



Electrical Design Criteria

PL666

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AMENDMENT RECORD

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Contents

	Page
1 General	1
1.1 Summary	1
1.2 Reference Documents	1
1.3 Deliverables	9
1.4 Site Conditions	10
1.5 Area Classification	10
2 Power Supply	10
2.1 Main Supply	10
2.2 Standby Supply	10
3 Design Criteria	11
3.1 Load Evaluation	12
3.2 Voltage Levels	13
3.3 Short Circuit Levels	13
3.4 Voltage Regulation	14
3.5 Power Factor Correction and Harmonic Filtration	16
3.6 Sparing Philosophy	16
3.7 Operating Philosophy	16
3.8 System Analysis and Calculations	17
4 Equipment Design Requirements	17
4.1 Switchgear	17
4.2 Protective Devices	18
4.3 Metering and Control	19
4.4 Power Transformers	21
4.5 Battery Charger Systems	21
4.6 UPS System	22
4.7 Electric Motors	22
4.8 Standby Generator	24
5 Facilities Design Requirements	24
5.1 Control and Administration Buildings	24
5.2 Substation Buildings	24
5.3 Earthing Installations	26
5.4 Lighting	28
5.5 Cable and Wiring System	33
5.6 Electric Surface Heating Systems	36
5.7 Socket Outlets	37

1 General

1.1 Summary

1.1.1 Scope of Specification

This specification prescribes the basic minimum requirements and principles for the electrical design, selection, and protection of electrical equipment, materials and installation of electrical facilities on the Transnet Pipelines projects.

All designs shall ensure continuous and reliable service, the safety of personnel and equipment during operation, ease of maintenance, energy efficiency, interchange ability of equipment, reasonable spare capacity for the addition of future loads, safe starting, safe operation, minimum power losses, and safe shutdown of units under all circumstances.

1.1.2 Scope of Facilities

The electrical facilities shall include power, lighting, earthing and supplies to electricity consuming apparatus throughout the installations.

This document will not completely specify the details of the equipment and the services that will form part of an Engineering Contractors scope of supply. As part of the engineering services, Contractors shall make Employer aware of available equipment type options that will be beneficial when considering cost performance, maintainability, quality and energy efficiency. Such options shall be considered for installation by evaluating the suitability and benefits offered.

1.2 Reference Documents

Where reference is made to a specification, standard or code, the reference shall be taken to mean the latest edition of such specification, standard or code, including addenda, supplements and revisions thereto, current at the date of award of contract.

The following lists of specifications standards, as well as all associated references, shall be applied on any project as the basis of design, manufacture and construction, as appropriate.

1.2.1 Transnet Pipelines Specifications

Wherever Transnet Pipelines specifications cannot be made available, the engineering contractor shall supplement with an applicable specification. *Employer* approval of Equipment and Materials specifications is required prior to the same being applied to the Works.

PL 100	Drawings Standards Document
PL 101	Plant and Equipment Tag Numbering Standard
PL 102	Equipment, Instrument and Electrical Symbolology Standards
PL 103	General Drawing Standards
PL 145A	Transnet Pipelines's Requirements for the Supply of Power Factor Correction Modules
PL 619C	Specification for Three Phase Electric Actuators
PL 622H	Standby Plant Specification
PL 627G	Routine Protection Testing and Refurbishment of Selected Protection Equipment at Transnet Pipelines's Distribution Substations / MV Switchgear Facilities

PL 630A	Transnet Pipelines's Requirements for the Re-design and Alterations to Existing HV Substation Layouts and protection Configurations
PL 631	Specification for Low Voltage Switchgear and Distribution Boards
PL 632	Specification for Medium Voltage Switchgear
PL 647	Requirements for the Supply of 110VDC Battery Charger
PL 648	Requirements for the Supply of 50VDC Battery Charger
PL 720	Specification for a small Uninterruptible Power Supply
PL 727	Cabling, Racking, Trenching and Earthing Installation codes of Practice
Explolabs report no XPS/1015/13013Rev2- TPL Hazardous Areas Classification guidelines	

1.2.2 South African Regulations

The Occupational Health and Safety Act (Act No 85 of 1993)

