of all systems shall be such as to prevent any water entering the building by any means whatsoever.

23.1.6 Ducting shall be installed not closer than 50 mm from adjacent building surfaces to facilitate painting from time to time.

23.1.7 This general specification shall be applicable to the manufacture, supply, installation, testing, Commissioning and maintenance of any Plant or Employer’s Equipment as required of the Contractor.

23.2 GUARDS

23.2.1 All guards shall comply with the OHS Act and have the approval of SANRAL, and are to be completely safe and easy to remove. No bare shafts, couplings, drives or potentially dangerous moving parts shall be exposed.

23.3 DUST CONTROL

23.3.1 All equipment shall at least be of a dust-tight design.

23.4 PAINTING

23.4.1 All painting shall be carried out in accordance with this specification.

23.5 MANUFACTURER'S RATINGS

23.5.1 All equipment such as prime movers, fans, compressors, pumps, valves etc., shall be operated well within the manufacturer's ratings.

23.5.2 The Contractor shall submit manufacturer's ratings of all Equipment for the full range of capacities, speeds, power requirements, pressure ranges etc. Ratings shall preferably be given in the SI system.

23.6 WORKS ON CONCRETE, PLASTERED AND BRICK SURFACES

23.6.1 The Contractor shall take all due care during installation and all other times to protect the exposed off-shutter concrete beam, column surfaces and brick and plastered work surfaces from scuffing, smearing, chipping or any other damage that may arise from the installation Works. Any ladders or scaffolding rested on these surfaces shall be padded and carefully moved.

23.6.2 Where no surface finishes are applied, the surfaces shall be maintained in pristine condition. Chasing of surfaces will be allowed, providing the Works is neatly and accurately done and filled and finished off to SANRAL's satisfaction.

23.6.3 Fixings to concrete surfaces and bricks shall only be carried out in accordance with this specification.

23.7 FIXING OF EQUIPMENT FITTINGS

23.7.1 The Contractor shall ensure that all equipment and fittings are securely fixed to concrete and brick surfaces (walls and ceilings) by suitable bolts, or to structural steelwork by suitable bolts or bolt-on mounting brackets (welding-on will not be permitted). Where fittings are required to be suspended, approved robust hangers shall be provided.

23.7.2 Shot bolts will be permitted in steelwork but not in concrete or brickwork, where holes shall be drilled for patent type anchor bolts or plugged with approved material to receive galvanised screws. Only SANRAL approved fixings shall be used.

23.7.3 All equipment and fittings shall be easily removable and shall be mounted in accessible positions to facilitate maintenance.

23.8 INSTALLATION

23.8.1 The units shall be installed in accordance with the manufacturer's recommendations and in line with sound engineering practice. The units shall be free from discernible vibration and shall not exceed the manufacturers or contractual noise levels.

23.8.2 The roof adjacent to the cut outs for roof mounted Equipment shall be flashed and effectively sealed to SANRAL's satisfaction.

24. CORROSION PROTECTION

24.1 SCOPE

24.1.1 This section covers corrosion protection of electrical components in general and for materials or coatings for specific components. The requirements of this specification are additional to any corrosion protection that may be covered under any other section of these specifications. In the case of discrepancies between this section and the drawings, this section shall have preference.

24.1.2 Where alternative specifications are given to cover areas of high or low corrosivity and the environment of the component in service is not known, the specification for high corrosivity shall be used. In cases where specific brand names are mentioned in this Clause 18, the Contractor may use any product of similar quality as approved by SANRAL.

24.2 LIST OF RELEVANT NATIONAL AND INTERNATIONAL CODES OF PRACTICE, STANDARDS AND TEST METHODS

24.2.1 General

The following national and international Codes of Practice, standards and test methods shall be read in conjunction with this section:

24.2.1.1 Codes of Practice

SANS 10044-1 and 10044-2	-	Welding,
Part III:		The fusion welding of steel (including stainless steel) - Tests for the approval of welding procedures and production welds.
Part IV:		Tests for the approval of welders working to approved procedures.
Part V:		Tests for the approval of welders where weld procedure approval is not required.
Part VI:		The fusion welding of aluminium and aluminium alloys; Tests for the approval of welding procedures and production welds.
Part VII:		The fusion welding of aluminium and aluminium alloys; Tests for the approval of welders working to approved welding procedures.
SANS 10064	-	Preparation of steel surfaces for coating.
SANS 10140-1 to 5	-	Identification colour marking.
ARP – 001: 1987	-	Quality Management Systems.
SANS 10158	-	Glossary of terms for quality assurance and quality control.

SANS 0214	-	The design, fabrication and inspection of articles for hot diphot dip galvanising.

24.2.1.2 Standard Specifications

SANS 630	-	Decorative high gloss enamel paint for interior and exterior use.
SANS 681	-	Undercoats for paints.
SANS 121:2000/ISO 1461:1999	-	Hot dip (galvanised) zinc coatings (other than on continuously zinc coated sheet and wire).
SANS 934	-	Hot dip (galvanised) zinc coatings on steel sheet and strip.
SANS 999	-	Anodised coatings on aluminium (for architectural purposes).
SANS 1258	-	Two pack epoxy resin based primers.
SANS 1407	-	Anodised aluminium (general applications).
SANS 1274	-	Coatings applied by the powder process.
SANS 1319	-	Zinc Phosphate Primer.

24.2.1.3 Standard Test Methods

SANS Method 140	-	Dry film thickness of paints by means of a mechanical dial-indicator-type gauge ISBN 0-626-03551-1.
SANS Method 141	-	Dry film thickness of paints by means of a magnetic-flux -type gauge.
SANS Method 5767	-	Cleanliness of blast cleaned steel surfaces for painting.
SANS Method 5769	-	Cleanliness of blast cleaned steel surfaces for painting (assessed by freedom from dust and debris)
SANS Method 5772	-	Profile of blast cleaned steel surfaces for painting (determined by micrometer profile gauge).
SANS Method 5776	-	Adhesion of coatings (direct pull off method).
SANS Method 5159	-	Adhesion of paint and varnish films (cross-cut test).
ISO 8505-1	-	Pictorial surface preparation standards for painting steel surfaces.

24.2.1.4 British Standards

BS 4870	-	Part 1 - Coded Welders.

BS 6496	-	Powder organic coatings for application and stoving to aluminium alloy extrusions etc.

24.2.1.5 USA Specifications

ASME-IX 1983 - Coded Welders.

24.3 GENERAL

24.3.1 The Contractor shall ensure that he and his relevant sub-Contractors have available the latest edition of all the relevant Specifications and Codes of Practice, both SABS and others, as listed in the sub-clause titled "List of Relevant National and International Codes of Practice, Standards and test Methods" in this section, and the latest issues of manufacturer's data sheets for the materials to be used.

24.3.2 All paints in a paint system shall be purchased from one paint manufacturer. Identical paints used at one time or on one item shall be of the same batch number.

24.3.3 The Contractor shall proceed with purchase of the paints only upon receipt of written approval from SANRAL of the brand or manufacturer.

24.3.4 The materials and procedures shall comply with the appropriate SABS Specifications and Codes of Practice when relevant, and with the manufacturer's printed data sheets.

24.3.5 Strict attention shall be paid to fettling of surfaces by the fabricator (refer to the clause titled "Fettling or Dressing by the Fabricator") prior to coating. Surface preparation requirements and the need for strict cleanliness and adherence to specification requirements are emphasised.

24.3.6 Areas, which are or potentially may be inaccessible after assembly, shall be prepared and fully coated with the specified system and to the specified requirements before assembly. The coating shall be fully hard dry before assembly.

24.3.7 Mating surfaces shall be coated with primer or first coat only. The coating shall be uniform in thickness and shall not interfere with the mechanical tolerances. After assembly the outside surface of the joint shall be fully coated and sealed where necessary in accordance with the relevant specification.

24.3.8 The painting sub-contractor shall provide evidence of his competence to apply the specified materials in the specified manner and to apply the necessary quality control procedures. SANRAL, at his discretion, may demand a quality audit of the Contractor's facilities by a technically competent and independent organisation (refer to the clause titled "Quality Assurance Requirements").

24.3.9 The Contractor shall provide a quality plan to show the stages at which quality control will be carried out. Further details are given in the clause titled "Quality Assurance Requirements".

The quality plan is subject to approval by SANRAL, who may require it to be revised if considered inadequate.

24.3.10 The Contractor shall furnish material suppliers with the specified descriptions of materials to be used and shall receive from them a written assurance that the materials to be supplied comply with the requirements specified in the project specifications.

24.3.11 If the Contractor wishes to offer an alternative to the specified system, he shall supply to SANRAL adequate technical information to enable a proper evaluation of the proposed system. The Contractor shall not proceed with application of the system until authorized by SANRAL in writing.

24.4 DESIGN

24.4.1 General

24.4.1.1 All items shall be designed to minimize corrosion in outdoor environments, under immersion conditions and in interior aggressive situations such as in chlorination rooms. The following notes may be used as guidelines:

24.4.2 Water retention areas

24.4.2.1 Water retention areas shall be avoided wherever possible. For example, angle or U section steel shall be used with the toes pointing downwards and the concrete base of columns shall be sloped away from the steel. Where water retention cannot be avoided, drain holes, suitably radiused, shall be fitted at the lowest point. Joints between steel and concrete shall be sealed with a suitable sealant.

24.4.3 Crevices

24.4.3.1 Accelerated corrosion results from crevices when water is present. Crevices may be avoided by using:

(a) Continuous welding, not space welding,

(b) Mastics or sealants to seal unavoidable crevices such as bolted connections,

(c) Insertion rubber or suitable plastic between mating surfaces.

24.4.4 Bimetallic couples

24.4.4.1 Electrical contact between dissimilar metals gives rise to a corrosion cell when an electrolyte such as water is present. Joints between dissimilar metals shall be electrically insulated, or effectively sealed to prevent water ingress.

24.4.5 Accessibility

24.4.5.1 Whenever possible, the surfaces of corrodible materials such as mild steel shall be accessible for maintenance. The use of angles back to back, partially open box sections or inaccessible stiffeners shall be avoided.

24.4.6 Differential aeration

24.4.6.1 Posts buried in soil are subject to accelerated corrosion due to differential aeration. Additional protection shall be given to that part which is buried and up to at least 100 mm above ground.

24.4.7 Sharp edges, weld spatter and weld slag

24.4.7.1 The designer shall specify that all sharp edges shall be ground to a radius not less than 2 mm and that all weld spatter and weld slag shall be removed by the fabricator.

24.4.8 Hot dip galvanising

24.4.8.1 The design of articles to be galvanised shall be referred to the galvaniser and shall comply with SANS Code of Practice 0214. Articles to be painted or powder coated after galvanising shall not be passivated. For galvanised articles to be powder coated, refer also to System F, detailed in the clause titled "System F - Powder Coatings".

24.4.9 Vapour corrosion inhibitors

24.4.9.1 Where vapour corrosion inhibitors are specified, the form, chemical composition and quantity of VCI shall be suitable for the metals used in the cabinet and shall be adequate for at least 12 months' protection in the environment in which the cabinet will be situated.

24.5 COATING MATERIALS

24.5.1 No variation in materials to be used shall be permitted without the approval of SANRAL in writing.

24.5.2 All coating materials shall be delivered in the manufacturer's original sealed containers, clearly marked with the following:

24.5.2.1 Manufacturer's name;

24.5.2.2 Product brand name and reference number;

24.5.2.3 Batch number, which may incorporate the date of manufacture;

24.5.2.4 Date of manufacture, unless already incorporated in the batch number;

24.5.2.5 Abbreviated instructions for storage and use of the material, which shall include mixing ratios of components of multi-component materials, the minimum temperature of application and the method of application;

24.5.2.6 The SABS mark where applicable.

24.5.3 Coating materials shall be kept in an approved store, which shall be dry and enclosed and in which the temperature is unlikely to exceed 40°C or drop below 0°C.

24.5.4 Usage of materials shall be on a first in, first out basis and no materials may be used which have exceeded the shelf life recommended by the manufacturer.

24.6 FETTLING OR DRESSING BY THE FABRICATOR

24.6.1 Before any surface preparation or painting is carried out, dressing shall be carried out to remove projections, sharp edges, weld slag and spatter that will interfere with the corrosion protection.

24.6.2 All weld flux and weld spatter shall be removed before painting. Flux is best removed by washing with clean water whilst weld spatter is normally removed by grinding to a smooth surface.

24.6.3 Sharp edges shall be ground to a radius not less than 2 mm, except where otherwise permitted by SANRAL, e.g. cable racking.

24.6.4 Welds shall be continuous and shall have a smooth contour. Rough welds shall be ground where necessary to achieve the required smooth profile. Undercuts shall not be permitted. Discontinuous welds shall not be permitted except by written approval of SANRAL.

24.6.5 Articles for hot dip galvanising shall not have any overlapping joints. Closed sections shall be suitably vented.

24.7 SURFACE PREPARATION FOR PAINTING

24.7.1 Mild steel, minimum 2 mm thickness

24.7.1.1 Oil and grease contamination, when present, shall be removed by degreasing before blast cleaning.

24.7.1.2 Mild steel shall be blast cleaned in accordance with Section 4.3 of SANS 10064 Code of Practice for "The preparation of steel surfaces for coating". An additional requirement is that water-soluble salts present in the steel after blast cleaning shall not exceed the appropriate values given in Table 1 below. Should these values be exceeded, the steel shall be cleaned by washing with clean potable water or by water shrouded or water injected blast cleaning until the soluble salts are within the limits specified in Table 1. The steel shall then be allowed to dry, after which it shall be flash blast cleaned to achieve the required degree of cleanliness.

24.7.1.3 The standards of blast cleaning required are given in the table below.

TABLE 24-1: STANDARDS FOR BLAST CLEANING

1	2	3	4	5
PROPERTY	**ABOVE WATER SURFACES**	**IMMERSED SURFACES**	**TAPE WRAPPING**	**INORGANIC ZINC**
Cleanliness to ISO 8501/1 (SIS 05 5900) (min)	Sa 2.5	Sa 3	Sa 2	Sa 2.5
Residual dust and debris (SANS Method 5769)	0,5%	0,3%	0,5%	0,3%
Oil grease and perspiration	Nil	Nil	Nil	Nil
Surface Profile min (micrometres) max	25 50	50 100	- -	50 100
Water soluble iron salts: - Maximum at any point - Average of any 250 cm^2	500 mg/m^2 100 mg/m^2	100 mg/m^2 10 mg/m^2	500 mg/m^2 100 mg/m^2	500 mg/m^2 100 mg/m^2

24.7.1.4 The time interval between blast cleaning and application of the first coat of paint shall not exceed that given in the table below.

TABLE 24-2: MAXIMUM TIME INTERVALS

AMBIENT RELATIVE HUMIDITY	MAXIMUM TIME (HOURS)
Below 50%	6
50 - 70%	4
70 - 85%	2
Over 85%	Coating not permitted - reblast and coat when RH below 85%

24.7.2 Mild steel, less than 2 mm thickness

24.7.2.1 Mild steel less than 2 mm thickness, may distort by blast cleaning. Such steel shall be cleaned by degreasing, pickling and phosphating in accordance with SANS 10064, Section 5, or by a proprietary multistage chemical pickling and passivating process approved by SANRAL. The specified primer shall be applied immediately after completion of phosphating, rinsing and drying (see Table 2 above).

24.7.3 Cast iron and cast alloys

24.7.3.1 Cast surfaces shall be blast cleaned with iron slag, copper slag, or platinum slag abrasives designed for blast cleaning. The abrasive shall not be recycled or re-used. Cast iron shall be blast cleaned until all sand particles, residual burnt on sand and casting skin have been completely removed. When castings are required to be painted, especially for immersion applications, all blowholes and omegas shall be opened up and filled with a suitable solvent free epoxy filler or putty, finished level and smooth with, or proud of the surrounding surface. Proud putty, after curing, shall be abraded to be flush with the surrounding surface.

24.7.4 Galvanised steel surfaces

24.7.4.1 The Galvaniser shall be advised of components to be painted after galvanising. Such surfaces shall not be passivated. Galvanised steel surfaces shall be thoroughly degreased prior to painting, using either a water rinsable solvent degreaser, or a mild acid detergent degreasing solution. In both cases, care shall be taken to avoid entrapment of cleaning agent in recesses or other retention areas. In both cases, the surfaces shall be thoroughly washed until a water break free surface is achieved. If necessary, the process shall be repeated until a water break free surface is obtained.

24.7.4.2 A water break free surface is one on which a continuous film of water is obtained when potable water is brushed thereon. The film of water shall not break up into islands or globules.

24.7.4.3 After degreasing, the surface shall be abraded to obtain a uniform matt finish by one of the following methods:

(a) The use of abrasive paper not coarser than grade 120, or by using non-metallic abrasive pads,

(b) By "sweep blast cleaning", using a nozzle pressure not greater than 300 kPa and a very fine abrasive. Cracking, flaking, or any form of delamination of the zinc coating due to excessive blast cleaning shall not be permitted. The thickness of zinc removed by blast cleaning shall not exceed 10 micrometres.

24.7.4.4 All dust and debris shall be removed by vacuum cleaning, or by dry brushing to attain a level of residual dust and debris not exceeding the values given in Table 1 above.

24.7.4.5 Alternatively, an approved multi-stage chemical treatment may be used. The instructions of the chemical supplier shall be strictly followed. The composition of the various treatment baths shall be regularly checked and adjusted where necessary. Since the rate of chemical attack on finely divided zinc is different from that on galvanising, no repair of galvanising prior to chemical treatment is permitted.

24.7.5 Stainless and corrosion resisting steel

24.7.5.1 Components fabricated from stainless or corrosion resisting steel shall be supplied in the fully passivated condition. Sheared edges, welds or surfaces subjected to any form of heat treatment or contamination with iron or mild steel, shall be pickled and passivated.

24.7.5.2 Surfaces shall be thoroughly degreased with a water rinsable solvent detergent, then rinsed with potable water to obtain a water break free surface.

24.7.5.3 When it is required to paint stainless steel exceeding 1,5 mm thickness, the surface shall be blast cleaned in accordance with the parameters given in Table 1 above, using non-metallic abrasive such as iron slag, copper slag or platinum slag. The use of steel shot, steel grit or cast iron grit is strictly prohibited. Any contamination with iron or mild steel is prohibited. Dust and debris shall be removed before painting to achieve residual values not greater than those given in Table 1 above.

24.7.5.4 Where blast cleaning is impractical, the surface shall be cleaned with detergent solution and roughened manually by the use of non metallic abrasive pads, followed by washing with clean potable water to a water break free surface. If a water break free surface is not obtained, detergent cleaning shall be repeated until the surface is water break free. Allow the surface to dry before coating.

24.7.6 Aluminium

24.7.6.1 Generally, aluminium surfaces will be anodised or powder coated and will require no further treatment. Where painting is required, the aluminium surface shall be thoroughly degreased then rinsed with clean potable water. If the surface is not water break free, repeat the degreasing process until a water break free surface is obtained. Allow to dry completely, then apply a thin coat (8 to 13 micrometres dry film thickness) of wash primer that complies with SANS 723, mixed and applied in accordance with the manufacturer's instructions.

NOTE : Wash primer is an adhesion promoter and does not replace the primer specified in the paint system.

24.7.7 Painted surfaces

24.7.7.1 Fully painted surfaces to be repaired or overcoated

(a) Exposed metal shall be cleaned with abrasive paper not coarser than 220 mesh to a bright metal surface. The surrounding paint, which must be intact, shall be feathered for a distance of 20 mm beyond the damaged area. Dust and debris shall be removed by the use of a clean rag dampened with water or clean solvent that will not attack the coating. Damaged areas shall be allowed to dry, after which spot repairs shall be carried out with all the coats previously applied and shall overlap the undamaged area by 20 mm. The requirements of the spot repair shall be not less than that specified for the undamaged coating.

(b) Where additional coats are required over the entire surface, the entire surface shall be abraded to a uniform matt finish, the dust and debris removed, and the surface allowed to dry.

(c) All further coats shall then be applied as specified to give a uniform finish.

24.7.7.2 Shop applied primers to be overpainted

(a) Primers shall be thoroughly sanded with fine abrasive paper to achieve a uniform matt surface, then scrubbed with a solution of suitable water based detergent degreaser using a bristle brush, followed by clean water rinses to remove all grease and water soluble matter. The surface shall be allowed to dry completely before application of the specified coating system over the whole surface.

(b) Plastic surfaces such as uPVC and polyester GRP

(c) Treat as specified for painted surfaces. The cleaned surface shall have a uniform matt finish, free from scratches and local glossy patches.

24.8 THE APPLICATION OF PAINTS

24.8.1 Environmental conditions

24.8.1.1 Paint shall not be applied in dusty conditions, nor when the steel surface temperature is less than 3°C above dew point, nor higher than that advised by the paint manufacturer, nor when humidity is greater than 85%, nor when the ambient temperature is less than the minimum or greater than the maximum specified by the manufacturer of the coating material.

24.8.2 Mixing

24.8.2.1 All coating materials shall be very thoroughly mixed until they are completely homogeneous. In the case of two pack materials, each component containing pigments shall be thoroughly mixed. The two components shall then be mixed together in the proportions supplied by the manufacturer until the mixture is completely homogeneous. In the case of solvent based epoxy materials, it is recommended that the mixed material be allowed to stand for an induction period of 20 to 30 minutes before use.

24.8.2.2 For two pack materials, the use of part of the contents (split packs) is strictly forbidden.

24.8.3 Method of application

24.8.3.1 Application shall be by brush, roller, airless spray, or other suitable equipment as appropriate for the material, for the surfaces to be coated and in accordance with the recommendations of the manufacturer. Application equipment shall be maintained in clean condition and in good working order. The use of equipment not maintained in good clean condition may lead to rejection of the coating.

24.8.4 Overcoating

24.8.4.1 Overcoating times shall be not less than the minimum nor greater than the maximum specified by the manufacturer relevant to the ambient temperature.

24.8.4.2 All surfaces shall be clean and free from dust, oil, moisture and perspiration before overcoating. Operatives handling blast cleaned or partially painted surfaces shall wear clean gloves to avoid contamination of the surfaces.

24.8.5 Permissible variations of film thickness

24.8.5.1 Minimum film thickness: Not more than 10% of readings shall be less than the minimum specified and no reading shall be less than 90% of the specified minimum.

24.8.5.2 Maximum film thickness: Unless otherwise agreed by SANRAL, no reading shall exceed the mean specified thickness by more than 50%.

24.8.5.3 Handling

24.8.5.4 Coated components shall not be handled earlier than the hard dry time recommended by the manufacturer, relevant to the ambient temperature. Coated components shall be handled with broad band slings and suitable packing to minimize damage to the coating.

24.8.5.5 All damage caused in handling, transportation, and erection, shall be repaired to the satisfaction of SANRAL at no extra cost. Storage on site shall be in suitable covered stores, where available, and on suitable soft packing to prevent damage to the coating.

24.9 HOT DIP GALVANIZING

24.9.1 Design and fabrication

24.9.1.1 Components for hot dip galvanising shall be designed and fabricated in accordance with the recommendations of SANS Code of Practice 0214, with the exception that the use of lead plugs is not permitted.

24.9.1.2 It is recommended that the manufacturer consults the galvaniser or the Executive Director of the South African Hot Dip Galvaniser's Association before design and fabrication to ensure that the fabrication will be suitable for galvanising.

24.9.1.3 The main requirements are as follows:

(a) Overlapping joints shall be avoided wherever possible. If essential, such overlap joints shall be thoroughly degreased before assembly and shall be vented by holes being drilled through one or both overlapping materials.

(b) Closed sections shall be suitably vented. If the inside of a closed section is not to be galvanised, a snorkel vent tube of suitable length and bore shall be attached to the vent hole.

(c) Gussets and internal baffles in tanks or boxes shall be cropped to allow free flow of zinc and air.