1.2.3 South African National Standards (SANS) Codes of Practices

SANS 10083	The measurement and assessment of occupational noise for hearing conservation purposes
SANS 10086	Installation and maintenance of electrical equipment used in explosive atmospheres
SANS 10089	The Petroleum Industry Part 1: The Handling, Storage and Distribution of Petroleum Products Part 2: Electrical Code
SANS 10108	The Classification of Hazardous Locations and the Selection of Apparatus for Use in Such Locations
SANS 10114	Interior Lighting Part 1: Artificial Lighting
SANS 10119	Reduction of explosive hazards presented by electrical equipment - Segregation, ventilation and pressurisation
SANS 10121	Cathodic protection of buried and submerged structures
SANS 10123	The Control of Undesirable Static Electricity
SANS 10131	Above-Ground Storage Tanks for Petroleum Products
SANS 10142	The wiring of premises
SANS 10191	Acoustics - determination of sound power levels of noise sources
SANS 10198	The selection, handling and installation of electric power cables of rating not exceeding 33 kV
SANS 10199	The Design and Installation of an Earth Electrode
SANS 10200	Neutral earthing in medium voltage industrial power systems
SANS 10292	Earthing of Low Voltage (LV) Distribution Systems
SANS 10313	The protection of structures against lightning

1.2.4 South African National Standards (SANS)

SANS 97	Electric cables - Impregnated-paper-insulated metal sheathed cables for rated voltages 3.3/3.3 kV up to 19/33 kV
SANS 1339	Electric Cables –Cross-linked Polyethelene (XLPE) insulated cables for rated voltages 3.8/6.6 to 19/33kV
SANS 156	Moulded Case Circuit Breakers
SANS 342	Automotive diesel fuel

SANS 767	Earth leakage protection units
SANS 780	Distribution transformers
SANS 808	Cable glands for use on flameproof enclosures (Ex 'd')
SANS 950	Unplasticised polyvinyl chloride rigid conduit and fittings for use in electrical installations
SANS 1019	Standard voltages, currents and insulation levels for electricity
SANS 1029	Miniature Substations
SANS 1063	Earth Rods and Couplers
SANS 1091	National colours standards for paints
SANS 1213	Mechanical cable glands
SANS 1339	Electric cables - Cross linked polyethylene (XPLE) insulated cables for voltages from 3.8/6.6 kV to 19/33 kV
SANS 1411	Materials of Insulated Electric Cables and Flexible Cords
SANS 1473	Low voltage switchgear and control gear assemblies
SANS 1474	Uninterruptible Power Systems
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations
SANS 1574	Electric cables – Flexible Cords and Flexible Cables
SANS 1632	Batteries
SANS 1652	Battery Chargers – Industrial Type
SANS 1804	Induction motors
SANS 1874	Metal Enclosed Ring Main Units for Rated Voltages above 1kV Up To and Including 24kV

1.2.5 South African National Rationalized User Specifications (NRS)

NRS 042	Guide for the Protection of Electronic Equipment against Damaging Transients
NRS 048	Electrical Supply – Quality of Supply Standards
Part 4:	Voltage characteristics, compatibility levels, limits and assessment methods
Part 8:	Application guidelines for utilities

1.2.6 SANS / International Electrotechnical Commission (IEC) Standards

SANS IEC 60034	Rotating electrical machines
SANS IEC 60034-25	Rotating electrical machines Part 25: Guide for the design and Performance of Cage Induction Motors Specifically Designed for Converter Supply.
SANS IEC 60044-1	Current Transformers
SANS IEC 60044-2	Voltage Transformers
SANS IEC 60050	International Electrotechnical vocabulary - Switchgear, control gear and fuses
SANS IEC 60056	High voltage alternating current circuit breakers
SANS IEC 60060	High Voltage Test Techniques
SANS IEC 60072	Dimensions and output series for rotating electrical machines
SANS IEC 60076	Power transformers
SANS IEC 60079	Electrical apparatus for explosive gas atmospheres
SANS IEC 60099	Surge arresters
SANS IEC 60129	Alternating current disconnectors (Isolators) and earthing switches
SANS IEC 60137	Insulated Bushings for Alternating Currents above 1000V
SANS IEC 60227	PVC Cables

SANS IEC 60265-1	High voltage switches for Rated Voltages above 1kV and up to and less than 52kV
SANS IEC 60269	Low voltage fuses
SANS IEC 60282	High voltage fuses
SANS IEC 60298	AC metal enclosed switchgear and controlgear for rated voltages between 1 kV and 52 kV
SANS IEC 60331	Tests for Electrical Cables under Fire Conditions
SANS IEC 60423	Conduits and fittings for electrical purposes
SANS IEC 60470	High Voltage Alternating Current Contactors and Contactor Based Motor Starters
SANS IEC 60478	Stabilised power supplies, dc output
SANS IEC 60529	Degrees of Protection Provided by Enclosures (IP Code)
SANS IEC 60686	Stabilised power supplies, ac output
SANS IEC 60614	Specification for Conduits for Electrical Installations
SANS IEC 60694	Common clauses for high voltage switchgear and controlgear standards
SANS IEC 60793	Optical Fibres
SANS IEC 60794	Optical Fibre Cables
SANS IEC 60871	Shunt Capacitors for ac Power Systems having a rated voltage above 660V
SANS IEC 60896-1	Stationary Lead-acid Batteries General Requirements and Methods of Test
SANS IEC 60934	Circuit breakers for Equipment
SANS IEC 60947-3	Low voltage switchgear and control gear Part 3: Switches, Disconnectors, Switch Disconnectors and Fuse Combination Units,
SANS IEC 61000	Electromagnetic compatibility
SANS IEC 61024	Protection of Structures against Lightning
SANS IEC 61084-1	Cable trunking and ducting systems for electrical installations Part 1: General Requirements
SANS IEC 61241	Electrical apparatus for use in the presence of combustible dusts.
SANS IEC 61312	Protection Against Lightning Electromagnetic Impulse
SANS IEC 61558	Safety of Power Transformers, Power Supply Units and Similar
SANS IEC 62271-100	High-Voltage Switchgear and Control Gear Part 100 : High-Voltage Alternating Current Circuit Breakers
SANS IEC 62271-102	High-Voltage Switchgear and Control Gear Part 102 : High-Voltage Disconnectors and Earth Switches

1.2.7 IEC Standards

IEC 60038	IEC Standard Voltages
IEC 60059	IEC Standard Current Ratings
IEC 60060	High Voltage Test Techniques
IEC 60071	Insulation Coordination (Application Guide)
IEC 60073	Basic and Safety Principles for Man-machine Interface, Marking and Identification – Coding Principles for Indicators and Actuators
IEC 60146-2	Semiconductor Convertors – Part 2 : Self-commutated Semiconductor Convertors Including Direct dc Convertors
IEC 60214-2	Tap Changers – Part 2 : Application Guide
IEC 60255	Electrical Relays

IEC 60289	Reactors
IEC 60296	Unused Mineral Insulating oils for Transformers and Switchgear
IEC 60358	Coupling capacitors and capacitor dividers
IEC 60376	Specification of Technical grade Sulphur Hexafluoride (SF ₆) for use in Electrical Equipment
IEC 60439	Low voltage Switchboards and Control Assemblies
IEC 60445	Basic and Safety Principles for Man-machine Interface, marking and identification. Identification of Equipment Terminals and of Terminations of Certain Designated Conductors, Including General Rules for an Alphanumeric System.
IEC 60466	Insulation-enclosed Switchgear and Control Gear for Rated Voltages Above 1kV and up to and Including 38kV
IEC 60593	Internal Fuse and Internal Overpressure Disconnectors for Shunt Capacitors
IEC 60664	Insulation Coordination for Equipment within LV Systems
IEC 60686	Stabilised power supplies, ac output
IEC 60614	Specification for Conduits for Electrical Installations
IEC 60632	High Voltage Motor Starters – Direct-On-Line Full Voltage Starters
IEC 60722	Guide to the Lightning Impulse and Switching Impulse Testing of Power Transformers and Reactors
IEC 60831-2	Shunt power capacitors of the self-healing type for AC power systems having a rated voltage up to and including 660 V
IEC 60931	Shunt power capacitors of the non healing type for ac systems up to 1000 V
IEC 61073-1	Mechanical and Fusion Splices Protectors for Optical Fibres and Cables
IEC 61140	Protection Against electric Shocks – Common Aspects for Installation and Equipment
IEC 61800	Adjustable Speed Electrical Power Drive Systems
IEC 62040	Uninterruptible Power Supplies (UPS)
IEC TR 61641	Enclosed LV Switchgear and Control Gear Assemblies – Guide for Testing Under Conditions of Arcing Due to an Internal Fault
IEC TR 62063	The Use of Electronic and Associated Technologies in Auxiliary Equipment of Switchgear and Control Gear