(d) Joints shall be continuously welded, using balanced welding techniques to avoid stresses. Welds shall be free from cavities, undercutting, weld slag and spatter.

(e) A symmetrical design shall be used whenever possible and the use of thin gauge steel adjacent to heavy sections shall be avoided.

(f) Openings and flanges of manholes and bosses shall finish flush on the inside to ensure complete drainage.

(g) Castings shall be designed to be of as uniform section as possible and shall be blast cleaned in accordance with the requirements of the clause titled "Surface Preparation for painting", sub-clause "Cast Iron and Cast Alloys" before they are despatched to the galvaniser.

24.9.1.4 The hot dip galvanising process

24.9.1.5 Hot dip galvanising shall comply with the appropriate SABS specifications, such as SANS 5763 for fabricated articles, SANS 5934 for pregalvanised sheet, or SANS 935 for wire.

24.9.1.6 Mating surfaces on fabricated or cast iron components shall be wiped or centrifuged immediately after they are removed from the galvanising bath to remove blobs, runs or excess metal that may impair the gas or liquid tightness of the joint.

24.9.1.7 Bolts, nuts and washers used for fixing shall be hot dip galvanised to SANS 5763. Electroplated fasteners will not be accepted unless otherwise agreed by SANRAL in writing.

24.9.1.8 When organic coatings such as paint or powder are to be applied to galvanised articles, the galvaniser shall be so advised. Passivation after galvanising is not permitted. Special requirements may also apply for galvanised articles to be painted. Refer to specifications for painted or powder coated galvanised steel.

24.9.2 Mechanical treatment of galvanised articles

24.9.2.1 Welding, flame cutting, or other heat processes shall not be carried out on galvanised articles unless permission has been granted by SANRAL, when repair to the damaged galvanising shall be carried out as described below.

24.9.3 Repair of galvanised articles

24.9.3.1 Repairs shall be carried out as follows:

(a) All scale, spatter and flux shall be removed by grinding and washing with clean water. Edges shall be ground to a radius not less than 2 mm.

(b) The repair process shall be by blast cleaning of the surface to bare steel and applying zinc by the thermal spray process in accordance with SANS 1391 Part 1, grade Zn150. On completion of metal spraying, the surface shall be burnished by means of a mechanical wire brush to give a uniform appearance. Such burnishing shall remove not more than 10 micrometres of zinc.

(c) Where small areas are to be repaired, the surface shall be thoroughly cleaned with fine abrasive paper, all debris removed with a damp cloth and the surface allowed to dry. An approved one pack zinc rich primer containing not less than 90% by mass of zinc in the dry film shall then be applied. A sufficient number of coats (usually 3 or 4) shall then be applied such that the repair coating thickness is not less than the average zinc thickness specified in SANS 5763, 934 or 5935, as appropriate. The repair shall extend not less than 5 mm beyond the damaged area.

(d) On completion of the repair and when the zinc rich primer is completely dry, one coat of alkyd resin based aluminium paint may be applied to obtain a uniform appearance.

(e) NOTE : The repair of galvanised surfaces by application of aluminium paint alone IS NOT PERMITTED.

(f) NOTE : For repair of painted or powder coated galvanised articles, refer to the painting or powder coating specification.

24.9.4 The storage of galvanised components

24.9.4.1 Galvanised components shall be stored in a manner to avoid the formation of "white rust" or other forms of storage staining.

24.9.4.2 Components shall be separated and supported on wooden battens to ensure adequate ventilation of all surfaces and in such a manner as to avoid "ponding" by rainwater.

24.9.4.3 If storage staining does occur, repairs may not be necessary if the residual zinc thickness meets the requirements of the specification. When necessary to meet the requirements of the specification, or when so instructed by SANRAL, repairs shall be carried out as specified in the clause titled "Repair of Galvanised Articles" above.

24.10 STAINLESS STEEL FABRICATIONS

24.10.1 Grades and welding techniques

24.10.1.1 The grade of stainless steel to be used shall be as specified in the appropriate section of the electrical specification or on the drawings.

24.10.1.2 Where welding is necessary, the appropriate "L" grade (low carbon content) shall be used.

24.10.1.3 Welding procedures shall be only those recommended by the manufacturer of the stainless steel or by the South African Stainless Steel Development Association. Only suitably coded welders shall be employed (Refer BS.4870 1980 Part 1 or ASME. 1X 1983).

24.10.1.4 The fabrication of stainless steel components shall be carried out in clean workplaces where contamination by mild steel does not occur. Grinding and polishing equipment shall be dedicated for this purpose only and shall not be contaminated with iron or mild steel.

24.10.1.5 Stainless steel shall be suitably handled to avoid any scratching of the surface.

24.10.2 Pickling and passivation

24.10.2.1 The cut edges, welds and heat treated surfaces of all stainless steel components shall be pickled and passivated to remove all discolouration. Proprietary pickling and passivating pastes shall be used in accordance with the manufacturer's recommendations. Care shall be taken not to exceed the maximum recommended contact time.

24.10.2.2 After passivation, surfaces shall be very thoroughly washed with clean potable water to remove all traces of acid. The surface shall be allowed to dry, then polished where necessary, using polishing compounds recommended by the manufacturer of stainless steel or the SASSDA.

24.10.2.3 NOTE: See safety precautions at the end of clause "Pickling and Passivation" of "Corrosion Resistant Steel 3CR12".

24.11 CORROSION RESISTANT STEEL 3CR12

24.11.1 Welding techniques

24.11.1.1 Welds shall be full penetration welds, using 309 austenitic electrodes or filler wire, as recommended by the manufacturers.

24.11.1.2 Welders shall be suitably coded for welding similar thickness of austenitic stainless steel (Refer BS.4870 1980 Part 1 or ASME. 1X 1983).

24.11.1.3 Welding procedures shall comply with the recommendations of the manufacturers of 3CR12.

24.11.1.4 Welds shall be smooth and free from blowholes, undercuts, sharp projections and similar visual defects.

24.11.2 Pickling and passivating

24.11.2.1 After completion of welding, both weld and heat affected zones shall be cleaned, pickled and passivated. Heat scale on steel shall also be pickled and passivated.

24.11.2.2 The procedure shall be as follows:

24.11.2.3 Blast clean with non metallic grit, or grind or wire brush, using dedicated grinders or stainless steel wire brushes to achieve the required smooth profile or remove scale.

24.11.2.4 Pickle with a thixotropic paste containing 15-20% nitric acid and 1-2% hydrofluoric acid, for a contact time of 15 to 20 minutes.

24.11.2.5 Rinse copiously with clean water.

24.11.2.6 Repeat the above process, if necessary to remove all discolouration.

24.11.2.7 Passivate with 10% nitric acid solution, or a proprietary passivating paste, for a contact time of 10-15 minutes, keeping the surface wet during this period.

24.11.2.8 Rinse copiously with clean potable water until the washings are neutral.

24.11.2.9 NOTE - SAFETY PRECAUTIONS:

(a) Operators shall wear protective aprons, gloves and safety glasses during pickling and passivating operations, since the solutions used are strongly acidic.

(b) Splashes on skin shall be copiously washed with clean water immediately after contact. A weak solution of sodium bicarbonate shall be kept available for neutralisation.

(c) Seek medical attention if in doubt.

(d) Disposal of effluent shall be in accordance with the requirements of the local authority in whose area the Works are being carried out.

(e) Generally, the effluent is stored in drums containing an excess of lime (calcium carbonate) before disposal at an approved disposal site.

24.12 ALUMINIUM

24.12.1 Anodising

24.12.1.1 Aluminium components, specified as anodised shall be natural anodised and sealed in accordance with SANS 999 or SANS 1407, in both cases to Grade AA25 or AG25. The corrosion resistance of the coating shall be not less than 8 when tested in accordance with 3.6 of specification SANS 999. Anodising shall be carried out after completion of all welding.

24.12.1.2 When coloured anodising is specified, the aluminium components shall be anodised in accordance with SANS 999, grade AA25.

24.12.2 Powder coating

24.12.2.1 When specified by SANRAL, aluminium components may be coated with polyurethane powder. Such coating shall only be carried out by Contractors with the necessary plant, equipment and experience to pre-treat and powder coat aluminium effectively. The coating shall comply with BS.6496.

24.12.3 Fixing

24.12.3.1 Fixing of aluminium components shall be carried out with Stainless Steel 304 bolts, nuts and washers. When fixed to steel components such as bridges, there shall be an effective insulation layer between aluminium and steel, such as PVC or polyethylene tape, not less than 0,25 mm thickness between aluminium base and steel. A nylon washer of adequate size shall be used between the steel main component and the nut in order to insulate aluminium from steel.

24.12.3.2 Whenever aluminium components, such as stop log frames, come into contact with concrete, the surface of the aluminium in contact with concrete shall be coated with two coats epoxy tar composition, as specified in System C2. The epoxy tar coating shall be fully cured before grouting in to the concrete.

24.13 COATING SYSTEMS

24.13.1 System A - Alkyd systems

24.13.1.1 General

(a) Alkyd systems are intended for use in environments of low corrosivity, where a good decorative finish is required. Materials shall therefore be applied with due cognisance of appearance and protection. Visual defects such as runs, sags, curtaining, shrivelling or wrinkling will not be permitted.

24.13.1.2 System A1 - Alkyd system on bare steel surfaces

(a) The surface to be coated shall be prepared as specified for the surface preparation for painting of mild steel of the appropriate thickness.

(b) Apply one coat zinc phosphate primer complying with SANS 1319, to a dry film, thickness not less than 30 micrometres. Allow to dry for a minimum of 16 hours.

(c) Apply one coat alkyd based undercoat complying with SANS 681 Type 2, to give a dry film thickness of not less than 30 micrometres. Allow to dry for a minimum of 16 hours.

(d) Apply one coat alkyd enamel complying with SANS 630 Type 2, in the colour specified by SANRAL, to give a dry film thickness of not less than 25 or greater than 40 micrometres. Allow to dry for a minimum of 16 hours.

(e) On exterior surfaces, apply a second coat of alkyd enamel, within 30 hours, to give a dry film thickness of not less than 25 or greater than 40 micrometres in the final colour as specified by SANRAL. Allow to dry for a minimum of 16 hours.

24.13.1.3 System A2 - Surfaces already cleaned and primed

(a) Clean and prepare the surface as specified for painted surfaces with shop-applied primers to be overpainted.

(b) Touch up bare areas with zinc phosphate primer complying with SANS 1319. Allow to dry for a minimum of 16 hours.

(c) Apply one coat all over of zinc phosphate primer to SANS 1319.

(d) Continue the system as given in System A1 (c) to (e) inclusive.

24.13.1.4 System A3 - Factory finished components

(a) The Contractor shall ensure that the existing coating is compatible with the system to be applied.

(b) Prepare the surface as specified for painted surfaces with fully painted surfaces to be repaired or overcoated.

(c) On interior non aggressive surfaces, apply one coat alkyd enamel complying with SANS 630 Type 1, in the colour specified by SANRAL, to give an applied dry film thickness of not less than 25 micrometres. Total dry film thickness shall not be less than 75 micrometres.

(d) On interior surfaces in an aggressive environment, use System B5 A rather than an alkyd system.

(e) On exterior surfaces, apply two coats alkyd enamel complying with SANS 630 Type 2, to give an applied dry film thickness not less than 50 micrometres. Total thickness shall not be less than 100 micrometres.

(f) If the total dry film thickness is less than the appropriate value given in (c) or (e), apply a further coat of alkyd enamel.

24.13.1.5 System A4 - Galvanised surfaces - above water and in non-corrosive environments

(a) Prepare the surface as specified for galvanised steel surfaces.

(b) Apply one coat of an approved water based vinyl chloride-vinylidene chloride copolymer primer containing zinc phosphate to give a dry film thickness of not less than 30 and not greater than 60 micrometres. Allow 16 hours to cure in dry conditions before overcoating. Since this material is water based, drying time will be extended under humid conditions.

(c) Continue the system as given in A1 (c) and (d) (one undercoat, one enamel coat).

24.13.1.6 System A5 - Plastic surfaces

(a) If required to paint for identification or decorative purposes, the following system shall be used:

(b) Prepare the surface by thorough abrasion as specified for painted surfaces with shop-applied primers to be overpainted.

(c) Apply water-based primer as specified in System A4 (b).

(d) Apply alkyd undercoat and finish as specified in System A1 (c) and (d).

24.13.1.7 Requirements of the finished alkyd system

(a) The finished system shall be smooth, glossy, and free from excessive runs, sags, blisters, wrinkling, dirt, occlusions or other visual defects. The colour shall be a commercial match to the colour specified by SANRAL.

(b) The total dry film thickness shall not be less than 75 micrometres in the case of interior surfaces and not less than 100 micrometres in the case of exterior surfaces.

24.13.1.8 Site repair of alkyd systems

(a) It is anticipated that alkyd systems will generally be applied on site, either onto bare steel (see System A1), prepared and primed steel (see System A2), fully coated components (see System A3), galvanised steel (see System A4), or plastic surfaces for the purpose of colour coding (see System A5).

(b) Any site repair required by SANRAL shall be carried out in accordance with surface preparation method given in the clause of the surface preparation for fully painted surfaces to be repaired or overcoated followed by all the coats required to restore the damaged area to the original system requirements.

(c) Since patch application of the final coat rarely gives an acceptable uniform finish, the whole area in which damage has occurred shall be cleaned, abraded with fine wet or dry abrasive paper (not coarser than 200 mesh) and given one coat of enamel all over, unless otherwise accepted by SANRAL.

24.13.2 System B5 - Two pack Epoxy/Polyurethane system for exterior surfaces, steel substrates

24.13.2.1 General

(a) Epoxy systems have good chemical resistance and physical properties. When exposed to sunlight they degrade on the exposed surface, a defect known as "chalking". To overcome this defect, the epoxy system may be overcoated with aliphatic polyurethane, which has very good colour and gloss retention. This combination is therefore recommended for exposed, chemically polluted environments.

(b) Two component materials are chemically cured and, when fully cured, are difficult to recoat. It is therefore important to adhere to the overcoating times, both minimum and maximum given in the manufacturer's data sheets.

(c) Ambient and substrate temperatures must be measured, especially during winter months, in order to avoid dew deposition and to ensure adequate cure. Two component epoxy materials should not be applied when the ambient temperature is below 10°C.

(d) Polyurethanes are sensitive to moisture in the uncured state. Containers shall be kept in a dry store. Application shall be carried out in dry conditions. Air used for spray application shall be dry.

24.13.3 System B5 A - Steel substrates

24.13.3.1 Materials

(a) Two pack epoxy primer for steel,

(b) Two pack epoxy high build intermediate coat, in different colours,

(c) Two pack aliphatic isocyanate cured polyester based polyurethane.

24.13.3.2 Procedure

(a) Fettle all welds and sharp edges as specified in the clause on Fettling or Dressing by the Fabricator.

(b) Prepare the surface by a method appropriate to the fabrication. For hot rolled steel, refer to the clauses on the surface preparation for painting of mild steel. For cold rolled steel, refer to the clause on the surface preparation for mild steel less than 2 mm thick. For cast iron, refer to the clause on surface preparation for painting of cast iron and cast alloys.

(c) Apply one coat of two pack epoxy primer for steel at a dry film thickness of 20 to 30 µm.

(d) Apply one coat of two pack high build epoxy intermediate coat at a dry film thickness of 60 to 90 µm.

(e) Apply a second coat of two pack high build epoxy intermediate coat, in different colour from the first coat, at a dry film thickness of 60 to 90 µm.

(f) Apply one coat of two pack aliphatic polyurethane enamel at a dry film thickness of 30 to 50 µm.

(g) NOTE: Time interval between all coats shall be in accordance with the manufacturer's data sheet.

24.13.3.3 Repair

For the repair procedure, refer to the clause on surface preparation for painting of fully painted surfaces to be repaired or overcoated.

24.13.3.4 Requirements

(a) Each coat shall be uniformly applied at the appropriate wet film thickness to give a dry film thickness within the range specified.

(b) The completed system shall be smooth, glossy, and uniform in colour, free from runs, sags, bubbles, occluded dust and other visible defects.

(c) The colour shall be a commercial match to the colour specified by SANRAL.

(d) The dry film thickness, tested by SANS Method 5141, shall not be less than 180 or greater than 280 µm.

(e) When tested by SANS Method 5159 the adhesion shall not be less than 9.

24.13.4 System B5 B - Galvanised substrates

24.13.4.1 Materials

(a) Two pack epoxy primer for galvanised surfaces.

(b) Two pack epoxy high build intermediate coat.

(c) Two pack aliphatic isocyanate cured polyester based polyurethane.

24.13.4.2 Procedure

(a) Prepare the galvanised surface as specified in clause on surface preparation for painting of galvanised steel surfaces. Dross, ash occlusions and surface roughness are only permitted if the peak to valley profile (measured by SANS Method 5772) does not exceed 100 µm. Spikes of zinc shall be removed before coating.

(b) Apply one coat of two pack epoxy primer for galvanised steel at a dry film thickness of 20 to 30 µm.

(c) Apply one coat of two pack high build epoxy intermediate coat at a dry film thickness of 60 to 90 µm.

(d) Apply one coat of two pack aliphatic polyurethane enamel at a dry film thickness of 30 to 50 µm.

(e) NOTE: Time interval between all coats shall be in accordance with the manufacturer's data sheets.

24.13.4.3 Repair

For the repair procedure, refer to the clause on preparation for painting of fully painted surfaces to be repaired or overcoated.

24.13.4.4 Requirements

(a) Each coat shall be uniformly applied at the appropriate wet film thickness to give a dry film thickness within the range given.

(b) The completed system shall be smooth, glossy, and uniform in colour, free from runs, sags, bubbles, occluded dust and other visible defects.

(c) The colour shall be a commercial match to the colour specified by SANRAL.

(d) The dry film thickness of the organic system, tested by SANS Method 5141, shall not be less than 110 or greater than 170 µm.

(e) The total dry film thickness shall not be less than 150 µm.

(f) When tested by SANS Method 5159 the adhesion shall not be less than 9.

24.13.5 System F - Powder coatings

24.13.5.1 General

(a) Powder coatings comprise a wide range of polymeric materials, which are supplied in powder form and are converted to a coating by appropriate heating.

(b) The materials may be divided into thermoplastic, which can be repeatedly melted and revert to solid on cooling, or thermoset which are resins that chemically cure when heated to the appropriate temperature for the appropriate time. After curing, they no longer become liquid on reheating.

(c) Since thermoset materials have excellent adhesion to correctly prepared surfaces, this type is preferred at the present time.

(d) Curing of thermoset materials requires heating up to 220°C. It is therefore important that the substrate be free from blowholes, cracks, crevices, surface roughness and similar sources of air entrapment. All blowholes and omegas in castings shall be filled flush with the surrounding surface (refer to the clause on surface preparation for painting of cast iron and cast alloys).

(e) Rough surfaces shall be suitably prepared and primed with a liquid two pack epoxy primer, suitable for the substrate, prior to the application of powder. Blisters, pinholes and fish eyes in the final coating will not be accepted.

(f) The correct heating schedule is essential to ensure full cure of the powder. The mass of the article being coated affects the rate of heating, hence due allowance must be made for heavy components such as those made from cast iron.

24.13.5.2 Surface preparation of articles fabricated from steel plate

(a) Fettling and dressing by the fabricator shall be in accordance with the requirements of the clause on Fettling or Dressing by the Fabricator.

(b) Surface preparation required is as referred to in the clause on surface preparation for painting of mild steel less than 2 mm thickeners and it shall be carried out as follows:

(c) A recognized chemical pre-treatment shall be carried out on the steel just prior to priming. (See SANS 10064 Section 5.).

(d) The chemical pre-treatment shall consist typically of a seven stage zinc phosphate process.

(e) The process shall result in the complete removal of all foreign matter, i.e. scale, grease, cutting oil, soil, weld flux, rust etc. The pre-treatment shall impart a uniform texture to the surface to render it suitable for the coating, which is to be applied.

(f) A fine grained crystalline zinc phosphate is recommended at a coating weight of 1,5 - 2,5 g/mµ.

(g) Great care shall be taken with water rinsing so as not to contaminate the next cleaning process. The last rinse shall be sufficiently thorough to remove all water soluble material and any residual smuts.

(h) After phosphating, the articles shall be primed as soon as possible after drying. In any event, this time shall not be longer than 16 hours if the phosphated items are kept under dry cover. Clean cotton gloves shall be used for any manual handling prior to coating.

24.13.5.3 Surface preparation of galvanised articles

(a) Galvanising

i. The Fabricator shall observe the recommendations of SANS 0214. Galvanising shall be carried out after fabrication by the hot dip process in accordance with SANS 5763, except that:

ii. Dross and other inclusions that give a surface roughness exceeding 100 µm maximum peak to valley height shall not be permitted (SANS Method 5772).

iii. Runs, drips and spikes shall be removed by filing before coating. Such filing shall produce a smooth surface with a residual zinc coating not less than the specified minimum thickness.

iv. Repairs by zinc metal spray or by zinc rich primer are not permitted. Repairs by special solder are acceptable only if the solder does not interfere with the pickling and passivating process.

(b) Surface Preparation of the galvanised surface

i. The galvanised surface shall be degreased, etched and phosphated by a recognized 7-stage dip or spray process for chemical treatment of galvanised steel to give a surface suitable for painting.

ii. The process shall remove all foreign matter such as grease, oil, soil and white rust. It shall impart a uniform texture to the surface, free from loose particles, smuts, water soluble salts and other contaminants that will impair performance of the coating system.

(c) Priming

i. The specified primer shall be applied in accordance with the manufacturer's instructions to give a dry film thickness of 20 to 30 micrometres.

(d) Curing time for primer

ii. The primer shall be left for the period recommended by the manufacturer, relevant to ambient temperature and humidity. It is essential that all solvent shall have evaporated before the application of powder. Low temperature baking is permissible if recommended by the manufacturer.

24.13.5.4 Application of powder coating

(a) General

i. All dust shall be removed.

ii. The primer shall be cured as set out above.

iii. The powder coating shall be applied by the electrostatic spray application method to a dry film thickness of 75 to 100 micrometres.

(b) Stoving

i. The powder coated items shall be exposed to the stoving schedule recommended by the powder manufacturer.

ii. The oven conveyor speeds or oven temperatures shall be adjusted to accommodate various metal thicknesses to ensure that every part is ultimately exposed to the minimum stoving schedule. Preference will be given to travelling oven recorders.

(c) Test Plate

i. To avoid or minimize the use of destructive tests on the finished article, the Contractor may run a test plate of identical steel and approximately 150 x 100 mm in area. The test plate shall be attached to the article such that it is subjected to all the processes of cleaning, phosphating, priming, powder coating and stoving identical to the processes applied to the article. A second test plate of powder only, without primer shall also be prepared for powder cure tests.

ii. To check the curing of the stoved coatings, sample chips of the coating shall be subjected, if necessary, to a differential scanning calorimetry (DSC) test, when delta-Tg shall be not greater than 3°C.

24.13.5.5 Requirements of the finished system

(a) Appearance

i. The coating shall be smooth, glossy and free from excessive orange peel, bubbling, runs or sags, and shall comply with the requirements of SANS 1274 of the appropriate type.

(b) Coating Thickness

i. The dry film thickness shall not be less than the minimum specified, when tested non-destructively on the article(s) coated, using SANS Method 5141.

(c) Adhesion

i. Adhesion shall not be less than 9 when tested on the test plate by SANS Method 5159. In case of doubt, the test shall be repeated on the article or representative samples. Test areas shall be repaired to the satisfaction of SANRAL.