1.2.8 British Standards

BS 115	Metallic Resistance Materials for Electrical Purposes
BS 159	High Voltage Busbars and Busbar Connections
BS 381C	Specification for Colours for Identification, Coding and Special Purposes
BS 4999	General requirements for rotating electrical machinery
BS 5514	Reciprocating internal-combustion engines
BS 6133	Safe Operation of Lead-Acid Stationary Cells and Batteries
BS 6351	Electric Surface Heating
	Part 1 Specification for Electric Surface Heating
	Part 2 Guide to the Design of Electric Surface Heating Systems

	Part 3 Code of practice for the Installation, Testing and maintenance of Electric Surface Heating Systems
BS 6387	Performance Requirements for Cables required to Maintain Circuit Integrity Under Fire Conditions
BS 7361	Cathodic Protection
	Part 1: Code of Practice for Land and Marine Applications

1.2.9 Institute Of Petroleum Model Code Of Safe Practices

IP Code Part 1	Electrical safety code
IP Code Part 15	Area classification code for petroleum installations

1.2.10 International Organisation For Standardisation (ISO) Standards

ISO 3722	Determination of Sound Power levels of Noise Sources
ISO 1461767	Hot dipped galvanized coatings on fabricated iron & steel articles
EN ISO 9001	Quality Management Systems Requirements

1.2.11 National Association of Corrosion Engineers (NACE) Recommended Practices

NACE RP0169	Control of External Corrosion on Underground or Submerged, Metallic Piping Systems
NACE RP0193	External Cathodic Protection of On-grade Carbon Steel Storage Tank Bottoms
NACE RP0286	Electrical Isolation of Cathodically Protected Pipelines
NACE RP0572	Design Installation, Operation and Maintenance of Impressed Current Deep Groundbeds

1.2.12 RAL Deutsches Institut Fur Gutesicherung Und Kennzeichnung – RAL – Farben RAL Specification for Colours for Identification, Coding and Special Purposes

1.2.13 Electrical equipment and the installation thereof shall as a minimum satisfy the requirements of relevant internationally recognised specifications and codes of practice.

1.2.14 Where applicable, equipment items shall carry an internationally recognised mark to demonstrate compliance with the directives of codes of practice. Copies of the manufacturer's Declaration of Conformity' certificates and test reports shall be provided by equipment Suppliers.

1.2.15 Suppliers may at their discretion, elect to provide marking for the complete equipment assembly. In which case, the Suppliers shall describe the procedure to be followed and / or details of the documentary evidence that will be provided for each component item of the complete assembly, for which is necessary to demonstrate compliance with the relevant directives / regulations.

1.2.16 Hierarchy

The hierarchy determines which standard is to be followed if there is a dispute or difference. Transnet Pipelines standards and specifications shall take precedence over general industrial recommended practices and guides.

If a conflict exists between the codes or standards, the most stringent interpretation shall apply. Where reference is made to a specification, standard or code, the reference shall be taken to mean the latest edition of such specification, standard or code, including addenda, supplements and revisions thereto, current at the date of award of contract. In general, the order of precedence shall be:

- Transnet Pipelines Standards
- Statutory Requirements and issued directives
- The purchase order for an item of equipment of work package
- South African National Standards
- International Codes and Standards
- Industry Publications.

In the case of conflicting requirements, the most stringent or conservative approach shall be followed. Where there is any doubt as to the above order of precedence, the matter shall be referred to the Responsible Engineer for resolution.

1.2.17 Energy Efficiency

The electrical system will be designed to comply with Transnet Pipelines' energy efficiency strategy.

The following will be focused on but not be limited to include the energy efficiency design:

- Sizing of cables and busbars to limit copper losses and improve power usage
- Power factor correction to improve Measured Maximum Demand
- Optimal lighting design and use of LED / low power light fittings
- Use of high efficiency equipment throughout the project.
- Use of occupancy sensors or day/night switches
- Use of VSD's for motor applications
- Timers and blankets on geysers
- Limiting circuit breaker capacity in predefined areas
- Design for optimal minimum volt drop to the main distribution board.

1.3 Deliverables

Engineering technical services and the design deliverables that are to be provided by an Engineering Contractor shall be in general accordance with Transnet Pipelines's specified requirements.

Prior to manufacturing/procurement of panels all designs must be accepted by Transnet Pipelines. This includes internal and external general arrangements(GA's) and component layout inspections as a minimum.