24.13.5.6 Repair of powder coating

(a) Any chipped or damaged areas of the coating shall be repaired as follows:

(b) The area shall be abraded to white metal or to a uniform matt finish of the powder by using a 350 - 220 grit waterproof paper and water as a lubricant. Dry the area with a clean cloth. Apply by brush or spray the epoxy-polyamide primer recommended by the manufacturer of the powder to a dry film thickness of minimum of 30, maximum 50 micrometres to the bare metal. After the recommended minimum and before the recommended maximum overcoating time, apply a topcoat of polyurethane acrylic, as recommended by the powder manufacturer and tinted to the same colour as the powder coating. Care shall be taken not to overlap the abraded area by more than 10 mm. When cured, the repair may be burnished.

(c) The aesthetic appearance of the patch shall be subject to approval by SANRAL. If not approved, the whole item shall be returned to the manufacturer for stripping and recoating.

(d) Handling of powder coated items

(e) Powder coated items shall be packed and handled so as to prevent damage up to the point of completion of installation.

24.13.6 System F1 - Polyurethane powder coating on primed mild steel for exterior exposure

24.13.6.1 General

(a) The primer used shall be a solvent-based polyamide cured epoxy material containing strontium chromate as an anti-corrosive pigment. It shall be a material designed for use as a primer for polyurethane powder coating, and which will withstand the maximum stoving cycle associated with the powder coating process.

(b) The powder coating shall be a thermosetting polyurethane based material suitable for constant exterior exposure. The product shall comply with the requirements of SANS 1274 Type 6. The powder coating shall be suitable for application over the primer specified above.

24.13.6.2 Surface Preparation prior to powder coating

(a) Refer to the sub-clause on surface preparation of articles fabricated from steel plate for system F - Powder Coating.

24.13.6.3 Primer

(a) Apply the primer described above in accordance with the sub-clause on Priming for System F - Powder Coating.

24.13.6.4 Powder

(a) Apply the powder described above in accordance with the sub-clause on the application of Powder Coating for System F - Powder Coating to a dry film thickness of 75 to 100 µm.

24.13.6.5 Requirements of the Coating System

(a) The system shall comply with the requirements of the sub-clause on the requirements of the finished system for System F - Powder Coating and with the requirements of SANS 1274 Type 6. The total dry film thickness shall not be less than 95 µm.

24.13.7 System F2 - Corrosion resistant powder coatings for interior and exterior use

24.13.7.1 Materials

(a) The powder to be used shall comply with the requirements of SANS 1274, Type 5, Thermosetting.

24.13.7.2 Surface Preparation

(a) Refer to the sub-clause on surface preparation of articles fabricated from steel plate for System F - Powder Coating.

24.13.7.3 Primer

(a) No primer is required for this system.

24.13.7.4 Application of Powder Coating

(a) Refer to the sub-clause on the application of powder coating for System F - Powder Coating.

24.13.7.5 Requirements

(a) The system shall comply with the requirements of the sub-clause on the requirements of the finished system for system F - Powder Coating with a minimum dry film thickness of 75 µm, and with the requirements of SANS 1274 Type 5.

24.13.8 System F3 - Powder coating on aluminium for interior or exterior exposure

24.13.8.1 Material

(a) The powder to be used shall comply with the requirements of Section 2 of BS.6496.

24.13.8.2 Pre-treatment

(a) An approved chemical pre-treatment dedicated only to the pre-treatment of aluminium shall be carried out just prior to powder coating.

(b) The pre-treatment shall comply with the requirements of BS. 6496, Section 3, Clause 8.

(c) This is the only type of pre-treatment acceptable prior to powder coating on to aluminium components.

NOTE: The conductivity of the demineralised water draining off the rinsed work pieces shall not exceed 10 mS/m at 20µC. The metal surface after the pre-treatment and prior to coating shall be free from dust and powdery deposits.

After pre-treatment, the articles shall be powder coated as soon as possible after drying. In any event, this time shall not be longer than 2 hours if the items are kept under cover.

24.13.8.3 Application of Powder Coating

(a) The powder coating shall be applied to the clean pre-treated aluminium so as to result in a dry film thickness of minimum 50 micrometres. The thickness on any significant surface that requires a limited thickness of finish as indicated on suitably marked drawings, shall not exceed 120 micrometres.

(b) The stoving temperatures shall be such that the heat history of the final product is in accordance with the manufacturer's recommendations, and takes into account the effect of varying metal thicknesses.

24.13.8.4 Requirements of the Finished System

(a) The coating shall be smooth, glossy and free from excessive orange peel or bubbling runs or sags. The coating shall comply with the requirements of Section Three of BS. 6496.

(b) The dry film thickness shall not be less than 50 micrometres and where necessary, shall not be greater than 120 micrometres.

(c) Tests for full cure of thermosetting materials shall be carried out. If full cure is not achieved, the articles shall be reheated or they may be totally rejected, as determined by SANRAL.

(d) Touch up and repair of damaged areas

(e) Polyurethane and epoxy powders, when fully cured, are hard and impervious and difficult to overcoat without risk of delamination. The procedure given in the sub-clause on the repair of powder coating System F - Powder Coating shall be strictly adhered to.

24.13.9 System F4 - Polyurethane powder on galvanised mild steel for exterior exposure

24.13.9.1 Materials

(a) Primer shall be a two pack epoxy primer containing strontium chromate, designed for application to properly prepared galvanised steel.

(b) Powder coating shall be a Polyurethane Powder complying with all the requirements of SANS 1274 Type 6, Thermosetting.

24.13.9.2 Surface Preparation

(a) Refer to the sub-clause on surface preparation of galvanised articles for System F - Powder Coating.

24.13.9.3 Priming

(a) Apply the primer specified above in accordance with the requirements of the sub-clause on primary for System F - Powder Coating.

24.13.9.4 Powder Coating

(a) Apply the powder coating specified above in accordance with the sub-clause on the application of powder coating for System F - Powder Coating.

24.13.9.5 Requirements of the System

(a) The system shall comply with the requirements of the sub-clause on the requirements of the finished system for System F - Powder Coating and SANS 1274 Type 6. The minimum thickness of organic coating shall be 95 µm and the total coating thickness (galvanising plus organic coating) shall be minimum 135 µm.

24.13.10 System F5 - Polyester powder coating on galvanised steel

(a) The system shall be the same as specified for SYSTEM F4, except that SANS 1274 Type 6 shall be replaced by SANS 1274 Type 4.

24.14 QUALITY ASSURANCE REQUIREMENTS

24.14.1 Contractor qualification

24.14.1.1 SANRAL, at their discretion, may require a Quality Audit of the painting sub-contractor to ensure that he has the management, facilities and skilled staff, to meet all the requirements of the specification. He must also have the facilities and staff to carry out quality control during application of coatings to ensure compliance with the specification.

24.14.1.2 The Contractor shall accept full responsibility for the quality of his Works and of materials used, irrespective of any quality surveillance that may be carried out by SANRAL or their representative.

24.14.2 Data sheets, specifications and codes of practice

24.14.2.1 The Contractor shall have available the latest issues of manufacturer's data sheets for materials to be used, National Specifications and Codes of Practice relevant to the Works to be carried out, as well as a copy of this specification, all of which shall be available to the Contractor's Quality Control Manager, who shall read the relevant documents and follow the relevant instructions.

24.14.3 Quality control

24.14.3.1 The Contractor shall have the necessary equipment and staff knowledgeable in test procedures to carry out all the quality control required to ensure compliance with the specification. The Contractor will be required to produce a quality plan and a programme for carrying out the Works. The Contractor shall maintain quality control records of all stages of the Works, batch numbers of materials used, environmental conditions, as required by the specification. Quality control shall be inclusive in the Contractor's Tender price.

24.14.4 Quality control records

24.14.4.1 Proper and adequate quality control records shall be maintained by the Contractor for all stages of the Works. These records shall be available for inspection by SANRAL or their representative at the time of Quality Surveillance. Incomplete, inaccurate or inadequate records shall be regarded as non-conformance with the specification.

24.14.5 Alternative systems

24.14.5.1 Products or specifications considered equivalent to those specified may be submitted for approval by SANRAL. This approval will only be considered if the manufacturer of the products provides adequate written evidence of equivalence. Use of the system may not commence until approval in writing is given by SANRAL.

24.14.6 Quality surveillance

24.14.6.1 Independent surveillance - SANRAL may employ an independent technically qualified organisation to carry out quality surveillance of the Works.

24.14.6.2 Programme - The Contractor shall advise SANRAL timeously, in writing, when and where the following processes will be carried out:

24.14.6.3 Completion of fettling or dressing prior to leaving the Fabricator's works

24.14.6.4 Blast cleaning and application of the primer coat

24.14.6.5 Completion of factory painting

24.14.6.6 Commencement of site painting.

24.14.6.7 Failure of the Contractor to advise SANRAL of his program may result in rejection of the Works.

24.14.7 Access for surveillance

24.14.7.1 For the purpose of carrying out quality surveillance, SANRAL or their representative shall be granted access to any part of the Contractor's premises relevant to the Works being carried out, at any reasonable time. The Contractor shall provide, at his own cost, any equipment or labour necessary to gain access to surfaces which are coated, to be coated, or are in the process of being coated.

24.14.8 Samples

24.14.8.1 SANRAL or their representatives may remove any reasonable samples of materials to be used in the coating application. Rejection of the sample will place a hold on the use of materials of the same batch number and may lead to rejection of all material of that batch and the reworking of any components that have already been coated with rejected material.

24.14.9 Destructive testing

24.14.9.1 SANRAL or their representative may carry out reasonable destructive tests to ascertain compliance with the specification. Areas thus damaged shall be repaired by the Contractor to the satisfaction of SANRAL at no additional cost.

24.14.10 Cost of quality surveillance

24.14.10.1 Cost of quality surveillance shall be borne by SANRAL, except when surveillance results in rejection of the lot for non-conformance with specification or when notice by the Contractor results in a fruitless trip, in which cases the cost of the surveillance shall be borne by the Contractor.

24.15 SPECIFIC APPLICATIONS

24.15.1 Enclosures

24.15.1.1 Outdoor applications - For large cabinets in non-corrosive environments, use SYSTEM A1. In corrosive environments, use SYSTEM B5.

24.15.1.2 For enclosures small enough to be powder coated, in non-corrosive environments, use SYSTEM F1.

24.15.1.3 In corrosive environments, use SYSTEM F4.

24.15.1.4 Indoor applications - use SYSTEM A1 (Interior) for non-corrosive conditions, or SYSTEM B5 for corrosive environments.

24.15.1.5 Where powder coating is practical, use SYSTEM F2 for non-corrosive conditions or SYSTEM F4 for corrosive environments.

24.15.1.6 For all corrosive conditions, add VCI emitter after completion of the installation.

24.15.1.7 After completion of an installation, install VAPOUR CORROSION INHIBITORS in the form of EMITTERS. The size, number and chemical composition of the emitters shall be adequate for at least 12 months protection of all the metals inside the cabinet. Replacement of VCI emitters shall be included as part of the maintenance manual for the equipment.

24.15.2 Cable trays and ladders

24.15.2.1 Due to many edges, cable trays and ladders must always be hot dip galvanised. In corrosive environments, or when so specified by SANRAL, they shall also be coated. Note the special requirements for galvanising to be coated, in addition to the requirements of SANS 5763.

24.15.2.2 GALVANISING or SYSTEM F5 is required for interior conditions.

24.15.2.3 GALVANISING or SYSTEM F4 is required for exterior conditions.

24.15.3 Supports for cable racks

24.15.3.1 Use the same system for CABLE TRAYS and LADDERS or, if an air-drying system is required, use System A1 for non-corrosive conditions or System B5 for corrosive conditions.

24.15.4 Switch gear

24.15.4.1 Refer to the systems prescribed for enclosures.

24.15.4.2 In corrosive conditions, indoor or outdoor, add VCI emitters after installation. Reference to replacement of VCI emitters must be made in the maintenance manual.

24.15.5 Transformers

24.15.5.1 These are normally coated with specialist materials designed for Flood Coating. The system used shall be designed for 25 years maintenance free life and shall have a coating thickness not less than 100 micrometres, except in the case of hot dip galvanising, when the requirements of SANS 5763 will be acceptable.

TABLE 24-3: SUMMARY OF RECOMMENDED ELECTRICAL APPLICATIONS

ARTICLE	INDOOR		OUTDOOR	
	Non-Corrosive	Corrosive	Non-Corrosive	Corrosive
Enclosures - large	SYSTEM A1 (Interior)	SYSTEM B5 plus VCI after installation	SYSTEM A1 (exterior)	SYSTEM B5 plus VCI after installation
Enclosures - small	SYSTEM F2	SYSTEM F5 plus VCI after installation	SYSTEM F1	SYSTEM F4 plus VCI after installation
CABLE TRAYS AND LADDERS	GALVANIZED Or SYSTEM F5	SYSTEM F5	GALVANIZED or SYSTEM F4	SYSTEM F4
PEDESTALS	SYSTEM A1 (interior) or SYSTEM F2	SYSTEM B5 or SYSTEM F5	SYSTEM A1 (exterior) or SYSTEM F1	SYSTEM B5 or SYSTEM F4
	TAKE NOTE OF THE CLAUSES ON WATER RETENTION AREAS AND SERVICES IN THE GENERAL SPECIFICATION			
SUPPORTS FOR CABLE RACKS	SYSTEM A1 (interior) Or SYSTEM F5	SYSTEM B5 or SYSTEM F5	SYSTEM A1 (exterior) or SYSTEM F4	SYSTEM B5 OR SYSTEM F4
SWITCH GEAR	SYSTEM A1 (interior) Or SYSTEM F2	SYSTEM B5 or SYSTEM F5 plus VCI after installation	SYSTEM A1 (exterior) or SYSTEM F1	SYSTEM B5 or SYSTEM F4 plus VCI after installation

NOTE: Table 3 is for convenient reference only. Its use does not absolve the Contractor from compliance with any clause(s) of the detailed specification.

TABLE 24-4: SUMMARY OF COATING SYSTEMS

SYSTEM	GENERIC TYPE	SURFACE PREPARATION	TOTAL No OF COATS	BROAD ENVIRONMENT
A1	Alkyd	Blast clean or chemical	3 4	Interior non-corrosive Exterior non-corrosive
A2	Alkyd	Already primed	3 4	Interior non-corrosive Exterior non-corrosive
A3	Alkyd	Factory finished	As required	Interior non-corrosive Exterior non-corrosive
A4	Alkyd over vinyl primer	Galvanised	3	Interior and exterior non-corrosive
B1 - B4	Two-pack epoxy	Blast clean	Varies	Undercoat applications not required for this specification
C Systems	Epoxy Tar	Blast clean	Varies	Underwater applications only
D Systems	Vinyl	Blast clean	Varies	Chemical environments - not required for this specification
E Systems	Solvent-free Polyurethane	Blast clean	Varies	Special applications only - not required for this specification
F1	Polyurethane powder on primed steel	Chemical	2	Exterior use - non or mildly corrosive
F2	Epoxy polyester powder	Chemical	1	Interior and exterior - non- corrosive
F3	Special powder	Special chemical	1	For aluminium surfaces only
F4	Polyurethane powder on galvanised steel	Chemical	2	Exterior use - corrosive
F5	Polyester powder on galvanised steel	Chemical	2	Interior use - corrosive

NOTE: Table 4 is for convenient reference only. Its use does not absolve the Contractor from compliance with all clauses of the detailed specification.

24.16 CORROSION PROTECTION

TABLE 24-5: CORROSION PROTECTION DATA AND COMPLIANCE SHEET.

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
24.16.1	SANS 10044-1:2004 (SABS 044-1)	Welding Part 1: Glossary of terms				
24.16.2	SANS 10044-2:2004 (SABS 044-2)	Welding Part 2: Symbols				
24.16.3	SANS 10064:2005 (SABS 064)	The preparation of steel surfaces for coating				
24.16.4	SANS 12944-1:1998/ISO 12944-1:1998 (SABS ISO 12944-1)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems Part 1: General introduction				
24.16.5	SANS 12944-2:1998/ISO 12944-2:1998 (SABS ISO 12944-2)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems Part 2: Classification of environments				
24.16.6	SANS 12944-3:1998/ISO 12944-3:1998 (SABS ISO 12944-3)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems Part 3: Design considerations				
24.16.7	ANS 12944-4:1998/ISO 12944-4:1998 (SABS ISO 12944-4)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems Part 4: Types of surface and surface preparation				
24.16.8	SANS 12944-5:1998/ISO 12944-5:1998	Paints and varnishes - Corrosion protection of steel structures by protective paint				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
	(SABS ISO 12944-5)	systems Part 5: Protective paint systems				
24.16.9	SANS 12944-6:1998/ISO 12944-6:1998 (SABS ISO 12944-6)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems Part 6: Laboratory performance test methods				
24.16.10	SANS 12944-7:1998/ISO 12944-7:1998 (SABS ISO 12944-7)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems Part 7: Execution and supervision of paint work				
24.16.11	SANS 12944-8:1998/ISO 12944-8:1998 (SABS ISO 12944-8)	Paints and varnishes - Corrosion protection of steel structures by protective paint systems Part 8: Development of specifications for new work and maintenance				
24.16.12	SANS 10140-1:2008 (SABS 0140-1)	Identification colour marking Part 1: General				
24.16.13	SANS 10140-2:2008 (SABS 0140-2)	Identification colour marking Part 2: Identification of hazards and equipment in work situations				
24.16.14	SANS 10140-3:2003 (SABS 0140-3)	Identification colour markings Part 3: Contents of pipelines				
24.16.15	SANS 10140-4:2006 (SABS 0140-4)	Identification colour marking Part 4: Contents of taps and valves in laboratories				
24.16.16	SANS 10140-5:2007 (SABS 0140-5)	Identification colour marking Part 5: Coding of containers for carrying lubricants and associated fluids				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
CORROSION PROTECTION						
	CLAUSE					
24.16.17	25.4.1	General				
24.16.18	25.4.2	Water retention areas				
25.16.19	25.4.3	Crevices				
25.16.20	25.4.4	Bimetallic couples				
25.16.21	25.4.5	Accessibility				
25.16.22	25.4.6	Differential aeration				
25.16.23	25.4.7	Sharp edges, weld spatter and weld slag				
25.16.24	25.4.8	Hot dip galvanising				
25.16.25	25.4.9	Vapour corrosion inhibitors				
25.16.26	25.5	COATING MATERIALS				
25.16.27	25.6	FETTLING OR DRESSING BY THE FABRICATOR				
25.16.28	25.7	SURFACE PREPARATION FOR PAINTING				
25.16.29	25.7.1	Mild steel, minimum 2 mm thickness				
25.16.30	25.7.2	Mild steel, less than 2 mm thickness				
25.16.31	25.7.3	Cast iron and cast alloys				
25.16.32	25.7.4	Galvanised steel surfaces				
25.16.33	25.7.5	Stainless and corrosion resisting steel				
25.16.34	25.7.6	Aluminium				
25.16.35	25.7.7	Painted surfaces				
25.16.36	25.8	THE APPLICATION OF PAINTS				
25.16.37	25.8.1	Environmental conditions				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
25.16.38	25.8.2	Mixing				
25.16.39	25.8.3	Method of application				
25.16.40	25.8.3	Overcoating				
25.16.41	25.8.5	Permissible variations of film thickness				
25.16.42	25.9	HOT DIP GALVANIZING				
25.16.43	25.9.1	Design and fabrication				
25.16.44	25.9.2	Mechanical treatment of galvanised articles				
25.16.45	25.9.3	Repair of galvanised articles				
25.16.46	25.9.4	The storage of galvanised components				
25.16.47	25.10	STAINLESS STEEL FABRICATIONS				
25.16.48	25.10.1	Grades and welding techniques				
25.16.49	25.10.2	Pickling and passivation				
25.16.50	25.11	CORROSION RESISTANT STEEL 3CR12				
25.16.51	25.11.1	Welding techniques				
25.16.52	25.11.2	Pickling and passivating				
25.16.53	25.12	ALUMINIUM				
25.16.42	25.12.1	Anodising				
25.16.43	25.12.2	Powder coating				
25.16.44	25.12.3	Fixing				
25.16.45	25.13	COATING SYSTEMS				
25.16.46	25.13.1	System A - Alkyd systems				
25.16.47	25.13.2	System B5 - Two pack Epoxy/Polyurethane system for exterior surfaces, steel				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
		substrates				
25.16.48	25.13.3	System B5 A - Steel substrates				
25.16.49	25.13.4	System B5 B - Galvanised substrates				
25.16.50	25.13.5	System F - Powder coatings				
25.16.51	25.13.6	System F1 - Polyurethane powder coating on primed mild steel for exterior exposure				
25.16.52	25.13.7	System F2 - Corrosion resistant powder coatings for interior and exterior use				
25.16.53	25.13.8	System F3 - Powder coating on aluminium for interior or exterior exposure				
25.16.54	25.13.9	System F4 - Polyurethane powder on galvanised mild steel for exterior exposure				
25.16.55	25.13.10	System F5 - Polyester powder coating on galvanised steel				
25.16.56	25.14	QUALITY ASSURANCE REQUIREMENTS				
25.16.57	25.14.1	Contractor qualification				
25.16.58	25.14.2	Data sheets, specifications and codes of practice				
25.16.59	25.14.3	Quality control				
25.16.60	25.14.4	Quality control records				
25.16.61	25.14.5	Alternative systems				
25.16.62	25.14.6	Quality surveillance				

ITEM	STANDARD	DESCRIPTION	COMPLY			COMMENTS/ SIGNATURE
			YES (√)	NO (X)	N/A (X)	
25.16.63	25.14.7	Access for surveillance				
25.16.64	25.14.8	Samples				
25.16.65	25.14.9	Destructive testing				
25.16.66	25.14.10	Cost of quality surveillance				
25.16.67	25.15	SPECIFIC APPLICATIONS				
25.16.68	25.15.1	Enclosures				
25.16.69	25.15.2	Cable trays and ladders				
25.16.70	25.15.3	Supports for cable racks				
25.16.71	25.15.4	Switch gear				
25.16.72	25.15.5	Transformers				

25. PANEL AND BAG FILTERS

25.1 GENERAL

25.1.1 Filter units or components shall:

25.1.1.1 Be selected from the standard range offered by approved local suppliers

25.1.1.2 Be selected to provide a minimum period of 6 months between cleaning or replacement unless specifically instructed to the contrary by SANRAL

25.1.1.3 Be designed to provide the lowest life cycle cost, i.e. the best trade off between first cost, replacement cost, maintenance and energy costs

25.1.1.4 Have a face velocity that does not exceed 2,5 m/s

25.1.1.5 Be installed such that the air flow through the filter does not exceed the manufacturer's rated capacity for that specific filter.

25.1.2 All filters that require an ASHRAE dust spot efficiency in excess of 80 % shall be 2-stage filters.

25.1.3 Washable filter media are not acceptable.

25.1.4 The filter design shall ensure that:

25.1.4.1 Air distribution across the filter media is uniform

25.1.4.2 The filter elements are easily accessible for maintenance

25.1.4.3 Access doors shall be:

(a) Sufficient in number and of adequate size

(b) Located so as to facilitate easy access and working conditions

(c) Shall be gasketted and secured to prevent air leakage.

25.1.4.4 All plenum joints shall be sealed to prevent air leakage.

25.1.4.5 All filter panels shall rest on seals to prevent air bypass.

25.1.4.6 Electrical facilities to be provided by others:

(a) Adequate lighting in the service areas

(b) A 15 A switched socket outlet near to the filter chamber access doors.

25.1.4.7 Electric precipitator type filters shall be equipped with an alarm, which shall sound when the unit has tripped.

25.1.4.8 Filter frames and panels shall be of adequate strength to withstand the full dirty pressure thrust.

25.1.4.9 All mild steel filter parts, e.g. frames, retaining clips etc., except those that are in contact with oil, shall be galvanised. In corrosive environments, either polypropylene or stainless components will be specified.

25.1.4.10 Filters must only be installed immediately prior to running the fans, to which they are connected, for the first time. Should the systems not be required to run after testing has been completed, the filters shall be removed and stored in a clean place until the plant is put in use.