It's the Project Manager function to ensure all process are included in the schedule eg. FAT, release of equipment, SAT, commissioning phases,etc.

Docs to be submitted for acceptance prior procurement process or manufacturing:

- Installation specification
- SLD's, Internal and External General Arrangement drawings
- Floor plan layouts
- Cable racking layouts
- Component lists
- Equipment Data Sheets
- Cable schedules including volt drop and de-rating factors
- FAT and SAT procedures

At the close out of projects the CoC is must be completed. The CoC will be a comprehensive document with an index and supporting documentation to be included. The index shall be has per typical of Transnet Pipelines CoC's and must be submitted at the early stages for acceptance.

1.4 Site Conditions

Site specific environmental conditions shall be provided to Contractors with the relevant datasheets issued with enquiries for equipment.

Pests normally encountered are rats, birds and snakes. All installations should be designed to prevent them from accessing equipment and cabling.

Some sites have specific pests such as termites, venomous snakes, spiders, scorpions, snakes, bats, and burrowing animals. These should be identified and the specific preventative and curative measures should be made available

1.5 Area Classification

- 1.5.1** Installations shall be classified in accordance with SANS 10108 Annexure G and IP Model Code of Safe Practice in the Petroleum Industry - Part 15: Area Classification Code for Petroleum Installations.
- 1.5.2** The selection of the correct type of classified electrical equipment and the installations within each area that has been classified as hazardous shall be in accordance with the IP Model Code of Safe Practice in the Petroleum Industry - Part 15: Area Classification Code for Petroleum Installations.
- 1.5.3** All electrical equipment and each component utilised in the installation of such equipment shall be selected to be entirely suitable for the area classification in which it is to be located and shall as an absolute minimum be certified for the classification as reflected in the associated area classification schedules and / or on the plant Hazardous Area layout drawings. Certificates shall be issued by an authorised **local** laboratory.
- 1.5.4** The installation of certified equipment shall fully comply with any conditions and restrictions of installation and use imposed by the respective equipment certificate.

2 Power Supply

2.1 Main Supply

In general local Power Supply Authorities provide the required power supplies to the Transnet Pipelines installations. When necessary, Transnet Pipelines will supply contact details for the specific supply authority.

2.2 Standby Supply

- 2.2.1** The standby power supply at the installations shall be provided from a diesel engine driven generator set. The set will be arranged for automatic start-up and connection to the respective 400V switchboard / MCC following a mains supply failure.
- 2.2.2** The standby generator set shall generate power at 400V, 3 phase, 50 Hz and shall be rated to supply emergency power only to the installation, taking into account the starting duty of the largest connected motor load. In addition, the selected rating of diesel generators shall ensure that the continuous running load on the generator will not be less than 50% of the engine rated output power in order to avoid problems associated with engine choking and resultant loss of reliability. The acceptable minimum rating of a diesel generator set shall be 60kVA per Transnet Pipelines specification PL622H.
- 2.2.3** The generator set shall be provided with the necessary change-over control and electrical protection facilities to permit slow transfer of the load for regular routine on-load test and maintenance.

3 Design Criteria

3.1 Load Evaluation

- 3.1.1** An electrical Power User Schedule and load profiles shall be prepared for each installation. The Power User Schedule shall be generated from the

'Approved for Design (AFD)' Mechanical equipment list and shall thereafter be maintained throughout the design phase of the project to include all power consumers on the plant.

3.1.2 The load list may provide a breakdown of plant loads sorted by:

- Substation
- main distribution switchboards
- main or standby or emergency service
- motor drives and static loads
- voltage levels

3.1.3 The Power User Schedule shall tabulate the required loading for each installation on the basis of the highest loaded operating scenario. Consumer duties shall be defined as continuous, intermittent or standby as follows:

- Continuous: Loads that is normally running / energised during operating times.
- Intermittent: Loads in service on an intermittent basis e.g. motorised valves, or spares of continuously running consumers.
- Standby: Loads connected but not normally energised e.g. operational spares.
- Total loads shall be calculated for each duty category and each distribution switchboard. A summary sheet shall total loads for each installation.

3.1.4 When determining the rating of new power supply requirements and the continuous current rating of major electrical equipment (e.g. transformers), design margins shall be applied to the calculated maximum running load values so as to facilitate a minimum of 25% spare capacity.

3.1.5 When adding load to existing systems, the dual redundant rating of the existing power supply transformers shall not be exceeded.

3.1.6 Power System Studies

System studies shall be provided in support of the design. Depending on the type, size and complexity of the installation, such studies may comprise the following:

- Rating of major equipment
- Load assessment and load flow studies
- Fault level studies
- Harmonic and PFC studies on completion of installation

The scope of the system studies, drawings and documentation for each stage of the development shall be defined and agreed before their commencement.

The Electrical Design Criteria ensures uniformity and consistency of the design by describing:

- Technical documentation referred to during Electrical Design

- Electrical tools , software and procedures used in preparing the design
- Specific requirements for system design
- Requirements for protection and control systems
- Equipment sizing and selection methods
- Equipment specifications
- Definition of detail for all Electrical deliverables

While this document provides general guidance it shall not be a substitute for good engineering judgement which should be applied as appropriate with the approval of the respective Design Engineer.

The electrical equipment shall be designed and engineered to:

- Provide a safe working environment for personnel
- Minimise the environmental impact
- Operate with low maintenance for at least the 25 years lifetime of the facility
- Provide a reliable electrical system, by supplying critical equipment from alternative sources
- Integrate with the existing electrical infrastructure
- Provide standardisation to rationalise spares kept in stores.

3.2 Voltage Levels

3.2.1 Distribution

The following distribution voltage levels shall be used:

- Utility Supply (Various) 3 Phase; 3 Wire; 50 Hz
- 3,300V 3 Phase 3 Wire 50 Hz Resistance earth system or
- 6,600V 3 Phase 3 Wire 50 Hz Resistance earth system or
- 11,000V 3 Phase 3 Wire 50 Hz Resistance earth system.
- 400 V 3 Phase 4 Wire 50 Hz Solid earth system
- 230 V Phase and Neutral 50 Hz Unearthed UPS – control supplies

3.2.2 Utilisation

Equipment shall generally be suitable for operation at the following utilisation voltages:

- Medium Voltage Motors 3,300V or 6,600V or 11,000V, 3 Phase, 50 Hz, Resistance earthed system
- Motors 0.18 kW - 149 kW, 400 V, 3 Phase, 50 Hz, Solidly earthed system
- Motors below 0.18 kW, 230 V, 50 Hz, Phase & Neutral
- Lighting supply, 400 V / 230 V, 3 Phase, 4 Wire, 50 Hz
- Lighting, 230 V, 50 Hz, Phase & Neutral
- Instruments, 220V, 50 Hz, Phase & Neutral UPS
- Welding outlets, 400 V , 3 Phase + earth, 4 Wire, 50 Hz
- Convenience outlets, 230 V, 50 Hz, Phase & Neutral

- Switchgear closing and tripping, 110 V DC unearthed
- Control circuits, 220 V AC

3.3 Short Circuit Levels

- 3.3.1** Major electrical equipment and power distribution system design duties shall, as a minimum requirement, exceed the calculated peak and the steady state short circuit fault levels as calculated from the reactance parameters of the power supply network transformers and / or generator(s), and where appropriate the contribution from induction motors.
- 3.3.2** 400V MCC secondary distribution design to allow for MCB ratings determined by cascading tables as per SANS 10142.
- 3.3.3** On sites with both transformer and standby generator incoming supplies, maximum prospective fault level calculations shall include contributions from the transformer or the generator. The generator will not run in parallel with the transformer on the "Normal" busbar.

Worst case calculation for switchgear rating:

- Maximum Source Voltage
- Minimum Source Impedance
- Minimum Transformer Impedance (tolerance)
- All motors running
- Margin (minimum 5%)

Short Circuit Calculations shall be carried out using the guidelines of IEC 60909 - The calculation of short-circuit currents in three-phase AC systems. Minimum fault level calculations will be required for protection co-ordination.

3.4 Voltage Regulation

3.4.1 Steady State

The power distribution system and connected electrical equipment shall be designed for a steady state voltage regulation of + 5% / - 5% and a frequency variation of +/- 2%.

3.4.2 Motor Starting

The maximum voltage depression, on the nominal voltage, measured during motor starting at any distribution system busbar down-stream of the 'point of common coupling', shall be limited to 15%.

In addition, the minimum acceptable voltage at a running motor's terminals during the transient period of another motor starting shall be limited to 80% of the nominal voltage. Where system study calculations indicate that the transient voltage depression at the starting motor's terminals will exceed 20% of nominal, then the minimum voltage limits shall be co-ordinated with the motor manufacturer / driven equipment manufacturer/switchgear manufacturer.