25.1.4.11 Magnahelix type manometers shall be installed across each filter bank and red lined at the reading where filters have to be cleaned or replaced as specified by the filter manufacturer.

25.1.4.12 Air filters operated in areas with high ambient humidity (due to fog/rain) may become waterlogged and the differential pressure will indicate that they are “dirty”. These filters can normally be dried and re-used until the dust load warrants change.

25.2 DISPOSABLE MEDIA PANEL FILTERS

25.2.1 Each filter shall consist of a factory made robust sectional galvanised, polypropylene or stainless steel supporting frame, which shall accommodate the filter cells.

25.2.2 Media shall be kept in position by means of matching inner and outer retaining frames, forming a filter cell and shall be sufficiently robust to prevent deformation of the cell due to air pressure action on the dirty cell face.

25.2.3 Filter cells shall be easily removable preferably from the upstream side of the filter, or from the side of the filter assembly.

25.2.4 Filter media shall be a minimum of 50 mm thick unless otherwise specified herein or in SANRAL’s Requirements.

25.3 BAG FILTERS

25.3.1 Bag filters shall be of the extended pocket type with suitable spacers restraining expansion of pockets.

25.3.2 Filter cell holding clips shall ensure quick removal of units and shall be designed to ensure even pressure on the air seal.

25.3.3 Filter units shall be removable from the upstream or side of the filter housing.

25.4 HIGH EFFICIENCY FILTERS

25.4.1 All HEPA filters shall be preceded by a suitable primary filter.

25.4.2 High efficiency filters, where specified, shall be of the HEPA type. Where these are specified, allowance must be made for test openings upstream and downstream of the filter. The access openings and covers shall be of robust construction, gasketted and leak free.

25.4.3 A DOP test shall be carried out before handover and after each filter replacement during the Operation Service Period.

25.4.4 The seal shall be of the groove type. A pressure test shall be carried out in the groove to prove the integrity of the seal. A suitable permanent connection, which will be normally closed with a cock and accessible from outside, shall be provided in the groove to facilitate easy testing of seal air tightness.

25.4.5 HEPA filter boxes shall be of reputable manufacture and shall be installed strictly in accordance with the requirements of the manufacturer.

25.5 GREASE ELIMINATORS

25.5.1 Grease eliminators shall be “FARR” type or other approved inertia type.

25.5.2 Grease filter panels shall be “FARR 44HG” or approved equivalent.

25.5.3 Grease eliminators shall be made of:

25.5.4 Mild steel with a grey baked enamel finish

25.5.5 Stainless steel grade 430.

25.5.6 Panel filter frames shall be of stainless steel grade 430.

25.6 FILTER EFFICIENCIES

25.6.1 The following filter efficiencies shall apply:

25.6.1.1 Primary filters: 85% according to ASHRAE Standard 52-68 test

25.6.1.2 Secondary filters: 90-95% according to ASHRAE Standard 52-58 test.

25.6.2 HEPA filters must have a penetration of 0,01 % according to BS 3928.

26. PANEL CONTINUOUS ROLL TYPE AND ELECTROSTATIC TYPE FILTERS

26.1 GENERAL

26.1.1 Filter units or components shall be:

26.1.1.1 Selected from the standard range offered by approved local suppliers

26.1.1.2 Selected so as to provide a minimum period of 6 months between cleaning or replacement unless specifically instructed to the contrary by SANRAL or the Independent Engineer

26.1.1.3 Designed to provide the lowest life cycle cost, i.e. the best trade off between first cost, replacement cost, maintenance and energy costs

26.1.1.4 Selected to have a face velocity that does not exceed 2,5 m/s.

26.1.1.5 Installed such that the airflow through the filter does not exceed the manufacturers rated capacity for that specific filter.

26.1.2 All Filters which require an ASHRAE dust spot efficiency in excess of 80% shall be 2 stage filters.

26.1.3 Washable Filter media are not acceptable.

26.1.4 The Filter design shall ensure that:

26.1.4.1 Air distribution across the filter media is uniform.

26.1.4.2 The filter elements are easily accessible for maintenance.

26.1.4.3 Access doors shall be:

(a) Sufficient in number and of adequate size

(b) Located so as to facilitate easy access and working conditions

(c) Gasketted and secured to prevent air leakage.

26.1.4.4 All plenum joints shall be sealed to prevent air leakage.

26.1.4.5 All filter panels shall rest on seals to prevent air bypass.

26.1.4.6 Electrical facilities to be provided by others:

(a) Adequate lighting in the service areas

(b) A I5 A switched socket outlet near to the filter chamber access doors.

26.1.4.7 Electric precipitator type tilters shall be equipped with an alarm, which shall sound when the unit has tripped.

26.1.4.8 Filter frames and panels shall be of adequate strength to withstand the full dirty pressure thrust.

26.1.4.9 All mild steel filter parts, e.g. frames, retaining clips etc., except those that are in contact with oil, shall be galvanised. In a corrosive environment, either polypropylene or stainless components will be specified.

26.1.4.10 Filters must only be installed immediately before the fans to which they are connected are run for the first time.

26.1.4.11 Should the systems not be required to run after testing has been completed, the filters shall be removed and stored in a clean place until the plant is put in use.

26.1.5 Each filter bank shall be provided with a pressure differential switch, which shall operate when the pressure drop across the filter reaches a value recommended by the manufacturer. The switch shall energise a pilot light on the main control board.

26.1.6 Magnahelix type manometers shall be installed across each filter bank and red lined at the reading where filters have to be cleaned or replaced.

26.2 DISPOSABLE MEDIA PANEL FILTERS

26.2.1 Each filter shall consist of: factory made robust sectional galvanised, polyproylene or stainless steel supporting frame, which shall accommodate the filter cells.

26.2.2 Media shall be kept in position by means of matching inner and outer retaining frames, which form a filter cell and shall be sufficiently robust to prevent deformation of the cell due to air pressure action on the dirty cell face.

26.2.3 Filter cells shall be easily removable preferably from the upstream side of the filter, or from the side of the filter assembly.

26.2.4 Filter media shall be a minimum of 50 mm thick unless otherwise specified.

26.3 BAG FILTERS

26.3.1 Bag filters shall be of the extended pocket type with suitable spacers restraining expansion of pockets.

26.3.2 Filter cell holding clips shall ensure quick removal of units and shall be designed to ensure even pressure on the air seal.

26.3.3 Filter units shall be removable from the upstream side of the filter or side of the filter housing.

26.4 HIGH EFFICIENCY FILTERS

26.4.1 All HEPA filters shall be preceded by a suitable primary filter.

26.4.2 High efficiency filters, where specified, shall be of the HEPA type. Where these are specified, allowance must be made for test openings upstream and downstream of the filter. The access openings and covers shall be of robust construction, gasketted and leak free.

26.4.3 A DOP test shall be carried out before handover and after each filter replacement during the maintenance period.

26.4.4 The seal shall be of the groove type. A pressure test shall be carried out in the groove to prove the integrity of the seal. A suitable permanent connection, which will be normally closed with a cock and accessible from outside, shall be provided in the groove to facilitate easy testing of the seal's air tightness.

26.4.5 HEPA filter boxes shall be of a reputable manufacture and shall be installed strictly in accordance with the requirements of the manufacturer.

26.5 GREASE ELIMINATORS

26.5.1 Grease eliminators shall be "FARR" type or other approved inertia type.

26.5.2 Grease filter panels shall be "FARR 44HG".

26.5.3 Grease eliminators shall be made of:

26.5.3.1 Mild steel with a grey baked enamel finish

26.5.3.2 Stainless steel grade 430

26.5.4 Panel filter frames shall be of stainless steel grade 430.

26.6 FILTER EFFICIENCIES

26.6.1 The following filter efficiencies shall apply:

26.6.1.1 Primary filters: 85% according to ASHRAE Standard 52-68 test.

26.6.1.2 Secondary filters: 90-95% according to ASHRAE Standard 52-58 test.

26.6.1.3 HEPA filters must have a penetration of 0,01 % according to BS 3928.

27. THERMAL INSULATION

27.1 INTRODUCTION

27.1.1 All insulation Works shall be neatly carried out as described in this specification. A sample item, e.g. duct section, shall be provided for approval by SANRAL prior to the Contractor commencing insulation.

27.1.2 All insulation Works shall be carried out in accordance with the provisions of BS CP C3005, BS 1334, BS 1558 and BS 476.

27.2 GENERAL

27.2.1 All adhesive sealants and coatings shall be compatible with the insulation material used and also be resistant to rotting, mould, decay or attack by vermin. All insulation materials used shall comply with the fire resistant requirements stated in SANS 177. No Equipment shall be insulated until it has been tested and approved by SANRAL.

27.2.2 On request, the Contractor shall supply SANRAL with full technical details and data of proposed insulating materials and also provide a detailed method statement. Insulation may only commence once SANRAL has approved the material and method statement.

27.3 SURFACE PREPARATION

27.3.1 All steel surfaces shall be insulated and prepared as follows:

27.3.1.1 Loose rust and mill scale shall be removed by mechanical wire brushing

27.3.1.2 Oil and grease shall be completely removed using a suitable approved solvent

27.3.1.3 The surface shall then be treated with two brush applied coats of enamel synthetic zinc chromate primer or approved equivalent. Total dry film thickness shall not be less than 76 microns and not more than 100 microns.

27.4 PIPE INSULATION

27.4.1 Hot water and condensate pipes in plant rooms

27.4.1.1 Insulating material

Preformed resin bonded fibreglass insulation with a density of 96 kg/m³ shall be used. Insulation sections shall be equipped with factory applied canvas backings. 25 mm thick insulation shall be used on all pipes up to and including 125 mm nominal bore and 40 mm thick insulation shall be used on all piping in the excess of 125 mm nominal bore.

27.4.1.2 A vapour barrier comprising two coats of Foster Sealfas coating 30-36 or similar approved materials with Sealfas lagging cloth or similar approved material embedded between the coats shall be applied. In the case of insulations at the coastal areas and areas of high average relative humidity an additional overcoat of Foster vinyl vapour barrier 30-42 or similar approved material shall be applied.

27.4.1.3 All circumferential joints shall be treated with Foster Foamseal 30-45 or approved equivalent to prevent the migration of moisture through the circumferential joints.

27.4.1.4 All points where the pipe insulation has been broken due to the connection of pipe supports or uninsulated instrument take-offs etc. shall be treated as indicated herein.

27.4.1.5 All canvas joint laps (i.e. both circumferential and longitudinal) shall be treated with Foster Sealfas coating 30-36 or approved equivalent prior to final coating.

27.4.1.6 All insulation shall be protected by means of 0,5 mm thick galvanised sheet metal cladding over the insulation. The bends shall be of lobster back construction. All cladding segments shall be secured by either stainless steel bands or alternatively by pop rivets at regular intervals not exceeding 500 mm.

27.4.1.7 All valves and fittings shall be insulated with 25 mm thick asbestos plastic compound covered by a 15 mm thick layer of asbestos hard setting compound trowelled to a neat and smooth finish.

27.4.2 Hot water and condensate pipes outside plant rooms.

These pipes shall be insulated in the same manner as described above with the exception that in this case the canvas joints shall be treated with Foster Lagfas 81-42 W or similar approved material and the canvas backing finished with brush applied Foster Sealfas coating 30-36 or similar approved material.

27.5 DUCTING

All supply air ducting associated with air conditioning and ducted heated systems shall be insulated as described below.

27.5.1 Ducts in visible areas

27.5.1.1 All ducts with air velocities below 9 m/s shall be internally insulated with 25 mm thick neoprene coated resin bonded glass fibre. The glass fibre density shall be 24 kg/m^3.

27.5.1.2 This insulation shall be fixed to the ducting by both approved adhesive and mechanical fasteners (i.e. preferably weld pin type). The installation of this insulation shall comply with SANS 10173 and SANS 1238.

27.5.1.3 All ducts with air velocities exceeding 9 m/s shall be externally insulated with 25 mm thick glass fibre with a density of 72 kg/m^3. This insulation shall be fixed by both adhesive and weld pins as described above. The insulation shall be clad using 0,6 mm thick galvanised mild steel cladding neatly secured with pop rivets.

27.5.1.4 The cladding shall be stopped 35 mm from flanged joints to facilitate tightening of bolts and inspecting joints for air leakage. These areas shall be covered using galvanised mild steel cladding.

27.5.2 Ducts in non-visible areas (e.g. in ceiling voids)

27.5.2.1 Ducts with air velocities below 9 m/s shall be internally insulated as described under Clause 27.5.1.3 above.

27.5.2.2 Ducts with air velocities above 9 m/s shall be externally insulated using 29 mm thick foil backed glass fibre in the same manner as described under Clause 27.5.1.3 above.

27.5.2.3 The laps, joints and ends shall be neatly finished off using good quality and an approved make of duct tape.

28. PERMISSIBLE NOISE LEVEL

28.1 PERMISSIBLE NOISE LEVEL

28.1.1 Noise levels in buildings attributed to air conditioning plant shall not exceed 40 dB (A). The systems installed are not to exceed the average sound level given unless the background noise created by other equipment exceeds the average noise level in which case the noise levels in the immediate occupied zone, shall not be discernible above the background noise.

28.1.2 The maximum permissible noise levels shall be measured (if required), in the immediate occupied zone which is defined as 1 200 mm above floor level.

29. WALL AND SPLIT-TYPE AIR CONDITIONING

29.1 GENERAL

29.1.1 Equipment covered by this specification shall comply with the provisions of SANS 1125-1977 titled “Standard Specification for Room Air Conditioners” and be constructed, erected, inspected, tested and operated in accordance with SANS 10147-1992 titled “Refrigerating Systems Including Plants Associated with Air Conditioning”.

29.1.2 For coastal applications, all units will be fitted with copper-to-copper coils and 3CR12 outer casings.

29.1.3 All air conditioning equipment shall be installed and Commissioned strictly in accordance with the manufacturers specifications.

29.1.4 This specification is of a general nature and is intended to supplement the manufacturer’s specifications.

29.2 THROUGH THE WALL TYPE AIR CONDITIONING UNITS

29.2.1 A duct shall be supplied and built in by the Contractor. The Contractor shall ensure that the required inclination to facilitate correct and complete condensate drainage is achieved.

29.2.2 The installer shall ensure that the fit up between the wall and the air conditioner unit is neat. The length of electric cable between the unit and the isolator outlet to which it is connected shall be kept to a minimum.

29.2.3 The Contractor shall clearly mark the positions for each isolator outlet supplying through the wall air conditioners. The relative positions of air conditioning unit and isolator shall be the same for all units. Condensate drains shall be installed using lagged copper piping and in the case of complicated installations the Contractor shall provide a condensate pump that is interlocked with the unit and will cause the unit to switch off if a failure occurs.

29.3 SPLIT TYPE AIR CONDITIONING UNITS

29.3.1 Where the air handling units are fixed directly to walls (e.g. mid wall, console type), the fit shall be neat and the unit shall be mounted flush against the wall.

29.3.2 In case of air handling units mounted in the ceiling space, these shall be suspended from anti-vibration hangers and shall not be in direct contact with any part of the building structure or other building services.

29.3.3 Condenser units shall be either mounted on concrete plinths or bolted to Hot dip galvanised cantilever brackets by means of M10 approved type masonry anchors.

29.3.4 The plinths shall be supplied by the Contractor. Alternatively the condenser units could be mounted on galvanised mild steel frames/brackets supplied by and mounted onto a convenient wall by the Contractor.

29.3.5 These galvanised steel frames shall be constructed form “CABSTRUT” channel and mounted onto the wall by means of robust approved masonry anchors which shall not be less than M8 x 100 in size and 4 anchors per condenser unit. All exposed ends of the “CABSTRUT” channel shall be neatly plugged. Excessive bolt projections shall be neatly cut off. All bolts, washers and nuts shall be approved type and alloy coated, or stainless steel for coastal applications.

29.3.6 Refrigeration piping shall be of soft drawn copper in accordance with SANS 460. Installation and jointing shall be in accordance with the latest Maksal recommended code of practice.

29.3.7 Refrigeration piping shall be neatly run wherever possible against the face of a wall. All refrigeration piping shall be insulated using an approved type of insulation. Refer to section on “Thermal Insulation” in this document.

29.3.8 Refrigeration piping, associated cables and where possible condensate drains shall be enclosed in galvanised metal trunking mounted either against the wall or alternatively cast into the wall. The exposed parts of this trunking shall be painted to specification in the same colour as the rainwater down pipes.

29.3.9 Condensate pipes shall be run on an even grade of not less than 1:100 to facilitate condensate drainage. These pipes shall be supported at regular intervals to prevent local sagging.

29.3.10 Wherever pipes (i.e. condensate and refrigeration) are installed in a position where people could stand on them, they shall be supported continuously over the length with robust supports capable of withstanding the weight of the person. Furthermore, the section of pipes at risk of damage by people shall be encased in robust galvanised mild steel trunking for inland areas and stainless steel for coastal applications.

29.3.11 In the case of split systems using ducting, all ducting shall be designed for low air velocities with all transitions and fittings being aerodynamically efficient to minimize the resistance to air flow through the ducting to a minimum. The system external static resistance at design air flow rates shall not exceed the air conditioning unit supplier rated external static pressure for the air handling unit fan at this flow rate. In the event of this information not being available, the external static pressure of the system shall not exceed 70 Pa.

29.3.12 Ducting (i.e. both supply and return air) shall be lined with 25 mm thick sonic lining. Flexible ducting sections shall be of the attenuated type not exceeding 1 m in length and be installed so as to provide an as aerodynamic as possible airflow path.

29.3.13 All galvanised mild steel ducting shall comply with SANS 1238 and SANS 10173.

29.3.14 All flexible ducting shall comply with the SANS 10177 - Class 1 fire rating.

29.3.15 Dampers shall be installed on both the fresh air and return air circuits to facilitate the correct balancing of air flow rates.

29.4 GENERAL

29.4.1 The isolator shall be supplied and installed by the Contractor. All wiring from the outgoing side of this isolator to the condenser unit and from the condenser unit to the air handling unit shall be done by the Contractor.

29.4.2 The Contractor shall mark the positions required for all cast-in conduits, boxes, condensate drains, holes through walls etc. These cast-in items and holes shall be supplied and installed by others.

29.5 COMMISSIONING

29.5.1 All air conditioning units and systems shall be Commissioned in accordance with this Standard Specification.

30. ELECTRICAL HEATER BANKS

30.1 ELEMENT

30.1.1 The heater elements shall be made of Incoloy and comply with the provisions of the following SABS Codes of Practice: SANS 160, SANS 755 and SABS VC 8005. Elements shall be 8 mm diameter and have a wattage density not exceeding 3,1 W/cm². Elements shall have 25 mm diameter clinch bushes, M4 angle tab connections and elements bent to give 64 mm centres.

30.2 ENCLOSURE

30.2.1 The heater elements shall be fixed to a metal frame, which is in turn enclosed in a galvanised mild steel box. The heater elements shall preferably be installed in the horizontal plane and the elements staggered to avoid the air shielding effect. The elements shall be supported in the vertical plane to avoid sagging. Heater box design shall ensure that there is a uniform airflow across the elements and that there are no hot spots.

30.2.2 A distance of at least 10 mm shall be maintained between the cold elements and the inner face of the heater box insulation to allow for thermal expansion. This galvanised mild steel box shall be insulated internally using 10 mm thick mill board insulation suitable for operating continuously at a temperature of 500°C. This insulation shall be fixed to the galvanised steel casing using mechanical fasteners, which provide minimal thermal bridge affect.

30.2.3 The terminals of the elements shall be covered by a robust perforated galvanised metal plate, which is neatly fixed by means of bolts or alloy coated self tapping screws. The size of the perforations shall be such that it shall not be possible for a person to come in contact with the terminals by inserting a finger through a hole in the perforated plate. All coatings, adhesives, sealants and the like used, shall be of an approved type and suitable for use in environments up to 500°C. The dimensions and design of the heater box shall be such that the static pressure loss across the box under normal operational shall not exceed 50 Pa. The heater box casing shall be electrically insulated from the ducting.

30.2.4 The sections of ducting immediately upstream and downstream of the heater box shall be insulated in the same manner as required for the heater box for a distance of 600 mm from the connection to the heater box.

30.2.5 No other equipment may be installed either upstream or downstream from the heater box closer than 600 mm from the heater box flanges.

30.2.6 All heater boxes shall be supplied with filtered air with the filter banks being a minimum of 1 m away from the nearest heater element.

30.3 HEATER CONTROL AND SAFETY INTERLOCKS

30.3.1 The heater elements shall be electrically interlocked with a supply air fan so that in the event of the electrical supply to the fan being interrupted, the electrical supply to the heaters will be isolated.

30.3.2 A safety thermostat set to 65°C shall be installed in the downstream ducting 300 mm from the flange of the heater box. This safety thermostat shall be wired so as to isolate the electrical supply to the heater elements in the event of the heated air temperature in this position exceeding 75°C. Furthermore, it shall be necessary to manually reset this thermostat before power can be applied to the heater elements once again after such a trip-out.

30.3.3 An air flow switch shall be installed downstream of the heater box and connected so as to isolate power to the heater elements in the event of the air flow rate being reduced below the minimum design air flow rate.

30.3.4 The heater elements shall be connected in a number of banks and controlled by means of a multi-step thermostat. No heater bank step shall exceed 3 kW. This thermostat shall be set to switch on each successive heater bank at intervals of 1°C with an inter-step dead zone of 0,5°C.

30.3.5 The control panel shall be equipped with indicator lights to show which heater banks are in operation and which are not at any one moment in time. Furthermore, there shall be indicating lights to reflect operation of the over temperature safety thermostat, airflow rate too low and failure of the supply air fan. These indication lights shall be clearly labelled. The electrical components of the control panel shall comply with Employer specification if provided.

30.3.6 A copy of the wiring diagram shall be fixed to the inside of the control panel door and all contactors, timers, etc., shall be clearly labelled.

30.4 ELECTRICAL INTERFACE

30.4.1 The control panel described under Clause 30.3.5 above shall be supplied and installed by the air conditioning Contractor.

30.4.2 The Contractor will supply power to this panel and connect this supply cable to the main contactor in the panel.

30.4.3 All wiring from this panel to the safety thermostat, flow switch and fan shall be carried out under the air conditioning contract.

30.5 COMMISSIONING

All heating systems shall be Commissioned in accordance with this Standard Specification.

31. TESTING AND COMMISSIONING OF AIR-CONDITIONING AND VENTILATION SYSTEMS

31.1 GENERAL

31.1.1 No system shall be considered complete until the Contractor has carried out a comprehensive series of Commissioning tests to satisfy SANRAL that the Equipment complies with the contractual requirements and is safe to operate.

31.1.2 All modifications to the systems shall have been approved by SANRAL before they are executed.

31.1.3 All testing shall be conducted by responsible persons in the employ of the Contractor and only approved methods of testing shall be allowed..

31.1.4 Before any item or plant is tested or operated, it shall be thoroughly cleaned by the Contractor. The Contractor shall make available at his own cost all technical personnel for the full duration of test runs and he shall be responsible for all accidents or damage, which may occur from any cause whatsoever.

31.1.5 Test equipment and other materials as well as labour required for testing shall be supplied and applied by the Contractor at his own cost.

31.2 COMMISSIONING

31.2.1 Commissioning shall be carried out in accordance with the CIBSE Commissioning Code “A” as detailed under Clause 31.2.4.1. Initially pipes shall be pressure tested and then flushed as described under Clause 31.2.2. Equipment such as boilers, air conditioning plant etc., shall be initially inspected and pre-Commissioned by the equipment supplier prior to attempting Commissioning of any system.

31.2.2 Draining and Cleaning

31.2.2.1 On completion of the pressure test on a section of pipework, the water used for testing shall be drained away as quickly as possible to remove as much dirt and dross as possible. After completion of a pipework circuit, the circuit shall be flushed through to remove all pipe scale, dross and similar materials.

31.2.3 Equipment Plant Commissioning

31.2.3.1 The Contractor shall arrange at his cost for the manufacturers’ representatives to check over and fully Commission all major items of equipment.

31.2.3.2 These Works are to be carried out by skilled engineers, preferably employed by the manufacturers, who are completely familiar with the equipment involved and shall be capable of training the operating and maintenance staff in the duties they are to perform.

31.2.3.3 On completion of the plant Commissioning, the Contractor shall obtain written confirmation from the various manufacturers that they have completed all Commissioning and are satisfied that the items of plant for which they are responsible is functioning satisfactorily.

31.2.3.4 A copy of the manufacturer's test certificates shall be sent to SANRAL.

31.2.4 System Commissioning

31.2.4.1 The definitions used in CIBSE Commissioning Code "A", shall be used throughout the air conditioning and ventilation section of Works.

31.2.4.2 On completion of flushing and cleaning, the whole system shall be Commissioned to the requirements of CIBSE Commissioning Code "A".

31.2.4.3 On completion of the Commissioning, the checks listed in section A1 of Commissioning Code "A" shall be carried out. Each of these checks shall be tabulated on an approved form and signed for by both the Contractor and SANRAL.

31.2.4.4 This tabulated form shall be filed and ultimately presented with the Handover Manual to SANRAL.

31.2.4.5 After the approved completion of the preliminary checks, all pipework and ductwork shall be pressure tested as described in Appendices A and B of DW 142. The results of these tests shall be witnessed and present to SANRAL on the Specimen "air/water leakage tests sheet" shown in Appendix B of DW 142.

31.2.4.6 On successful completion of the pressure tests, the complete installation shall be set to work and regulated as indicated in section A2 of the CIBSE Commissioning Code "A".

31.2.4.7 The methods of measurements and tolerances laid out in Section A3 of CIBSE Commissioning Code "A" shall be used throughout this phase of the Works.

31.2.5 Test on Completion

31.2.5.1 On completion of the balancing and Commissioning of equipment, the plant shall be put into normal operation and the final adjustment of the equipment shall be made.

31.2.5.2 Thereafter, the Tests on Completion shall be carried out to ensure that the plant will fulfil the functions for which is has been supplied.

31.2.5.3 Such tests shall include the following:

(a) Simulated tests for all alarm and safety cut out equipment to prove the operation of the equipment.

(b) Simulated tests on automatic controls to prove the ability of the controls to correct conditions that are outside the required design conditions. The tests shall be carried out by manually changing the desired values to produce an incorrect condition and the re-setting of controls to the design conditions and checking the operation of valves, to restore the design conditions.

(c) Operational tests on the plant to demonstrate that it is giving the rated output and efficiency.

31.2.5.4 The Contractor shall provide all necessary temporary measuring and recording equipment. The equipment shall be of a type generally used for this type of testing and shall be to the approval of SANRAL. All instruments shall be accurately calibrated before tests begin.

31.2.5.5 On completion of the tests and when the Contractor is satisfied that the entire plant is operating satisfactorily and will fulfil the function for which it has been supplied, he then shall submit to SANRAL triplicate copies of all test records and charts together with reports on all tests called for in this Specification. SANRAL shall reserve the right to ask for any reasonable additional tests or for the repetition of previous tests in order to prove that the operation of the plant is satisfactory and is in accordance with the Specification and Drawings.

32. GENERAL EQUIPMENT

32.1 GENERAL PAINTING SPECIFICATION

32.1.1 The surface preparation and repainting of the control building interior and exterior

32.1.1.1 Walls and ceilings:

Walls and ceilings shall be painted with Dulux or similar approved acrylic PVA or similar approved.

32.1.1.2 Security steel gates:

Different shade of colours may be used on the security gate and frame, should SANRAL or the Independent Engineer require and approve this option. The required surface shall be repainted according to the following Specification:

(a) Cost 1 - Dulux or similar approved Primer where previous paint was removed.

(b) Cost 2 - Dulux or similar approved U/C for all surfaces.

(c) Cost 3 - Dulux or similar approved Pearlglo Polyurethane – Colour as per item 32.8.

32.1.1.3 Painted wooden doors:

Sand down and wash with sugar soap. Two coats of Dulux or similar approved Pearlglo Polyurethane shall be applied in the required colour.

Please take note of the surface preparation of the required surface form page 7.

32.1.1.4 Painted steel doors:

All exterior and interior steel doors shall be painted as per the Specification for security steel gates.

32.1.1.5 Door Frames:

All doorframes shall be painted according to the following specifications on mild steel work.

(a) Cost 1 - Dulux or similar approved Primer where previous paint was removed.

(b) Cost 2 - Dulux or similar approved U/C for all surfaces.

(c) Cost 3 - Dulux or similar approved Pearlglo Polyurethane – Colour as per schedule.

32.1.1.6 Varnish Exterior Wooden Doors:

All exterior wooden doors shall be varnished with Woodgard Double Life Varnish.

32.1.1.7 Palisade Steel fences:

All palisade steel fencing shall be painted according to the Standard Specification and required colour will be as per SANS 1021 – 1975; F11 (strong blue); twin pack urethane (Sigmadur Gloss on EPO-LUY595). One coat 50 – 70 DFT.

32.1.1.8 Window Frames:

(a) All exterior window frames shall be painted.

(b) F48 (Cloud grey) according to the SANS 1091-1975.

(c) All interior frames shall be painted with Dulux or similar approved Pearlglo Polyurethane or similar approved.

(d) Colour to match the walls.

32.2 THE SURFACE PREPARATION AND REPAINTING OF THE CONTROL BUILDING AND OUTBUILDING ROOFS.

32.2.1 Fascia

The following system shall be used by the subcontractor to paint the required area:

32.2.1.1 Carboline "Rustbond Penetrating Sealer" as a tie coat, only where the existing paint work was damaged to the surface. The paint suppliers must first approve the tie coat before the paint can be applied.

32.2.1.2 Intermediate and final coat: Polyurethane SANS 1091-1975; F11 (strong blue). (The sub-contractor shall test the generic type of existing paint before any paint will be ordered).

32.2.1.3 Spray application is preferred and the minimum DFT/Coat may be reduced to 30 µm.

32.2.1.4 The paint supplier must confirm that the pigments in the paint are light fast.

32.3 FLASHINGS

The following system shall be used by the subcontractor to paint the required area:

32.3.1.1 Carboline "Rustbond Penetrating Sealer" as a tie coat, only where the existing paint work was damaged to the surface. The paint suppliers must first approve the tie coat before the paint can be applied.

32.3.1.2 Intermediate and final coat: Polyurethane SANS 1091-1975; F11 (strong blue). (The sub-contractor shall test the generic type of existing paint before any paint can be ordered).

32.3.1.3 Spray application is preferred and the minimum DFT/Coat may be reduced to 30 µm.

32.3.1.4 The paint supplier must confirm that the pigments in the paint are light fast.

32.3.2 Roof

32.3.2.1 The following system shall be used by the subcontractor to paint the required area:

32.3.2.2 Carboline "Rustbond Penetrating Sealer" as a tie coat, only where the existing paint work was damaged to the surface. The paint suppliers must first approve the tie coat before the paint can be applied.

32.3.2.3 Intermediate and final coat: Polyurethane SANS 1091-1975 F11 (strong blue). (The sub-contractor shall test the generic type of existing paint before any paint can be ordered).

32.3.2.4 Spray application is preferred and the minimum DFT/Coat may be reduced to 30 µm.

32.3.2.5 The paint supplier must confirm that the pigments in the paint are light fast.

32.3.3 Ceiling

32.3.3.1 The subcontractor shall paint all the ceiling eaves with Dulux or similar approved Acrylic PVA or similar approved product, colour shall be white.

32.3.4 Down Pipes

32.3.4.1 All previously painted galvanised down pipes shall be repainted according to the standard specifications supplied for the fascia and flashing.

32.3.4.2 Please take note of the surface preparation of the required surface form page 7.

32.4 THE SURFACE PREPARATION AND REPAINTING OF THE CANOPY

32.4.1 Fascia

The following system shall be used by the subcontractor to paint the required area:

32.4.1.1 Carboline "Rustbond Penetrating Sealer" as a tie coat, only where the existing paint work was damaged to the surface. The paint suppliers must first approve the tie coat before the paint can be applied.

32.4.1.2 Intermediate and final coat: Polyurethane; SANS 1091-1975; F11 (strong blue). (The sub-contractor to test the generic type of existing paint before any paint can be ordered).

32.4.1.3 Spray application is preferred and the minimum DFT/Coat may be reduced to 30 µm.

32.4.1.4 The paint supplier must confirm that the pigments in the paint are light fast.

32.4.2 Flashings

The following system shall be used by the subcontractor to paint the required area:

32.4.2.1 Carboline "Rustbond Penetrating Sealer" as a tie coat, only where the existing paint work was damaged to the surface. The paint suppliers must first approve the tie coat before the paint can be applied.

32.4.2.2 Intermediate and final coat: Polyurethane; SANS 1091-1975; F11 (strong blue). (The sub-contractor shall test the generic type of existing paint before any paint can be ordered).

32.4.2.3 Spray application is preferred and the minimum DFT/Coat may be reduced to 30 µm.

32.4.2.4 The paint supplier must confirm that the pigments in the paint are light fast.

32.4.3 Down Pipes

32.4.3.1 All previously painted galvanised down pipes shall be repainted according to the standard specification supplied for the fascia. Please note that the client reserves the right to change the final colour.

32.4.4 Column

32.4.4.1 All previously painted steel columns shall be painted according to the standard specification for flashings or fascia. The colour shall match the colour of the fascia. Please note that the client must approve the final colour.

32.4.5 Ceiling

The following system shall be used by the subcontractor to paint the required area:

32.4.5.1 Carboline "Rustbond Penetrating Sealer" as a tie coat, only where the existing paint work was damaged to the surface. The paint suppliers must first approve the tie coat before the paint can be applied.

32.4.5.2 Intermediate and final coat: Polyurethane; SANS 1091-1975; F11 (strong blue).

32.4.5.3 Spray application is preferred and the minimum DFT/Coat may be reduced to 30 µm.

32.4.6 Toll Plaza Name

32.4.6.1 All Toll Plaza names shall be painted according to the standard specifications on steelwork (Polyurethane). The name shall be painted white. Only the name of the plaza will be painted. The plaza section will be removed and stored at the plaza.

32.4.6.2 The surface preparation and repainting of the lanes (bull noses, new jersey barriers, galvanised steel Armco barriers, load gauges and booth protection structures).

32.4.7 The surface of the bull nose and New Jersey barrier shall be cleaned before the proposed coating system is applied and damaged concrete shall be repaired with epoxy grout.

32.4.8 The concrete surfaces shall be coated with a protective coating, which offers resistance to the adverse effect of exhaust fumes and high pressure water jetting used for cleaning the toll islands. The protective coating shall be waterproof, easy to clean and shall have a smooth finish.

32.4.9 The proposed repainting shall consist of:

32.4.9.1 Red/white on grey bull noses:

32.4.9.2 The last coat of paint must be removed using a wire brush etc. Wash down surface well and allow to dry before masking and applying a tie coat if required and 2 coats of (Polyurethane) Sigmadur gloss or EPO – LUX in the required colours.

32.4.9.3 Grey bull noses and New Jersey barriers:

32.4.9.4 Apply 1 tie coat if required.

32.4.9.5 Apply 2 coats of Sigmadur gloss (Polyurethane) or EPO – LUX in the required colour.

32.4.9.6 The proposed coating system shall be used strictly in accordance with the prescriptions of the Manufacturer.

Please note that bull noses will only be painted red and white if there is no impact attenuator in front of the bull nose for oncoming traffic.

32.4.10 Toll booth protection barriers and load gauges.

32.4.10.1 Remove all corrosion, clean surface with sugar soap and lightly sand surface.

32.4.10.2 Test the generic type of paint used before the required paint is applied to the surface.

32.4.10.3 2 x Coats of bright yellow paint shall be applied to the required surface.

32.4.10.4 Should there be any paint specification outstanding the Subcontractor shall submit a specification for approval by SANRAL or the Independent Engineer/Client.

32.5 THE SURFACE PREPARATION AND REPAINTING OF THE CARPORT

All previously painted fibre cement fascias shall be tie coated and coated with Polyurethane based paint.

32.5.1 Air supply ducting:

32.5.1.1 The Subcontractor shall repaint the fresh air ducting system that was previously painted. The required areas shall be painted according to the Standard Specifications for Flashings and Fascia. The colour shall be F11 strong blue.

32.5.2 Support steelwork for the ducting system:

All exposed steelwork for the ducting system shall be painted to the standard specification strong blue F11.

(a) Coat 1 - Primer for steel (only where the previous paint was removed)

(b) Coat 2 – Under-coat for all surfaces

(c) Coat 3 - Polyurethane enamel in required colour.

32.5.3 Catladder and Platform:

The catladder and platform shall be painted according to the SABS standard colour F11 strong blue.

The following coats shall be applied:

(a) Coat 1 - Primer for steel (only where the previous paint was removed)

(b) Coat 2 - Under coat for all surfaces

(c) Coat 3 - Polyurethane enamel in required colour.

32.6 GENERIC TYPE

32.6.1 Testing to determine the generic type of painting system: MEK test shall be executed on all surfaces before the required paint is applied to ensure that the specified paint will adhere.

32.6.2 Due to the different generic systems previously used on the load gauges, the Subcontractor shall execute the Methyl Ethyl Ketone (MEK) solvent test on the booth protection structure, bull noses and New Jersey barriers, etc. to determine the correct generic type of paint to be applied.

Please take note of the surface preparation of the required surface form page 7.

32.7 CLEANING OF THE CANOPY CEILING (ALTERNATIVE)

32.7.1 The Subcontractor shall clean the canopy with a sugar soap solution. Should the ceiling still be in a good condition and no paintwork is required, this item can then be claimed. Item 4.1.5 will then be discarded. All equipment below the canopy shall be covered against spillage of paint or cleaning solution.

Please take note of the surface preparation of the required surface form page 7.

32.8 COLOURS

32.8.1 Specification to be followed as set out in the Standard Specification.

32.8.2 The following colour schedule shall be used and the Contractor The Contractor may change the colour if approved by SANRAL or the Independent Engineer.

Item	Description	Paint Colour	Paint Code
1	Canopy (steel) and beams	Strong blue	F11
2	Canopy (concrete) and beams		
3	Bullnose with IA	Medium sea grey	G24
4	Bullnose without IA	Red/White	A11
5	New Jersey barrier	Medium sea grey	G24
6	Steel barriers	Red/yellow	A11
7	Load gauges	Golden yellow	B49
8	Booth protection structure	Golden yellow	B49
9	Booth inside	Medium sea grey	G24
10	Road markings		
11	Control building:		
12	Doors (painted)	Lace Corsage	19YY 83/140
13	Door frames mild steel (painted)	Peach	00YY 57/299
14	Control room	Orange blossom	05YY 72/254
15	Corridor	Orange blossom	05YY 72/254
16	Cash-up & cash dispatch rooms	Orange blossom	05YY 72/254
17	Bathrooms	Orange blossom	05YY 72/254
18	Administration office	Orange blossom	05YY 72/254
19	Board room	Orange blossom	05YY 72/254
20	Technician room	Orange blossom	05YY 72/254
21	SANRAL office	Orange blossom	05YY 72/254
22	Store room	Orange blossom	05YY 72/254
23	UPS room	Orange blossom	05YY 72/254
24	Generator room walls	Orange cantaloupe	90YR 54/440
25	Generator room floor	Green	
26	Security gates and doors inside building	Peach	00YY 57/299
27	Security gates entrance to building	Forever amber	00YY 45/431
28	Pedestrian/vehicle gate and fence	Forever amber	00YY 45/431
29	Plaza building roof	Strong blue	F11

Item	Description	Paint Colour	Paint Code
30	Plaza name	White	
31	Street light labels	Black	
32	Varnish for all wooden doors at see level	Double live varnish	Clear
33	Varnish for all wooden doors at high level	Double live varnish	Clear

33. SURFACE PREPARATION

33.1 INTERIOR CEILING PANELS ACOUSTIC TILES PREVIOUSLY PAINTED WITH A WATER BASED COATING

33.1.1 Surface Preparation

33.1.1.1 Clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow to dry.

33.2 INTERIOR CEMENT PLASTER OR CONCRETE PREVIOUSLY PAINTED WITH A SOLVENT BASED COATING

33.2.1 Surface Preparation

33.2.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be “feathered” with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas of bar substrate shall be patch primed using a suitable primer. Then patch these areas with coat 2 before overcoating the whole area with the finishing coat.

33.2.2 Efflorescence

33.2.2.1 Efflorescence is a result of water within the structure, dissolving salts, then evaporating and leaving a white loose salt deposit on the surface. This often occurs on new brickwork or plaster and can also appear on old surfaces where there is a damp problem. The white deposits should be removed by brushing off as they appear and the process repeated at regular intervals until they no longer form on the surface. A final brush down and a wipe with a dampened (not wet) sponge are advised. Painting must not take place until efflorescence has ceased. If there is a damp problem, this must also be cured before painting commences.

33.2.3 Paint Flaking, Peeling or Poor Adhesion

33.2.3.1 All loose paint must be scraped down to a sound substrate. Loose paint is defined as any paint which can be removed by firm hand pressure with a sharp paint scraper. If the paint is loose between coats and the lower layer of paint well bonded to the substrate, check this paint for compatibility to the new paint system. It should not be necessary to remove well-bonded layers of old paint. Edges of tightly bonded paint shall be “feathered” and unevenness filled flush and smooth.

33.2.4 Weak Plaster

33.2.4.1 Probing the plaster with a sharp instrument such as a penknife blade or screwdriver may test this. If the point enters the surface readily, then it should be considered suspect. In extreme cases, the only remedy is to strip the plaster, re-plaster and re-coat. If it is only slightly soft, then all paint must be removed and the bare plaster sealed with a coat of Dulux or similar approved primer/sealer (bonding liquid) thinned 20% with Mineral Turpentine. It must be completely absorbed into the plaster and not leave a glossy surface.

33.2.5 Chalky or Powdery

33.2.5.1 Chalky surfaces can be caused by old and weathered paint, poor quality stopping or was lime wash or distemper surface underneath. Loose paint must be removed.

The surface, in the case of lime wash or distemper should be scraped or wire brushed to remove as much of the material as practical. If the existing paint has merely weathered to a chalky finish but is otherwise in good condition, it should be scrubbed free of chalky material using Fixit sugar soap and water. Rinse thoroughly with clean water and allow drying. The entire surface should then be coated with a coat of Dulux or Durabond or similar approved primer/sealer (bonding liquid) clear thinned 29% with Mineral Turpentine, and then painted the normal way. It must be completely absorbed into the plaster and not leave a glossy surface.

33.3 INTERIOR CEMENT PLASTER OR CONCRETE PREVIOUSLY PAINTED WITH A WATER BASED COATING

33.3.1 Surface Preparation

33.3.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be “feathered” with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas of bare substrate shall be patch primed using a suitable primer. Then patch these areas with Coat 2 before over-coating the whole area with the finishing.

33.3.2 Efflorescence

33.3.2.1 Efflorescence is a result of water within the structure, dissolving salts, then evaporating and leaving a white loose salt deposit on the surface. This often occurs on new brickwork or plaster and can also appear on old surfaces where there is a damp problem. The white deposits should be removed by brushing off as they appear and the process repeated at regular intervals until they no longer form on the surface. A final brush down and a wipe with a dampened (not wet) sponge are advised. Painting must not take place until efflorescence has ceased. If there is a damp problem, this must also be cured before painting commences.

33.3.3 Paint Flaking, Peeling or Poor Adhesion

33.3.3.1 All loose paint must be scraped down to a sound substrate. Loose paint is defined as any paint which can be removed by firm hand pressure with a sharp paint scraper. If the paint is loose between coats and the lower layer of paint well bonded to the substrate, check this paint for compatibility to the new paint system. It should not be necessary to remove well-bonded layers of old paint. Edges of tightly bonded paint shall be “feathered” and unevenness filled flush and smooth.

33.3.4 Weak Plaster

33.3.4.1 Probing the plaster with a sharp instrument such as a penknife blade or screwdriver may test this. If the point enters the surface readily, then it should be considered suspect. In extreme cases, the only remedy is to strip the plaster, re-plaster and re-coat. If it is only slightly soft, then all paint must be removed and the bare plaster sealed with a coat of Dulux or similar approved primer/sealer (bonding liquid) thinned 20% with Mineral Turpentine. It must be completely absorbed into the plaster and not leave a glossy surface.

33.3.5 Chalky or Powdery

33.3.5.1 Chalky surfaces can be caused by old and weathered paint, poor quality stopping or if the previous surface was lime wash or distemper. Loose paint must be removed.

The surface, in the case of lime wash or distemper should be scraped or wire brushed to remove as much of the material as practical. If the existing paint has merely weathered to a chalky finish but is otherwise in good condition, it should be scrubbed free of chalky material using Fixit sugar soap and water. Rinse thoroughly with clean water and allow drying. The entire surface should then be coated with a coat of Dulux/Durabond or similar approved primer/sealer (bonding liquid) clean thinned 20% with Mineral Turpentine, and then painted the normal way. It must be completely absorbed into the plaster and not leave a glossy surface.

33.4 CRACKED PLASTER, HOLES AND UNEVENNESS

33.4.1 Repair all cracks, holes and unevenness by removing loose sand and plaster. Fill cleaned areas using an acrylic type sealant, e.g. Profill. Apply as per manufacturer’s instructions.

33.4.2 Large exterior cracks (+2mm) must be opened out to 3mm or larger with a carborundum disk and filled flush with a plaster mix or an Acrylic Sealant. The manufacturer’s instructions must be followed.

33.5 INTERIOR WOODWORK PREVIOUSLY PAINTED WITH A SOLVENT BASED COATING VARNISHED DOOR

33.5.1 Surface Preparation

33.5.1.1 Clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas back to the bare substrate must be “feathered” with sandpaper to smooth them off. Patch prime these areas with a suitable primer followed by Coat 2 before over-coating the whole area with the finishing coat. All glossy surfaces must be sanded to ensure good intercoat adhesion.

33.6 INTERIOR WOODWORK PREVIOUSLY PAINTED WITH A SOLVENT BASED COATING PAINTED DOORS

33.6.1 Surface Preparation

33.6.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be “feathered” with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas of bare substrate shall be patch primed using a suitable primer. Then patch these areas with Coat 2 before over-coating the whole area with the finishing coat.

33.6.1.2 When finishing coats are specified in bright colours such as reds, yellows, blues etc., or deep tint based, the undercoat should be tinted to a lighter shade of the finishing coat. If this is not done, two finishing coats might be required.

33.6.2 Holes and Cracks

33.6.2.1 Holes, cracks and unevenness in the timber should be filled with wood filler, smoothed off and lightly sandpapered before proceeding with the coating. Knots shall be coated with knotting compound.

33.7 INTERIOR MILD STEEL PREVIOUSLY PAINTED WITH A SOLVENT BASED COATING ALL STEELWORK

33.7.1 Surface Preparation

33.7.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be “feathered” with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas of bare substrate shall be patch primed using a suitable primer. Then patch these areas with Coat 2 before over-coating the whole area with the finishing coat.

33.7.1.2 When finishing coats are specified in bright colours such as reds, yellows, blues etc., or deep tint based, the undercoat should be tinted to a lighter shade of the finishing coat. If this is not done, two finishing coats might be required.

33.7.2 Corroded or Rusty

33.7.2.1 All corrosion products must be removed from the surface. Abrasive blast cleaning, wire brushing, chipping or sand papering to remove rust or mill scale, can achieve this. A bright metal condition must be achieved. In coastal areas, the prepared steel should be thoroughly rinsed with clean water to remove any salt deposits before priming.

33.7.3 Flaking and Peeling Paint

33.7.3.1 All paint exhibiting poor adhesion should be removed from the surface by scraping, the use of paint remover or other suitable means so that the paint remaining is firmly bonded to the surface.

33.7.4 Chalky or Powdery

33.7.4.1 If the paint is chalky, it should be sandpapered and cleaned to remove all traces of powderiness to ensure a firm base.

33.8 EXTERIOR COASTAL OR INLAND GALVANISED STEEL (EXCLUDING ROOF) PREVIOUSLY PAINTED WITH A SOLVENT BASED COATING GUTTERS & DOWNPIPES

33.8.1 Surface Preparation

33.8.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be “feathered” with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas of bare substrate shall be patch primed using a suitable primer. Then patch these areas with Coat 2 before over-coating the whole area with the finishing coat.

33.8.1.2 When finishing coats are specified in bright colours such as reds, yellows, blues etc., or deep tint based, the undercoat should be tinted to a lighter shade of the finishing coat. If this is not done, two finishing coats might be required.

33.8.2 Red Rust

33.8.2.1 This will take place where the galvanised surface has weathered away exposing the mild steel beneath. Such rusty areas should be sanded clean and primed with a suitable primer.

33.8.3 Flaking and Peeling

33.8.3.1 If severe flaking or peeling has taken place the failed coating must be completely removed. All bare galvanised steel must then be cleaned with Dulux or similar cleaner for new galvanised iron in accordance with the manufacturer’s instructions.

33.8.3.2 If peeling or flaking is only patchy, scrape back to a firm edge and then feather all edges. It should however be pointed out that in some areas, where the old paint appeared firm, flaking could reappear later. This is due to the greater contraction and expansion of the new paint causing the old paint to delaminate at weak points. Patch prime the bare areas with the coating system in order to build it up flush with the old paint surface. If necessary, lightly sand these areas before applying the final coat.

33.8.4 Chalky Surface

33.8.4.1 If the paint is chalky, it should be pressure hosed to remove all traces of powderiness. The surface must then be checked to ensure that it is chalk free.

33.9 EXTERIOR COASTAL OR INLAND MILD STEEL PREVIOUSLY PAINTED WITH A SOLVENT BASED COATING ALL STEELWORK

33.9.1 Surface Preparation

33.9.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be “feathered” with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas of bare substrate shall be patch primed using a suitable primer. Then patch these areas with Coat 2 before over-coating the whole area with the finishing coat.

33.9.1.2 When finishing coats are specified in bright colours such as reds, yellows, blues etc., or deep tint based, the undercoat should be tinted to a lighter shade of the finishing coat. If this is not done, two finishing coats might be required.

33.9.2 Corroded or Rusty

33.9.2.1 All corrosion products must be removed from the surface. Abrasive blast cleaning, wire brushing, chipping or sand papering to remove rust or mill scale, can achieve this. A bright metal condition must be achieved. In coastal areas, the prepared steel should be thoroughly rinsed with clean water to remove any salt deposits before priming.

33.9.2.2 If the area affected is extensive and the exposure conditions severe, advice should be sought from the paint manufacturer.

33.9.3 Flaking and Peeling Paint

33.9.3.1 All paint exhibiting poor adhesion should be removed from the surface by scraping, the use of paint remover or other suitable means so that the paint remaining is firmly bonded to the surface.

33.9.4 Chalky or Powdery

33.9.4.1 If the paint is chalky, it should be sandpapered and cleaned to remove all traces of powderiness to ensure a firm base.

33.10 EXTERIOR COASTAL OR INLAND WOODWORK PREVIOUSLY PAINTED WITH A SOLVENT BASED COATING VARNISHED DOORS, ETC

33.10.1 Surface Preparation

33.10.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be "feathered" with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow drying. Areas of bare substrate shall be patch primed using a suitable primer. Then patch these areas with Coat 2 before over-coating the whole area with the finishing coat.

33.10.2 Loose, Flaking Varnish

33.10.2.1 Scraping, sanding or the use of paint remover should remove all loose bonded varnish. If the timber beneath the varnish has discoloured and it is desired to make the surface colour even again, then total removal of all the existing varnish and sanding are essential. Once the surface preparation is complete, the surface may be re-varnished in the usual way.

33.10.3 Holes and Cracks

33.10.3.1 Holes, cracks and unevenness in the timber should be filled with wood filler, smoothed off and lightly sandpapered before proceeding with the coating. Knots shall be coated with knotting compound.

33.10.4 Timber Decay

33.10.4.1 Timber, which has started to rot cannot be successfully painted. For this reason, such areas must be replaced.

33.10.4.2 If the area concerned is large, the total replacement of the rotten section, with a new piece of timber, is essential.

33.10.4.3 If small areas have rotten, cutting out the rotten section and building up the timber using epoxy putty or wood filler can repair these. The timber can then be coated in the usual way.

33.11 EXTERIOR INLAND ONLY CEILING BOARDS PREVIOUSLY PAINTED WITH A WATER BASED COATING

33.11.1 Surface Preparation

33.11.1.1 All loose or defective paint must be removed. Edges of tightly bonded paint shall be "feathered" with sandpaper to smooth them off. After rectifying defects, clean thoroughly by washing the whole area with Fixit sugar soap solution and rinse off with clean water. Allow to dry. Areas of bare substrate shall be patch primed using a suitable primer. Then patch these areas with Coat 2 before over-coating the whole area with the finishing coat.

33.11.2 Paint Flaking, Peeling or Poor Adhesion

33.11.2.1 All loose paint must be scraped down to a sound substrate. Loose paint is defined as any paint that can be removed by firm hand pressure with a sharp paint scraper. If the paint is loose between coats and the lower layer of paint well bonded to the substrate, check this paint for compatibility to the new paint system. It should not be necessary to remove well-bonded layers of old paint. Edges of tightly bonded paint shall be “feathered” and unevenness filled flush and smooth.

33.11.2.2 If the original surface is weak and powdery, then it should be rectified by the procedures outlined for weak and powdery substrates.

33.11.3 Chalky or Powdery

33.11.3.1 Chalky surfaces can be caused by old and weathered paint, poor quality stopping or if the previous surface was lime wash or distemper. Loose paint must be removed.

33.11.3.2 The surface, in the case of lime wash or distemper should be scraped or wire brushed to remove as much of the material as practical. If the existing paint has merely weathered to a chalky finish but is otherwise in good condition, it should be scrubbed free of chalky material using Fixit sugar soap and water. Rinse thoroughly with clean water and allow drying. The entire surface should then be coated with a coat of Dulux or similar approved Durabond approved primer/sealer (bonding liquid) clear thinned 20% with Mineral Turpentine, and then painted in the normal way. It must be completely absorbed into the plaster and not leave glossy surface.

33.11.4 Dampness

33.11.4.1 Where dampness is occurring, the source of water ingress must be established and cured, before any surface preparation commences.

33.12 EXTERIOR COASTAL OR INLAND GALVANISED STEEL (EXCLUDING ROOF) – UNPAINTED SUBSTRATE

33.12.1 Surface Preparation

33.12.1.1 Clean the galvanised steel with Dulux or similar approved cleaner for new galvanised iron in accordance with the manufacturer’s instructions. Repeat the process until a waterbreak free surface is achieved.

33.12.1.2 When finishing coats are specified in bright colours such as reds, yellows, blues etc. or deep tint based two finishing coats are usually required.

33.12.2 Surface Preparation

33.12.2.1 Toll canopy fascias, ceiling: Choromadek Sheets.

33.12.2.2 Control Room Roof: Chromadek Sheets.

33.13 SURFACE PREPARATION

33.13.1 Wash with sugar soap, abrade with medium grit abrasive paper to remove excessive chalking to grade 6-8 of ASTM D650-44 and provide a key. Rinse thoroughly.

		DFT		
		Minimum	**Maximum**	**Mean**
Patch Primer	Corrocote (see note 1)	30	40	35
Intermediate Coat	Polyurethane	40	70	55
Finish Coat	Polyurethane	40	70	55

33.14 NOTES

33.14.1 Only where existing coating has been damaged down to substrate

33.14.2 Final colour to Engineer's requirements

33.14.3 Coverage and hiding power shall be checked with supplier

33.14.4 Apply in accordance with manufacturer's instructions

33.14.5 Sigmadur Gloss Ref. 7528 may be used as an alternative

33.14.6 This specification should be used in conjunction with the relevant product Data Bulletins and the General Preamble.

33.14.7 Order sufficient paint of the same batch number in order to prevent colour variations.

34. GENERAL MAINTENANCE

34.1 GENERAL MAINTENANCE

34.1.1 The Contractor shall carry out all maintenance work from the Commencement Date.

34.1.2 Routine Maintenance shall include, without limitation, the systematic inspection, cleaning, making of minor adjustments, lubricating, testing, measuring and recording, replacing of minor components or consumables and other similar measures necessary to prevent wear and/or to assure reliability of the Assets.

34.1.3 Corrective Maintenance shall include, without limitation, scheduled overhauls, replacement of worn or failed components, correction of problems found during Routine Maintenance of the Assets and any other similar procedures necessary to prolong economic life and/or assure reliability. This includes the subsequent repair or replacement of any components or major spares found to be defective during corrective maintenance of the Assets.

34.1.4 Breakdown Maintenance shall include, without limitation, the unscheduled restoration of Assets to a condition equal to original or design capacity in the event of a random Asset (including Equipment) fault and includes the subsequent repair or replacement of any components or major spares found to be defective during breakdown maintenance.

34.1.5 Should any asset need to be repaired or replaced during any of the above-mentioned types of maintenance, then the complete repair shall be carried out with 21 days.

34.2 DAY-TO-DAY MAINTENANCE

34.2.1 Maintenance of the following aspects shall be done by the Contractor on a daily basis.

34.2.2 The Contractor shall keep all -

34.2.2.1 buildings in a clean, litter-free, hygienic, safe and tidy condition, internally and externally. Without limitation, the Contractor shall ensure that, inter alia, all doors (hinges, handles and locking mechanisms) and windows (hinges, handles and locking mechanisms) toilets, showers, basins, urinals and geysers are maintained in Good Working Condition.

34.2.2.2 parking areas, paving and access roads in a clean, litter-free, hygienic, safe and tidy condition, free of weeds, vegetation and debris; and

34.2.3 The Contractor shall ensure that all drainage structures and channels are kept clean of debris and litter to ensure that they function properly and in the manner intended.

34.2.4 The Contractor shall ensure that all perimeter and security fencing and all access gates are maintained in good working order and condition.

34.2.5 The Contractor shall do all things necessary to ensure that the Assets are clean, tidy and generally in good working order and condition.

34.2.6 The Contractor shall maintain all paint work of all Assets in a good condition and shall treat and/or remove any flaking paint and/or rust from such structures. Painting shall be performed as specified in the Standard Specification for Operations and Maintenance: Electrical and Mechanical Equipment.

34.2.7 The Contractor shall maintain all structures, including all buildings, structures for parking areas, canopies and water towers in a safe condition.

34.2.8 The Contractor shall ensure that all rust be treated, water leaks repaired on occurrence, including leaking building roofs, and repairs effected of all joints and structural defects due to normal wear and tear forthwith upon their occurrence. The Contractor shall not be responsible for the repair of major structural failure, unless it is a result of the Contractors negligence.

34.3 ROUTINE MAINTENANCE, CORRECTIVE MAINTENANCE AND BREAKDOWN MAINTENANCE

34.3.1 The Contractor shall effect all maintenance including, without limitation, Routine, Corrective and Breakdown maintenance, and keep all Assets in Good Working Condition in a manner sufficient to ensure the performance of such Assets' intended functions for Operations and Maintenance in terms of this Agreement, meeting the specifications provided in this Agreement.

34.3.2 SANRAL or the Independent Engineer may at any time during the Works Period inspect and test any Asset.

34.3.3 Earthing tests: 6 (six) monthly inspection and test

34.3.3.1 The Contractor shall appoint a competent earthing specialist to perform 2 (two) earthing tests per annum of which 1 (one) shall be performed at the height of the dry season (June) and 1 (one) during the rainy season (December). SANRAL or the Independent Engineer may if he deems it necessary, instruct the Contractor to change the earthing specialist if found that the testing or the reports are not to standard. The Contractor will be informed of any shortcomings in the testing or reports to the Contractor to comply with the contract requirements. The Contractor shall provide SANRAL or the Independent Engineer with an "as built" drawing indicating the test points with the test values obtained at the earth node. Each earth node shall be numbered so that it can be referred back to a comprehensive test report. The comprehensive test report shall be updated with every earthing test and submitted to the Operational Manager every six months. The test reports and drawings shall be loaded onto the SCADA system when implemented. All historical reports shall be loaded onto the SCADA system.

34.3.3.2 The earthing nodes will be tested as indicated on the "as built" drawings with the values on the "as built" drawings taken as the base values. Any changes in the earthing values will be investigated and corrective action motivated by the Contractor.

34.3.3.3 The Contractor shall also include a soil resistivity test in their six monthly earthing reports. The final earthing report shall be approved by the Operation Manager with the option to add or change the report when required.

34.3.3.4 These reports shall be made available by the Contractor. All historical records shall be made available to the Next Contractor or Operational Contractor at the Completion Date.

34.3.4 Corrosion protection

34.3.4.1 The Contractor shall appoint a competent registered corrosion specialist to submit a comprehensive corrosion protection report to SANRAL or the Independent Engineer once every 3 (three) years.

34.3.4.2 The report shall discuss the corrosion status of the Manual/ORT Toll Plaza, (including water reservoir, fencing, building elements, poles and masts, structural steelwork, etc.) and contain recommendations regarding the paint systems required to protect the Assets.

34.3.5 Lighting

34.3.5.1 The Contractor shall replace all luminaire lamps (Building inside and outside, canopy, road and area lighting installation) as per the replacement intervals in the table under item 33.17.5.5. The lamp replacement shall include replacement of lenses and reflectors, and checking of seals, if necessary. All the lamps shall be replaced within 60 days after the commencement date for existing installations.

34.3.5.2 Where lighting levels are considered by SANRAL to be unsatisfactory, SANRAL shall instruct the Contractor to upgrade such lighting to the desired levels specified in the Standard Specification for Operations and Maintenance: Electrical and Mechanical Equipment (Volume 2 Book 3) or in the Project Document. This upgrade work shall be for the cost of SANRAL.

34.3.5.3 The Contractor shall maintain the lighting installation on a group lamp replacement maintenance system. Any other toll facility used shall also form part of the group lamp replacement maintenance system.

34.3.5.4 Lighting maintenance undertaken by the Contractor shall be done according to SANS ARP 035: 1993.

34.3.5.5 Group lamp replacement intervals shall not exceed the following:

Lamp type		Economic life	Replacement interval
70 W	High pressure sodium	12 000 hrs	40 months
150 W	High pressure sodium	16 000 hrs	40 months
250 W	High pressure sodium	16 000 hrs	40 months

Lamp type		Economic life	Replacement interval
400 W	High pressure sodium	16 000 hrs	40 months
125 W	Mercury vapour lamps	16 000 hrs	40 months
250 W	Mercury vapour lamps	16 000 hrs	40 months
400 W	Mercury vapour lamps	16 000 hrs	40 months
8-24 W	Compact Fluorescent lamps (CFLs)	15 000 hrs	24 months
35 W	Halogen lamps	5 000 hrs	12 months
58 W	Fluorescent 26 mm ø Cool white lamps	15 000 hrs	24 months
1-9W	Light Emitting Diode (LED)	25 000 hrs	96 months

34.3.5.6 All lamps at a toll plaza shall be replaced within 1 (one) working week. Replacement shall be done during daylight hours.

34.3.5.7 The Contractor shall provide the Operational Manager with a report on the group lamp replacement and indicate when the next replacement is due per lamp type.

34.3.6 Generator

34.3.6.1 The Contractor shall inspect and test run the generator (mains failure) for a minimum of 30 (thirty) minutes, on a weekly basis for the duration of this Agreement to identify any defects. All defects shall be noted in a logbook and SCADA system report and reported to SANRAL or the Independent Engineer timeously.

34.3.6.2 The Generator shall be serviced every six months and a report stored on the SCADA or any other electronic approved maintenance file system. See pro-forma report under item 17.32.

34.3.6.3 The generator oil and fuel shall be tested with the generator six monthly services and the test results stored on the SCADA or any other approved electronic maintenance file system.

34.3.6.4 The Contractor shall attend to any problem reported during the service inspection.

34.3.6.5 All alarm conditions shall be tested and verified on the SCADA or other approved electronic database.

34.3.6.6 Copies of all the maintenance and test reports with findings shall be sent to SANRAL or the Independent Engineer.

34.3.7 UPS

34.3.7.1 The Contractor shall visit the UPS room to verify that the UPS and electronic equipment are functioning according to specification during the test run of the generator. The visit shall be recorded in the UPS logbook with any comments.

34.3.7.2 The UPS shall be serviced on a bi-monthly basis and the report stored on the SCADA or any other electronic approved maintenance file system. See pro-forma report under item 16.8.

34.3.7.3 The Contractor shall perform a load test every time the UPS is serviced. Use the pro-forma under item 16.8 as a guideline on the information to be submitted. The information shall be loaded onto the SCADA or approved maintenance file system.

34.3.8 Inspection by the Operations Manager

34.3.8.1 The Operations Manager may and the Operator shall allow him, accompanied by the Responsible Person at the Toll Plaza, to perform ad hoc inspections, during which a qualitative assessment of the standard of general Maintenance shall be done by the Operations Manager. The Operations Manager shall determine whether the standard of general Maintenance is substandard, acceptable or above standard. Such qualitative assessment shall be reasonable.

34.3.8.2 The Operations Manager shall provide the Responsible Person with a written notice of not less than 1 (one) hour prior to such Responsible Person's required presence at these ad hoc inspections.

34.3.8.3 The Operations Manager shall submit to the Operator the findings and results of his inspection in writing within 2 (two) days after the end of the month during which such inspection was carried out.

34.3.8.4 An example of a typical checklist and scoring system that the Operations Manager shall utilise in ascertaining whether the Operator has complied with its obligations relating to General Maintenance is contained in the Project Document (Volume 3). The Operations Manager may if he deems it necessary, in his sole

34.4 REPORTING ON EQUIPMENT

34.4.1 Electrical and Mechanical Equipment

34.4.2 General Electrical Installation report

34.4.2.1 The Operator shall submit a comprehensive electrical and mechanical status report on the general electrical installation to the Operations Manager once every two years after the Commencement date and every 2 (two) years thereafter.

34.4.2.2 The report shall contain the following minimum results/information:

(a) Condition of the distribution boards i.e. rust, dust, locks, etc..

(b) Condition and function of all switch gear, wiring, earth leakage units, etc.

(c) Condition of all labelling. Replace poor labelling, update legend cards, update wiring diagrams, etc

(d) Special attention to check for loose connections (hot connections).

(e) Infrared image of each distribution board, including meter kiosk.

(f) Special attention to any modification to current ECOC. Operator to update the ECOC status with any changes. Copy of the new or additional ECOC to be provided with the report. The Operator shall request the Accredited Inspection Authorities (AIA) or the Association of Accredited Electrical Inspection Bodies of South Africa (AAEIASA) where required by the OM.

34.4.3 Generator: 6-monthly report

34.4.3.1 The Operator shall submit a comprehensive electrical and mechanical status report on the standby diesel generator to the Operations Manager 6 months after the Commencement date and every 6 (six) months thereafter.

34.4.3.2 The report shall contain the following minimum results/information:

(a) Generator status

(b) Generator room condition

(c) Generator test results

(d) Oil sample test results by an approved lubrication analyst laboratory.

(e) Diesel fuel sample test results by an approved lubrication analyst laboratory.

(f) Availability of spares and the supplier's details.

(g) Dummy load test.

(h) A copy of the Generator lock book for the period of the report.

34.4.3.3 The Operator shall change or add information to the generator report if instructed by the Operational Manager. The Operator shall provide a comprehensive generator report per generator should more that one generator be installed or be on standby.

34.4.3.4 A typical pro-forma generator inspection and testing report sheet to form the basis of the Operators report is provide under item 17.32 in the Standard Specification for Operations and Maintenance: Electrical and Mechanical Equipment Volume 2 Book 3.

34.4.4 UPS: 2-monthly report

34.4.4.1 The Operator shall submit a comprehensive status report on the UPS to the Operations Manager 2 months after the Commencement date and every 2 (two) months thereafter.

34.4.4.2 The report shall contain the following minimum results/information:

(a) The UPS status i.e. all available voltages frequencies, currents and alarm conditions. Any data recoded by the UPS to be included in the UPS report. The Operator to obtain the required communication device from the manufacturer to extract data if required at their own cost.

(b) The condition of the UPS room i.e. cleanliness of the room, room temperature, etc.

(c) UPS load test. The load test will be done over a period of 30min with readings every 5 minutes. The results shall be plotted on a graph to estimate the total battery standby time.

(d) The Operator shall also execute an impedance test on each battery and report the value.

(e) A copy of the UPS log book for the period of the report.

34.4.4.3 The operator shall change or add information to the UPS report if instructed by the Operational Manager.

34.4.4.4 A typical pro-forma UPS inspection and testing report sheet to form the basis of the Operators report is provide under item 16.8 in the Standard Specification for Operations and Maintenance: Electrical and Mechanical Equipment Volume 2 Book 3.

34.4.5 Earthing and lightning protection status report

34.4.5.1 The Operator shall submit a comprehensive earthing and lighting report to the Operations Manager 6 months after the commencement date and every 6 (six) months thereafter.

34.4.5.2 The earthing and lightning protection inspection shall be executed during the following months:

Wet Season	**Dry Season**
February	July

34.4.5.3 The report shall contain the following minimum results/information:

(a) As-built based drawing indicating the test points with the test values obtained at the earth node.

(b) Each earth node on the drawing shall be numbered that can be referred back to a comprehensive test report.

(c) A comprehensive test report that shall be updated with every earthing test and submitted to the Operational Manager every six months

(d) The earthing nodes shall be tested as indicated on the as-built drawings with the base values on the as-built drawings as reference. Any changes in the earthing values will be investigated and corrective action motivated by the Operator with reference to the SANS regulation

(e) The comprehensive test report shall also include a soil resistively test taken on the day of the earthing test.

(f) The final earthing report to be approved by the Operational Manager with the option to add or change the report when required.

(g) All surge arrestors shall be inspected and the status reported.

34.4.5.4 The operator shall change or add information to the earthing and lightning report if instructed by the Operational Manager

34.4.6 Corrosion protection report

34.4.6.1 The Operator shall submit a comprehensive corrosion protection report compiled by a competent registered corrosion specialist to the Operations Manager once every 3 (three) years. The report shall discuss the corrosion status of the Toll Plaza, (e.g. water reservoir, fencing, building elements, poles and masts, structural steelwork, etc) and contain recommendations regarding the paint systems required to protect the Assets. The first report shall be submitted within 3 months of the contract commencement date.

34.4.6.2 The Operator shall also provide a program to attend to the corrosion problems identified in the corrosion report.

34.4.7 Handyman report

34.4.7.1 The Operator shall submit a comprehensive handyman report compiled by a competent person to the Operations Manager on a monthly basis. The report shall list all damaged are failed equipment i.e. taps doors, windows locks, paint, cracks, etc.

34.4.7.2 The Operator shall also provide corrective action and an estimated completion date with a program if necessary or as requested by the Operational Manager.

34.4.8 Heating Ventilation and Air Conditioning report

34.4.8.1 The Operator shall submit a comprehensive Hearting Ventilation and Air Conditioner (HVAC) report compiled by a competent person to the Operations Manager on a monthly basis. The report shall discuss the status of the HVAC equipment and maintenance.

34.4.8.2 The Operator shall also provide corrective action and an estimated program on the repairs to the Operational Manager on problems identified in the HVAC report.

34.4.9 Equipment failure report

34.4.9.1 The Operator shall submit an equipment failure/damage report on a monthly basis as approved by the operations Manager. The report shall cover all the equipment failures/damages that were notified during the month to the Operational Manager as and when the failure/damage occurred.

34.4.9.2 The Operator shall also provide corrective action and an estimated program on the repairs to the Operational Manager.

34.4.10 SCADA, security and access control report

34.4.10.1 The Operator shall submit a comprehensive SCADA, security and access control report compiled by the SCADA system to the Operations Manager on a monthly basis. The report shall discuss the alarms, events, status of the SCADA, security and access control system with action taken to restore any problem or alarm condition. .

34.4.10.2 The Operator shall also provide a program to attend to problems identified in the security and access control report.

34.4.11 SCADA system

34.4.11.1 The Operator shall maintain any SCADA equipment installed in an adequate way to ensure reliability and the life expectancy is not compromise.

34.4.11.2 The Operator shall maintain the SCADA system to limit the down time and data loss at all times to protect the fixed or semi-fixed assets under the systems control.

34.4.11.3 The Operator shall provide a comprehensive report on the SCADA and fixed or semi-fixed assets controlled by the SCADA system to the approval of the Operations Manager. The report to provide details of all the controlled fixed or semi-fixed assets and there status.

34.4.11.4 Any problems shall be reported and details provided on the repairs to be undertaken.

34.4.11.5 The SCADA system shall automatically E-mail monthly status reports to the OM in an electronic file format.

34.4.12 Security system

34.4.12.1 The Operator shall maintain any security equipment installed in an adequate way to ensure reliability and the life expectancy is not compromise. The Operator shall improve or compliment the existing security system should it be required at their cost.

34.4.12.2 The Operator shall train their personnel to use and keep the environment secure at all times for their safety and to protect the loss of equipment.

34.4.12.3 The Operator shall provide a comprehensive report on the security installation to the approval of the Operations Manager. The report to provide details of all the security equipment and there status. Any problems shall be reported and details provided on the repairs to be undertaken.

34.4.12.4 The security system shall be link to the SCADA system to store and report all the alarms and events.

34.4.13 Access control system

34.4.13.1 The Operator shall be responsible for maintaining any access control system installed that might be in place and ensure the system records all access to the toll facility as all times.

34.4.13.2 The access control system will have a data base capturing the date and time an authorised person enters or exit the toll facility. Additional technology may form part of the access control i.e. CCTV, finger print reader, etc.

34.4.13.3 The Operator shall be responsible for maintaining (and upgrading where necessary) all facilities for Site security, including fencing, intercom systems, access control systems, alarm systems, etc.

34.4.13.4 The access control system shall be link to the SCADA system to store and report all the alarms and events.

35. GENERAL MAINTENANCE SCORING SYSTEM

35.1 GENERAL MAINTENANCE SCORING SYSTEM

The Employer Representative shall have a scoring system based on the General Maintenance check list to ascertain whether the Contractor has complied with its obligations relating to the General checklist provided in Volume 4 Book 1.

The Employer Representative shall allocate a score between 1 and 10 for each item per lane or facility on the General Maitnenance check list. The table below explains the scoring system:

Above standard	10	100	The Contractor has maintained, repaired or replaced assets to a level above the required standard (i.e. no dust, very clean assets, etc.)
	9	90	
	8	80	
	7	70	
	6	60	
Acceptable	5	50	The Contractor has maintained, repaired or replaced assets to an acceptable condition (i.e. assets are clean and still functional, etc.)
	4	40	
	3	30	
	2	20	
Substandard	1	10	The Contractor has not maintained, repaired or replaced assets to an acceptable level (i.e. assets not clean, rusting, loose, etc).

36. GLOSSARY OF TERMS

36.1 GLOSSARY OF TERMS

36.1.1 The glossary of terms for this Standard Specification for Electrical and Mechanical Equipment (Volume 2 Book 3) to be read in conjunction with the Glossary of Terms as defined in the Project Specification (Volume 2 Book 1a).

36.1.2 The terms listed in this Glossary of Terms are for ease of reference only and are not intended to be legally binding. Such terms are intended to aid the reader in understanding technical terms commonly used in the construction and engineering industry and/or in this Standard Specification for Electrical and Mechanical Euipment and must be read to include Good Industry Practice.

36.1.3 Unless inconsistent with the context, terms used in this Standard Specification for Electrical and Mechanical Euipment and not otherwise defined or listed herein, shall have the meaning ascribed thereto in the Project Specifications Volume 2 Book 1b.

36.1.4 Should there be any conflict between terms defined in the Project Specifications Volume 2 Book 1b and terms defined in this Standard Specification for Electrical and Mechanical Equipment, the terms defined in the Project Specificaitons Volume 2 Book 1b shall prevail.

36.1.5 Unless otherwise expressly stated, or the context otherwise requires, the words and expressions listed below shall, when used in this Standard Specification for Electrical and Mechanical Equipment, bear the meanings ascribed to them below.

AC	Alternating Current (AC) is electric current that alternates between a positive maximum value and a negative maximum value at a characteristic frequency, usually 50 cycles per second (Hertz).
Active Power	Active power is the real power (kW) supplied by the generator set to the electrical load. Active power creates a load on the generator set's engine and is limited by the horsepower of the engine. Active power does the work of heating, turning motor shafts, etc.
Air Circuit Breaker	An air circuit breaker automatically interrupts the current flowing through it when the current exceeds the trip rating of the breaker. Air is the medium of electrical insulation between electrically live parts and grounded (earthed) metal parts.
Alternator	Alternator is another term for AC generator.
Ampere	The ampere is a unit of electric current flow. One ampere of current will flow when a potential of one volt is applied

	across a resistance of one ohm.
Ampere-hour (Ah)	A figure indicating battery capacity, generally defined for 5, 10 or 20 hours discharge time. The Ah figure should be divided by the discharge time to get the maximal discharge current. The Ah capacity is a function of discharge time, decreasing at short backup times. Thus, a 20 h rated 10 Ah battery may supply only 3.5 Ah for 15 minutes or 2.5 Ah for 5 minutes. Battery capacity also depends on temperature, ageing, number and depth of discharge cycles, and preventive maintenance.
Acoustic Material	Acoustic material is any material considered in terms of its acoustic properties, especially its properties of absorbing or deadening sound. AP (Access Point)
A Wireless Access Point (WAP)	A wireless access point (WAP or AP) is a device that "connects" wireless communication devices together to create a wireless network. The WAP is usually connected to a wired network, and can relay data between devices on each side.
Apparent Power	Apparent power is the product of current and voltage, expressed as kVA. It is real power (kW) divided by the power factor (PF).
Armature	The armature of an AC generator is the assembly of windings and metal core laminations in which the output voltage is induced. It is the stationary part (stator) in a revolving-field generator.
Audible Alarm	An audible signal enunciated upon mains outage or UPS failure or warning. Intermittent tone signals may indicate various announcements. An alarm silence button disables the audible signal. Audible noise: Noise emitted by the UPS generally measured in dBA units, at a distance of 1 or 1.5 m from the UPS. Most UPS systems are less than 55 dBA, which is relatively quiet. High power systems (above 60 kVA) may present a noise figure of about 65 dBA, which is the level of main road high traffic environment.
Authentication	Authentication is the process of verifying an identity claimed by or for a system entity. Also, any security measure designed to establish the validity of a transmission, message, or originator, or a means of verifying an individual's eligibility to receive specific categories of

	information [http://www.its.bldrdoc.gov/fs-1037/]. As perceived by a computer user, authentication is generally associated with a password and/or token(s) entered into a host system for the purpose of gaining access to computer application(s). As examples of user authentication to a host computer, the authentication mechanism might be a password or string of characters provided by the user at a prompt (something you know), and/or a token (something you have), and/or a fingerprint (something you are).
Authorization	Authorization is a right or a permission that is granted to a system entity to access a system resource.
Automatic (Exciter) Paralleling	Automatic (Exciter) Paralleling describes a system where two or more generator sets can be started and paralleled while coming up to rated frequency and voltage. Because the generator excitation system is not turned on until the generator set is started (thus the term "dead field"), the generator sets automatically synchronize as they come to rated speed and voltage.
Automatic Battery test	A preventive test and alarm aimed at revealing weak or damaged batteries. The test is generally performed at user-selectable programmed intervals.
Automatic Mains Failure panel (AMF)	Shall mean a microprocessor controller with modbus Ethernet, RS232, RS 485, etc. communication to a remote SCADA or other approved data acquisition system that control the generator and change-over.
Automatic Restart	A function that enables, upon Mains Power restoration, an Automatic Restart of a UPS that was turned off, due to discharged batteries, during the Power outage.
Automatic Retransfer	An Automatic transfer from Bypass to Inverter in an On-Line system. For Conditions: see Retransfer.
AVR (Automatic Voltage Regulator)	An electronic circuit that regulates output voltage in order to keep it within allowed limits.
Backup Protection	Backup protection consists of protective devices, which are intended to operate only after other protective devices have failed to operate or detect a fault.
Balanced Load	Equal loading on each phase at the output of a three-phase UPS.

Bandwidth	The amount of data that can be transmitted in a fixed amount of time. For digital devices, it is expressed as bits per second, or bytes per second. For analog devices, it is usually expressed as cycles per second, or Hertz.
Base Load	Base load is that portion of a building load demand which demand that is constant. It is the "base" of the building demand curve.
Battery Charger	Functional UPS module that converts the utility mains AC voltage to DC voltage for charging batteries, in order to restore the charge that was withdrawn during mains outage. Generally, the system's Rectifier fulfils also the charging function.
Battery end Voltage	The lowest battery voltage for system operation. Generally, the UPS will shut down when battery voltage drops to end voltage set point. Certain systems adjust this set point automatically according to the actual discharge current. Typical end voltage rating is 1.75 V/cell, or 10.5 V for a 12V battery.
Baud Rate	The speed of data transmission in serial data communications approximately equal to the number of code elements (bits) per second (BPS). Bits per second are also termed BPS, with the prefix (k) denoting thousands.
Circuit	A circuit is a path for an electric current across a potential (voltage).
Circuit Breaker	A circuit breaker is a protective device that automatically interrupts the current flowing through it when that current exceeds a certain value for a specified period of time. See Air Circuit Breaker, Main Breaker, Moulded Case Circuit Breaker and Power Circuit Breaker.
Client	A Client is any computer whose identification and authorization privileges for network connection are hosted by a server. An HMI interface (e.g., at operator desks in a Control Room) is an example of a client computer configuration.
Cold Standby operation	A sleep or idle mode operation of the UPS (generally normal mode in Off-Line systems), aimed at decreasing power consumption. The UPS starts operating in case of power failure or upon receiving an external command and will be

	able to support load after the turn-on interval.
Contactor	A contactor is a device for opening and closing an electric power circuit.
Control System	An interconnection of components (computers, sensors, actuators, communication pathways, etc.) connected or related in such a manner as to command, direct, or regulate itself or another system (e.g., chemical process plant equipment/system, oil refinery equipment/systems, electric generation/distribution equipment/systems, water/waste water systems, manufacturing control systems, etc.).
Current Limiting Fuse	A current limiting fuse is a fast-acting device that, when interrupting currents in its current-limiting range, will substantially reduce the magnitude of current, typically within one-half cycle, that would otherwise flow.
Database Server	A server hosting a database system (usually an RDBMS) typically used as a historian and/or business link to the process control environment.
DNP3 (Distributed Network Protocol)	DNP3 is an open, standards-based communication protocol commonly used in the utility industry. DNP3 provides multiplexing, data fragmentation, error checking, link control, prioritisation, and layer 2 addressing services for user data.
Distribution Switchgear	Distribution switchgear may include automatic transfer switches, draw out air frame circuit breakers, fusible switches, or moulded case breakers. Double Conversion
Topology of On-Line UPS (VFI class per IEC 62040-3).	The AC mains voltage is converted to DC by means of an AC to DC Rectifier (or Charger). The DC voltage is then converted to conditioned AC by means of the Inverter.
DSL	Digital Subscriber Line (also, ADSL, RDSL) is the typical technology used for delivering broadband communications over copper circuits. Widely used for home and small office broadband connection.
Earth	An earth is a connection, either intentional or accidental, between an electrical circuit and the earth or some conducting body serving in place of the earth.
Earth fault - UPS	Leakage or short circuit to ground (Chassis) from isolated battery, isolated input or output power lines, including Neutral. Some standards require activation of an earth fault

	alarm if the earth fault current exceeds a rated value.
Earth Fault Protection	A grounding bar is a copper bar that electrically joins all the metal sections of the switchgear. This bar is connected to the earth or ground connection when the system is installed. The grounding or earthing protects personnel from stray currents that could leak to the metallic enclosures.
Earth Fault Protection	This function trips (opens) a circuit breaker or sounds an alarm in the event that there is an electrical fault between one or more of the phase conductors and earth. This earth fault protection function may be incorporated into a circuit breaker.
Earth Return	Earth return is a method of earth fault detection that employs a single sensor (CT) encircling the main bonding jumper between the power system neutral and earth. This device in itself is not capable of locating the faulted circuit but when used in conjunction with earth fault sensors on all feeders and source connections, can provide bus fault protection when properly coordinated (delayed).
Earthed Neutral	A earthed neutral is the intentionally grounded centre point of a Y-connected, four-wire generator, or the mid-winding point of a single phase generator.
Effective value	Effective voltage or current. See RMS.
Efficiency (EFF)	Efficiency is the ratio of energy output to energy input, such as the ratio between the electrical energy input to a motor and the mechanical energy output at the shaft of the motor.
Efficiency	UPS efficiency is defined as AC output Watts divided by AC Input Watts. The full load efficiency of a Standby or Line Interactive UPS is generally within 95% to 98%, and within 90% to 95% for an Online Dual conversion system. For AC to DC (Output Watts to DC bus) efficiency see Inverter Efficiency.
Electrical Operator	An electrical operator is the electric motor driven closing and tripping (opening) devices that permits remote control of a circuit breaker.
Emergency System	An emergency system is independent power generation equipment that is legally required to feed equipment or systems whose failure may present a life safety hazard to

	persons or property.
EMI (Electro Magnetic Interference)	Electromagnetic disturbance, generated mainly by switching circuits and devices, that interrupt, obstruct or degrade the limits of performance of electric equipment.
Encryption	In cryptography, encryption is the process of obscuring information to make it unreadable without special knowledge.
Energy	Energy is manifested in forms such as electricity, heat, light and the capacity to do work. It is convertible from one form to another, such as in a generator set, which converts rotating mechanical energy into electrical energy. Typical units of energy are kW/h, Btu (British thermal unit), Hp/h, ft/lbf, joule and calorie.
Ethernet	Ethernet is a frame-based computer networking technology for local area networks (LANs). It defines wiring and signalling for the physical layer, and frame formats and protocols for the media access control (MAC)/data link layer of the OSI model. Ethernet is mostly standardized as IEEE 802.3.
Exciter	An exciter is a device that supplies direct current (DC) to the field coils of a synchronous generator, producing the magnetic flux required for inducing output voltage in the armature coils (stator). See Field.
Exciter Paralleling Control	An exciter paralleling control initiates the start of generator excitation in generator sets used in automatic paralleling systems.
Fault	A fault is any unintended flow of current outside its intended circuit path in an electrical system.
FIELDBUS	Field bus control system is a form of decentralized control which links PLCs via a Controller Area Network (CAN) to control the manufacturing processes at the workshop floor level. Such systems include Profibus, Netbus, LonWorks, Industrial Ethernet and many others.
Firewall	Firewall is hardware and/or software which functions in a networked environment to prevent some communications forbidden by the security policy. It has the basic task of controlling traffic between different zones of trust. Typical

	zones of trust include the Internet (a zone with no trust) and an internal network (a zone with higher trust).
Float Charging	Constant voltage charging method. See also Float voltage.
Float Current	Current drawn by a charged battery in float charging regime.
Float Voltage	DC Voltage applied to the battery by the charger (or rectifier) in constant voltage charging regime. The float voltage value at 25 degrees Celsius is generally 2.3 V/cell for a Lead-Acid battery and 1.42 V/cell for a Nickel-Cadmium battery. To extend battery life, the float voltage should be adjusted (compensated) with temperature according to the battery manufacturer's recommendation.
FTP (File Transfer Protocol)	The File Transfer Protocol is a software standard for transferring computer files between machines. It belongs to the application layer of the TCP/IP protocol suite. Since FTP is non-secure, it is being replaced by sftp - Secure File Transfer Protocol.
Grounded Neutral	A grounded neutral is the intentionally grounded center point of a Y-connected, four-wire generator, or the mid-winding point of a single phase generator. Gateway
Gateway	Gateway in a communications network is a network node equipped for interfacing with another network that uses different protocols.
Generator	A generator is a machine which converts rotating mechanical energy into electrical energy.
Governor	A governor is a device on the engine which controls fuel to maintain a constant engine speed under various load conditions. The governor must have provision for adjusting speed (generator frequency) and speed droop (no load to full load).
GPRS	GPRS is the General Packet Radio Service standard for digital overlay on the GSM digital cellular system. It allows high speed digital and IP connections to be established using existing GSM voice infrastructure and is generally used to provide IP connectivity to RTUs.
Graceful Shut Down	Software function that shuts down computers fed by the UPS, after mains outage, a few minutes before it turns off

	due to battery discharge. Graceful shut down resembles manual computer turn off, no data are lost and the computer reboots.
GSM	GSM is Global System for Mobile communications. It is the most common digital cellular system. GSM can be used for both voice and data applications. It is also used to provide serial communications to RTUs.
Harmonic Distortion (Total Harmonic Distortion)	The total harmonic distortion, or THD, of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.
Harmonics	Harmonics are voltage or current components which operate at integral multiples of the fundamental frequency of a power system (50 or 60 Hertz). Harmonic currents have the effect of distorting the shape of the voltage wave form waveform from that of a pure sine wave.
HMI (Human-Machine Interface)	A term that refers to the "layer" that separates a human that is operating a machine from the machine itself. One example of an HMI is the computer hardware and software that enable a single operator to monitor and control large machinery remotely.
IEC	International Electro technical Commission is a European standards body that developed the IEC60870-5 series of SCADA protocols. IEC is now working on IEC-62351, a secure protocol envelope for DNP3 and IEC60870-5.
IED (Intelligent Electronic Device)	A device on the network that contains an embedded system (an embedded system is a special-purpose computer system, which is completely encapsulated by the device it controls).
IGBT (Insulated Gate Bipolar Transistor)	A transistor which combines FET input and bipolar Transistor output, forming a switching device requiring very low drive power with high blocking voltage, and low conduction losses. IGBT is the most popular power-switching element in UPS inverters.
Input current distortion	The distortion of the AC input current due to harmonics. The distortion is expressed as the input current THD figure measured at the AC input of the UPS. Some standards limit the maximum allowed input current distortion. Most systems

	today limit THD to less than 10%.
Input voltage distortion	The distortion of the AC input voltage due to harmonics. The distortion is expressed as the input voltage THD figure measured at the AC input of the UPS.
Inrush current	The initial current at the input of the UPS upon turn on (see Rectifier walk-in). Also the initial current a consumer draws from the UPS upon turning on the consumer. The inrush current is generally caused by charging of DC filter capacitors, or because of sub-cycle magnetizing current of a transformer, located in the turned on equipment.
Insulation	Insulation is non-conductive material used to prevent leakage of electric current from a conductor. There are several classes of insulation in use for generator construction, each recognized for a maximum continuous-duty temperature.
Interharmonics	Waveforms with frequencies that are not integers of the fundamental source frequency.
Internal Battery	A battery located inside the UPS cabinet.
Interoperability	Design to allow one product to work with another product without modification.
Inverter Efficiency	Also called AC to DC efficiency: AC Output Watts divided by Inverter Input Watts, when load is connected to Inverter output. (Inverter input watts equals DC buss voltage multiplied by the current drawn by the Inverter). Inverter efficiency is used for calculating battery capacity. Ratings vary from 80% at low DC voltages to 95% at high DC buss voltages.
Inverter	Functional UPS module that inverts the DC battery voltage to 50Hz AC voltage.
IP (Internet Protocol)	A data-oriented protocol used by source and destination hosts for communicating data across a packet-switched internetwork. Data in an IP internetwork are sent in blocks referred to as packets or datagrams (the terms are basically synonymous in IP).
Isolation transformer	A transformer connected at the input of the UPS to isolate the battery from the utility grid, or at the output of a UPS to

	isolate the load from the utility grid.
Isolation	Generally refers to the allowed maximum kV (kilo-Volts) between input and ground, output and ground and input to output in UPS systems with isolation transformer.
kVA (kilo-Volt-Amperes)	kVA is a term for rating electrical devices. A device's kVA rating is equal to its rated output in amperes multiplied by its rated operating voltage. In the case of three-phase generator sets, kVA is the kW output rating divided by 0.8, the rated power factor. kVA is the vector sum of the active power (kW) and the reactive power (kVAR) flowing in a circuit.
kVAR	kVAR (kilo-Volt-Amperes Reactive) is the product of the voltage and the amperage required to excite inductive circuits. It is associated with the reactive power which that flows between paralleled generator windings and between generators and load windings that supply the magnetizing currents necessary in the operation of transformers, motors and other electromagnetic loads. Reactive power does not load the generator set's engine but does limit the generator thermally.
kW	This is an abbreviation for kilowatt, an alternate term for rating electrical devices. Generator sets in the United States are usually rated in kW. Sometimes called active power, kW loads the generator set engine.
kW-h(kilo-Watt-hour)	This is a unit of electric energy. It is equivalent to one kW of electric power supplied for one hour.
Lagging Power Factor	Lagging power factor in AC circuits (a power factor of less than 1.0) is caused by inductive loads, such as motors and transformers, which cause the current to lag behind the voltage. See Power Factor.
Lagging Power Factor	Power factor of an Inductive type circuit, in which the current lags behind the source voltage (negative cos phi)
LAN (Local Area Network)	A LAN is a computer network that spans a relatively small area. Most LANs are confined to a single building or group of buildings (campus).
Lead Acid Battery	A rechargeable battery common in UPS systems, it is composed of lead plates suspended in electrolyte solution of

	sulphuric acid and water.
Leading Power Factor	Leading power factor in AC circuits (0.0 to -1.0) is caused by capacitive loads or overexcited synchronous motors which cause the current to lead the voltage. See Power Factor.
Leading Power factor	Power factor of a capacitive type circuit, in which the current leads the voltage (positive cos phi).
Line Interactive UPS	A system which energizes the load from the utility mains providing conditioned power by filtering and stabilizing mains voltage (VI class per IEC 62040-3). Upon mains outage, the load is energized from batteries via the Inverter.
Linear Load	Load comprised of linear (non switching) components such as resistors, lamps, capacitors, inductors, motors, transformers, etc.
Line-To-Line Voltage	Line-to-line voltage is the voltage between any two phases of an AC generator.
Line-To-Neutral Voltage	In a 3-phase, 4-wire, Y-connected generator, line-to-neutral voltage is the voltage between a phase and the common neutral where the three phases are tied together.
Load Demand	Load Demand is a paralleling system operating mode in which the system monitors the total kW output of the generator sets, and controls the number of operating sets as a function of the total load on the system. The purpose of load demand controls is to reduce fuel consumption and limit problems caused by light load operation of reciprocating diesel generator sets.
Load Factor	The load factor is the ratio of the average load to the generator set power rating.
Main Breaker	A main breaker is a circuit breaker at the input or output of the bus, through which all of the bus power must flow. The generator main breaker is the device, usually mounted on the generator set, that interrupts the genset generator set's power output. Main breakers provide overcurrent protection and a single disconnect point for all power in a switchboard or device.
Mains	Mains is a term used extensively outside of the United States to describe the normal power service (utility).

Malware	Malware is malicious software designed to infiltrate or damage a computer system, without the owner's consent. Malware is commonly taken to include computer viruses, worms, Trojan horses, root kits, spyware and adware.
Modbus	A communication protocol which enables monitoring and control of distributed devices in a network from a master supervisory computer.
MODEM	A modem is a device that modulates an analogue carrier signal (sound), to encode digital information, and that also demodulates such a carrier signal to decode the transmitted information.
Modules	Modules are also called nodes or devices. These are devices such as Genset Generator set Communication Modules (GCMs), Control Communication Modules (CCMs), and Digital Input/Output Modules (DIMs).
Moulded Case Circuit Breaker	A moulded case circuit breaker automatically interrupts the current flowing through it when the current exceeds the trip rating of the breaker. Moulded case refers to the use of moulded plastic as the medium of electrical insulation for enclosing the mechanisms, and for separating conducting surfaces from one another and from grounded (earthed) metal parts. Moulded case circuit breakers usually contain thermal-magnetic trip units, although larger sizes can be equipped with solid state trip sensors.
Neutral	Neutral refers to the common point of a Y-connected AC generator, a conductor connected to that point or to the mid-winding point of a single-phase AC generator.
Neutral Current	Neutral current is the current that flows in the neutral leg of a paralleling system. Often, this term is used in reference to circulating currents or cross currents.
Node	A module that can communicate over the network data to other modules. A module contains a Neuron Chip. Certain devices are nodes such as Genset Generator set Communication Modules (GCMs) and Control Communication Modules (CCMs). Other devices are not nodes, as they cannot communicate with other devices, but only receive messages. An example is the Network Annunciator Module (NAM).

Non-Linear Load	Load comprised of switching components, such as diodes, rectifiers, Thyristors, Switching or Pulse modulating systems or circuits. Non-linear loads generate current and voltage harmonics with integral multiple frequencies of fundamental source frequency. A nonlinear load is a load for which the relationship between voltage and current is not a linear function. Some common nonlinear loads are fluorescent lighting, SCR motor starters and UPS systems. Nonlinear loads cause abnormal conductor heating and voltage distortion.
Normal UPS Operation:	Operational state is termed Normal when Utility Power is available and within ratings, the battery is charged, the load is within rating and it is fed from the preferred (default) source (Mains Power if Stand-By, Inverter if On-Line system).
OFF-LINE UPS (Passive Standby)	A system that normally energizes the load directly from the utility mains (see VFD classification by IEC 62040-3). It contains a charger and an Off-Line Inverter. The Inverter is switched ON upon mains outage to supply the load.
Ohm	The ohm is a unit of electrical resistance. One volt will cause a current of one ampere to flow through a resistance of one ohm.
ON-LINE UPS (True on line)	A double conversion system, which energizes the load continuously from the inverter (see IEC 62040-3, VFI Classification). The inverter is fed from mains via a rectifier in normal operation, or from batteries upon mains outage.
OPC (Open Connectivity via Open Standards)	OPC is open connectivity in industrial automation and the enterprise systems that support industry. Interoperability is assured through the creation and maintenance of open standards specifications. OPC has been termed “OLE for Process Control”.
Out-Of-Phase	Out-Of-Phase refers to alternating currents or voltages of the same frequency which are not passing through their zero points at the same time.
Output current limit	The maximum current the Inverter is able to supply at rated voltage.
Output harmonics	The Harmonics at the output voltage of the UPS. These Harmonics are expressed as the output voltage THDV

	figure.
Output regulation	The deviation of output voltage from its nominal rating, due to changes in other parameters, like load, battery voltage, ambient temperature, mains voltage, within their allowed and rated limits.
Output Waveform	Generally, the output waveform of the inverter. It can be either Sinusoidal, or Rectangular. Some manufacturers call the rectangular waveform by such names as Semi-Sinusoidal or Quasi Sinusoidal. Rectangular waveform may cause undesirable operation with certain loads. The manufacturer should therefore be consulted before application.
Overcrank	Overcrank is an alarm function provided with most generator sets that indicate that the generator set has failed to start.
Overload Rating	The overload rating of a device is the load in excess of the nominal rating the device can carry for a specified length of time without being damaged.
Overload	The maximum load current allowed for a limited time while still keeping rated conditioned voltage. Typically, Inverter overload is 125% of full load for 10 minutes or 150% for 30 seconds.
Overvoltage category	A numerical value that specifies a surge withstand voltage. Note: Overvoltage categories termed I, II, III and IV are used.
Overvoltage category	The overvoltage category classifies overvoltages into categories I, II, III and IV depending on the nominal voltage. The overvoltage category is one of the factors that decides clearance distance. The nominal voltage is the rated impulse voltage or rated voltage of the component.
Overvoltage	RMS voltage increase above the rated value, generally for a duration of a few seconds (Shorter time, see Transient or Swell).
Parallel Operation	Operation of two or more systems with outputs connected to a common Load Buss for Redundancy or power enhancement purpose. To enable parallel operation the UPS systems should have equal output voltages, operate synchronously (same frequency and same phase), and have

	load-sharing capabilities.
Parallel Redundancy	A combination of more than two systems operating in parallel that includes at least one Redundant (extra) unit, which is not required to provide the total expected load. A failure of a single UPS does not affect system performance, thus dramatically increasing load power Availability.
Patch	A fix for a software program where the actual binary executable and related files are modified.
PCI Express	PCI Express is an implementation of the PCI computer bus that uses existing PCI programming concepts and communications standards, but bases it on a much faster serial communications system.
PFC (Power Factor Correction)	Correction of input Power factor by means of decreasing the harmonic currents at the input of the UPS. PFC is generally implemented by means of special filters, multiple pulse rectifiers or electronic functional modules.
Phase	Phase refers to the windings of an AC generator. In a three-phase generator, there are three windings, typically designated as A-B-C, R-W-B or R-Y-B. The phases are 120 degrees out of phase with each one another. That is, the instants at which the three phase voltages pass through zero or reach their maximums are 120 degrees apart, where one complete cycle is considered 360 degrees. A single-phase generator has only one winding.
Phase Angle	Phase angle refers to the relation between two sine waves which do not pass through zero at the same time. Considering one full cycle to be 360 degrees, the phase angle expresses how far apart the two waves are in relation to each other in degrees.
Phase Imbalance	A condition (or figure) in which the angle between phases in a three-phase system differs from 120 degrees. Example: UPS output phase imbalance at 50% unbalanced loads is 120° ± 3°.
Phase Rotation	Phase rotation (or phase sequence) describes the order (A-B-C, R-W-B, or R-Y-B) of the phase voltages at the output terminals of a three-phase generator. The generator phase rotation must match the facility phase rotation. This must be checked prior to operation of the electrical loads in a facility

	with an on-site generator.
Pitch	Pitch is a mechanical design characteristic of a generator that indicates the ratio of the number of winding slots per generator pole to the number of slots enclosed by each coil. The generator designer may use the pitch of a machine to optimize the generator cost versus the quality of the voltage waveform generated.
PLC (Programmable Logic Controller)	A small computer used for automation of real-world processes, such as control of machinery on factory assembly lines.
Pole	Pole is used in reference to magnets, which are bipolar. The poles of a magnet are designated North and South. Because magnets are bipolar, all generators have an even number of poles. The number of poles determines how fast the generator will have to be turned to obtain the specified frequency . frequency. For example, a generator with a 4-pole field would have to be run at 1800 rpm to obtain a frequency of 60 Hz (1500 rpm for 50 Hz). Pole can also refer to the electrodes of a battery or to the number of phases served by a switch or breaker.
Port	Hardware Port: A hardware port is an outlet on a piece of equipment into which a plug or cable connects. Network port: A network port is an interface for communicating with a computer program over a network. I/O or machine port - port-mapped I/O: Nearly all processor families use the same assembly instructions for both memory access and hardware I/O. Software port: Software is sometimes written for specific processors, operating systems, or programming interfaces. A software port is software that has been changed to work on another system.
Power	Power refers to the rate of performing work or of expending energy. Typically, mechanical power is expressed in terms of horsepower and electrical power in terms of kilowatts. One (1) kW equals 1.34 hp.
Power Factor	Power factor is the cosine of the angle between the active power (kW) and apparent power (kVA) in a circuit.
Power Factor (W/VA)	Actual Power divided by Apparent (or Total power). In new UPS systems with power factor (PF) correction, UPS input power factor is greater than 0.95. UPS Output power factor

	is currently 0.7 in most cases. New regulations require to increase servers input power factor above 0.9. UPS Watts and VA should exceed respective load ratings.
Power Failure (Power Outage)	Any degradation of AC power below the minimum rated value, generally lasting more than 10 ms, which may cause the loss of service to a customer or facility.
Power Line Disturbances	The ten most frequent disturbances (IEC 62040-3): 1. Power outage (>10 ms); 2. Voltage fluctuations (< 16 ms); 3. Voltage transients (4 -16 ms); 4. Undervoltage (continuous); 5. Overvoltage (continuous); 6. Lightning effects (sporadic <1 ms); 7. Voltage surges (< 4 ms); 8. Frequency fluctuations (sporadic); 9. Voltage bursts (periodic); 10. Voltage harmonics (continuous).
Power source	Energy source feeding the UPS. Generally Utility power (See primary power) or Standby Generator.
PPP	The Point-to-Point Protocol, or PPP, is commonly used to establish a direct connection between two nodes. It can connect computers using serial cable, phone line, trunk line, cellular telephone, specialized radio links, or fibre optic links. Most internet service providers use PPP for dial-up access to the Internet.
Primary Power (Mains)	External AC supply from the Utility grid (or other AC power source). Generally: Single-phase 230 V 50 Hz Three Phase 230/400 V 50 Hz.
Prime Power	Prime Power describes an application where the generator set(s) must supply power on a continuous basis and for long periods of time between shutdowns. No utility service is present in typical prime power applications.
Priority Control	Priority control is the process by which the total loads on the bus is limited to the most critical loads in the system until adequate generation capacity is available to serve all loads.
Process Control	An engineering discipline that deals with architectures, mechanisms, and algorithms for controlling the output of a specific process. For example, heating up the temperature in a room is a process that has the specific, desired outcome to reach and maintain a defined temperature (e.g. 20℃), kept constant over time. Here, the temperature is the controlled variable. At the same time, it is the input variable

	since it is measured by a thermometer and used to decide whether to heat or not to heat. The desired temperature (20℃) is the set point. The state of the heater (e.g., the setting of the valve allowing hot water to circulate through it) is called the manipulated variable since it is subject to control actions.
Protocol	A set of rules used mutually by two or more devices to communicate, also, known as the "language" used in a network.
Proxy Server	Computer process often used as, or as part of, a firewall that relays a protocol between client and server computer systems, by appearing to the client to be the server and appearing to the server to be the client.
Radio Frequency (RF)	Any frequency within the electromagnetic spectrum associated with radio wave propagation.
Radio Interference	Radio interference refers to the interference with radio reception caused by a generator set.
Radio Interference Suppression	Radio interference suppression refers to the methods employed to minimize radio interference.
Silicon Controlled Rectifier	A three-electrode solid-state device which permits current to flow in one direction only, and does this only when a suitable potential is applied to the third electrode, called the gate. Rated surge voltage
Surge Withstand Voltage	Value of a surge withstand voltage, indicated by the manufacturer for an equipment or a part of it, indicating the specified withstand capacity of the respective insulation with regard to the periodic peak voltages.
Reactance	Reactance is the opposition to the flow of current in AC circuits caused by inductances and capacitances. It is expressed in terms of ohms and its symbol is X.
Reactive Differential Compensation	Reactive differential compensation (also called cross current compensation) is compensation) is a method of controlling the reactive power supplied by generators in a paralleling system so that they equally share the total reactive load on the bus, without inducing significant voltage droop in the system.
Reactive Droop	Reactive droop compensation is one method used in

Compensation	paralleled generator sets to enable them to share reactive power supplied to a load. This system causes a drop in the internal voltage of a set when reactive currents flow from that generator. Typically, at full load, 0.8 PF, the output voltage of a set is reduced by 4% from that at no load when reactive droop compensation is used.
Reactive Power	Reactive power is power that flows back and forth between the inductive windings of the generator and the inductive windings of motors, transformers, etc., which are part of the electrical load. This power does no useful work in the electrical load nor does it present load to the engine. It does apply load to the generator and limits the capacity of the generator.
Real Power	Real power is the product of current, voltage and power factor (the cosine of the angle by which current leads or lags voltage) and is expressed as W (watts).
Rechargeable battery	Battery which can be recharged (as opposed to one time battery).
Rectifier current limit	Rectifier protection that limits the maximum current that can be drawn from the rectifier. Rectifier's current limit setting takes into account the DC current drawn by the Inverter at full rated load, and in addition, the current required to recharge the batteries.
Rectifier	Functional UPS module that converts the utility mains input voltage to DC voltage.
Redundancy	A method based on using one or more extra backup modules, which enable normal system performance even in case of system failures. For example, redundancy is achieved by feeding a consumer of 1 kVA by means of two 1 kVA rated UPS systems connected in parallel, hence single unit failure does not affect load performance.
Reliability	The probability that equipment will perform satisfactorily during a specific time.
Remote Control	The ability to turn a system on or off, monitor its behaviour or to change its setting from a remote location.
Resistance	Resistance is the opposition to the flow of current in DC and AC circuits. It is expressed in ohms and its symbol is R.

Retransfer	Manual or automatic Retransfer of Load from Bypass to Inverter in an online system. Generally enabled only when no fault condition exists, Inverter output voltage is in phase with Bypass voltage and the load is within its nominal rating.
RMS (Root Mean Square)	RMS value, also called Effective value, equals the square Root of the Mean value of the Squared amplitudes of all harmonics in a waveform divided by square root of 2 (1.414). Current RMS value equals the equivalent direct current that would produce the same power dissipation in a given resistor. The RMS values of current or voltage are generally measured with a “ True RMS ” meter.
Router	A router is a computer networking device that forwards data packets toward their destinations between disparate networks through a process known as routing. Routing occurs at layer 3 of the OSI seven-layer model. Routers can implement other functions and the
RPM	Revolutions Per Minute.
RTU (Remote Terminal Unit)	An RTU, or Remote Terminal Unit is a device which interfaces objects in the physical world to a DCS or SCADA system by transmitting telemetry data to the system and/or altering the state of connected objects based on control messages received from the system.
SCADA (Supervisory Control and Data Acquisition)	A SCADA computer system is developed for gathering and analysing real time data. SCADA systems are used to monitor and control a plant or equipment in industries such as telecommunications, water and waste control, energy, oil and gas refining and transportation.
SCR	Silicon Controlled Rectifier - a three-electrode solid-state device which permits current to flow in one direction only, and does this only when a suitable potential is applied to the third electrode, called the gate.
Serial Communications	Serial communications is the process of sending data one bit at one time, sequentially, over a communications channel or computer bus. Serial communications is used for all long-haul communications and most computer networks, where the cost of cable and synchronization difficulties makes parallel communications impractical. Serial computer busses are becoming more common as improved technology

	enables them to transfer data at higher speeds.
Server	A server is a computer or device on a network that manages network resources. For example, a file server is a computer and storage device dedicated to storing files, a web server for access to web content, a DNS server for domain name services, a database server for access to relational tables, an email server for access to email, etc.
Short Circuit	A short circuit is generally an unintended electrical connection between current carrying parts.
Shunt Trip	Shunt trip is a feature added to a circuit breaker or fusible switch to permit the remote opening of the breaker or switch by an electrical signal.
Sine Wave	A sine wave is a graphical representation of a sine function, where the sine values (usually the y axis) are plotted against the angles (x axis) to which they correspond. AC voltage and current wave shapes approximate such a curve.
Slave	A networked device that is controlled by another device. Slave devices do not initiate data transmission. They respond to commands or requests initiated by a master device.
Soft Loading	Soft loading refers to the ramping of load onto or off a generator in a gradual fashion for the purpose of minimizing voltage and frequency transients on the system.
Sound	Sound is considered both in terms of the sound pressure waves travelling in air (pressures superimposed on the atmospheric pressure) and the corresponding aural sensation. Sound can be "structure-borne", that is, transmitted through any solid elastic medium, but is audible only at points where the solid medium "radiates" the pressure waves into the air.
Sound Level Meter	A sound level meter measures sound pressure level. It has several frequency-weighted decibel (dB) scales (A, B, C) to cover different portions of the range of measured loudness. Sound level meters indicate RMS sound, unless the measurements are qualified as instantaneous or peak sound level.
Sound Pressure Level (SPL)	Sound pressure level is a measurement of the pressure

	fluctuations of a sound wave as it propagates through the air. Because of the wide range of pressures to which the ear responds, a logarithmic scale is used and is expressed as a ratio of the measured pressure referenced to a pressure of 2x10-5 N/m2 (20 m Pa) which), which is the threshold of human hearing at 1000 Hz. The measure is expressed in decibels (dB). The Bell unit is named after Alexander Graham Bell.
Standby System	A standby system is an independent power system that allows operation of a facility in the event of normal power failure.
Starting Current	The initial value of current drawn by a motor when it is started from standstill.
Stator	The stator is the stationary part of a generator or motor. See Armature.
Steady State Rating	Steady state rating is the maximum continuous load that a generator set or paralleling system can carry, on a continuous basis, for the duration of a utility power outage.
Surge	Surge is the sudden rise in voltage in a system, usually caused by load disconnect.
Surge (Spike)	Sharp high voltage increase (lasting up to 1 ms).
Surge Arrester	An electronic device or component used to protect electric circuits from spikes and overvoltages. The surge arrester is generally connected in parallel to the input of the protected circuit. It limits the maximum voltage by absorbing excess energy.
Surge energy rating	A measure of maximal energy in joules a Surge arrester can absorb without damage.
Surge Rating	Surge rating is the rating of a machine, usually in excess of its normal operating level, for which it can provide power for a very short time.
Surge Suppressor	Surge suppressors are devices capable of conducting high transient voltages. They are used for protecting other devices that could be destroyed by the transient voltages.
Surge withstand voltage	Maximum value of surge voltage of conventional shape and polarity which does not lead to spark over puncture or

	punctured spark over of the insulation under specific conditions. See surge withstand voltage wave form waveform under clause 11.4.4.
Switch	A network switch is a computer networking device that serves as a connection point for devices in a network. A switch forwards packets to the appropriate port based on the packet's address
Switching Hub	Short for port-switching hub, a special type of hub that actually forwards information to the appropriate port based on the IP address assigned. Conventional hubs simply rebroadcast information to every port. Switching hubs forward information only to the required port.
Sync Check Relay	A sync check relay is an electrical device that monitors the phase relationship between two voltage sources and provides a signal when the voltage sources are within specific preset parameters.
Synchronization	In a paralleling application, synchronization is obtained when an incoming generator set is matched with and in step to the same frequency, voltage, and phase sequence as the operating power source.
Synchronization (Phase Lock or Sync.)	Operation that causes an ac waveform to be at the same frequency and in phase with another waveform. Generally refers to synchronizing the output of the Inverter to the Utility mains, in order to allow smooth transfer of load from mains to Inverter and vice versa.
Synchronous Generator	A synchronous generator is an AC generator having a DC exciter. Synchronous generators are used as stand-alone generators for emergency power and can also can be paralleled with other synchronous generators and the utility system.
TCP (Transmission Control Protocol)	TCP is one of the main protocols in TCP/IP networks. Whereas the IP protocol deals only with packets, TCP enables two hosts to establish a connection and exchange streams of data over many packets. TCP includes mechanisms and protocols to ensure delivery of the data in the correct sequence from source to destination.
THD (Total Harmonic distortion)	RMS value of all harmonics in a waveform (excluding fundamental) divided by the RMS value of the fundamental.

	THDV refers to a Voltage waveform. THDI refers to a Current waveform.
	Total harmonic distortion is an expression of the total harmonic content of a voltage waveform. The harmonic distortion (or harmonic content) of a waveform is usually expressed as the square root of the sum of the squares of each of the harmonic amplitudes (with amplitudes expressed as a percentage of the fundamental voltage amplitude).
Unbalanced Load	Conditions in which at least two phases at the output of a three-phase UPS have different (magnitude or PF) loads.
Undervoltage	A voltage below the rated RMS value, generally for a duration of a few seconds (Shorter time under voltages, see Transient or Sag).
UPS Battery	A battery feeding the inverter. In most cases, it is a VRLA type battery.
UPS By-Pass	Functional UPS module that connects the load of an On-Line UPS directly to mains in case of overload or UPS failure.
UPS TYPES	Standard IEC 62040-3 defines three standardized UPS systems:
UPS (Uninterruptible Power Supply)	An Electronic device connected between the Utility Power and electric consumers, generally comprising filters, Rectifier, Battery, DC/AC Inverter, Transfer Switch and associated circuits. The UPS is intended to provide a clean undisturbed stabilized AC voltage, within strict amplitude and frequency limits, to protect the consumer from any Utility Power disturbances and irregularities including outages for a limited time, dictated by the capacity of the Battery Bank. The term UPS generally refers to AC Static systems, Other types include DC and Rotary UPSs.
USB (Universal Serial Bus)	Universal Serial Bus (USB) provides a serial bus standard for connecting devices, usually to a computer, but it also is in use on other devices.
Virus	See Malware.
VLAN (Virtual LAN)	A virtual LAN, commonly known as a VLAN, is a logically

	segmented network mapped over physical hardware.
VOIP	Voice over Internet Protocol (also called VOIP, IP Telephony, Internet telephony, and Digital Phone) is the routing of voice conversations over the Internet or any other IP-based network. The voice data flows over a general-purpose packet-switched network, instead of traditional, dedicated, circuit-switched voice transmission lines.
Volt	The volt is a unit of electrical potential. A potential of one volt will cause a current of one ampere to flow through a resistance of one ohm.
Voltage Control	The voltage control is a rheostat that sets the operating point of the voltage regulator and therefore controls the output voltage of the generator set, within its design limits.
Voltage Dip	Voltage dip is the dip in voltage that results when a load is added, occurring before the regulator can correct it, or resulting from the functioning of the voltage regulator to unload an overloaded engine-generator.
Voltage Regulation	Voltage regulation is a measure that states the difference between maximum and minimum steady-state voltage as a percentage of nominal voltage.
VPN (Virtual Private Network)	A private, encrypted communications network usually used within a company, or by several different companies or organizations, used for communicating in a software tunnel over a public network.
Watt	The watt is a unit of electric power. In direct current (DC) circuits, wattage equals voltage times amperage. In alternating current (AC) circuits, wattage equals effective (RMS) voltage times effective (RMS) amperage times power factor times a constant dependent on the number of phases. 1,000 watts equal one kW.
Watt-Hour Demand Meter	A watt-hour demand meter is similar to a watt-hour meter except that it also provides an indication of the highest kW load level achieved during operation.
Watt-Hour Meter	A watt-hour meter records the total power output at a specific point in a system. Typical recording increment is in kW-hours.

Wattmeter	A wattmeter records power being delivered from a source to the load. Wattmeters for paralleling systems are calibrated in kilowatts (kW).
WEP (Wired Equivalent Privacy)	WEP is part of the IEEE 802.11 standard, and is a protocol used to secure wireless networks (WiFi).
WiFi (Wireless Fidelity)	Short for wireless fidelity and is meant to be used generically when referring of any type of 802.11 network, whether 802.11b/a/g dual-band, etc.
WiMax (Worldwide Interoperability of Microwave Access)	WiMax is the name commonly given to the IEEE 802.16 standard. A wireless protocol designed for distances as far as 30 miles but more commonly 3 - 5 miles.
WPA	Wi-Fi Protected Access (WPA and WPA2) are wireless standards providing higher levels of security than WEP. WPA2 is based on IEEE 802.11i and provides government grade security based on NIST standards and AES encryption.
Wye Connections	A Wye connection is the same as a star connection. It is a method of interconnecting the phases of a three-phase system to form a configuration resembling the letter Y. A fourth (neutral) wire can be connected at the center point.
Zero Sequence	Zero sequence is a method of ground fault detection that utilizes a sensor (CT) that encircles all the phase conductors as well as the neutral conductors. The sensor will produce an output proportional to the imbalance of ground fault current in the circuit. This output is then measured by a relay to initiate circuit breaker tripping or ground fault alarm.