3.4.3 Normal Operation

The allowable steady state voltage drop in cables, based on circuit full load current values, shall not exceed the following. To prevent over sizing of cables, volt-drop and de-rating calculations will be based on SANS 10142:

Primary distribution feeder cables (3.3 kV)	2%
Secondary distribution feeder cables (400 V)	2%
Motor feeder cables (400 V) between the Motor controller and the motor terminals	2%
Distribution board feeder cables	2.5%
Lighting and small power circuits between the distribution board and the most remote luminaire or outlet	4%

3.5 Power Factor Correction and Harmonic Filtration

- 3.5.1** Because of various operating scenarios, the power factor at Transnet Pipelines installations is normally controlled by adding power factor correction to the individual MV induction Direct On line motor starter circuits.
- 3.5.2** Power factor correction equipment shall be sized to maintain the operational power factor of its respective motor to not more than 0.96
- 3.5.3** PFC equipment is not required wherever Variable Speed Drive units are employed to control the operation of MV induction motors.
- 3.5.4** A harmonic study may be required to assess the harmonic distortion of the supply system for the 12 or 18 pulse VSDs. Should the harmonic study indicate the 12 or 18 pulse VSDs cannot comply with the harmonic values as required by NRS048, harmonic filters will be used to prevent resonance from occurring.

3.6 Sparing Philosophy

- 3.6.1** The electrical distribution system shall be designed to provide a dual redundant system with high reliability and availability, and to ensure continuous operation of the installation between planned maintenance shutdowns.
- 3.6.2** The distribution system of installations shall be configured on the radial feeder and not ring feeder principle with the main distribution busbar having duplex, 100% load rated, incoming supplies. 2x incomers with a split bus and bus section should be more reliable and flexible than the "radial" feed system.
- 3.6.3** Main LV distribution switchboard busbars shall comprise of two single bus sections: a "Normal" and an "Emergency" bus.
- 3.6.4** Automatic transfer facilities between the two incoming MV supplies shall be provided.
- 3.6.5** Automatic transfer between the normal and standby generator supplies shall be provided.

3.7 Operating Philosophy

- 3.7.1** The electrical operating philosophy will generally be as follows: If any individual supply to a switchboard is lost due to a primary distribution fault and if the primary Incomer protection has not operated, then if the primary supply voltage is available on the standby Incomer, the supply shall automatically transfer to the standby incomer.
- A primary incomer Master trip operation is to block the automatic transfer to prevent the standby incomer closing onto a fault.
- The Automatic Change-Over (ACO) shall be conducted within 500ms to 1.5sec to accommodate ride through on a VSD/pump motor combination. The transfer will be slow; in that the standby Incomer will only close after the primary Incomer opens to prevent back-feeding currents.
- Operating motor drives affected by the temporary loss of power will be re-accelerated by Transnet Pipelines when power has been seen to be restored. VSD auxiliary control circuit power shall be sourced from the UPS to facilitate ride through and reacceleration. During normal operation, the VSD ride through function caters for re-acceleration.
- At such time as the primary supply has been re-established, the affected switchboard will be reinstated to its normal operating scenario. This process will be executed manually.
- The final Operating Philosophy at each facility will be determined once the supply configurations are finalised.

3.8 System Analysis and Calculations

- 3.8.1** The following system analysis studies or calculations shall be carried out during the detail design of the power distribution system:
- Load Flow
 - Short circuit analysis - confirm switchgear ratings and provide information for protection studies
 - Motor starting and acceleration analysis (only for large drives)
 - Harmonic analysis
 - Protective relay setting and co-ordination

- Earthing and lightning Protection Study

The following documentation will be created and used during the detailed design phase:

- Electrical Load List
- Electrical Equipment List
- Equipment Datasheets
- HVAC where applicable will require HVAC design criteria, heat load schedules, Layout plans, System flow diagrams, Control philosophy.
- Cable Calculation and Schedule
- Main Incomer Fault Level Calculation
- Single line diagrams
- Room site layout
- Earthing and Lightning Protection Drawing
- Components lists- signed off prior to purchase
- QA/QC plan indicating milestones reflecting client witness of tests, FAT, SAT and Commissioning and Handover processes.

Data Validation

All calculations and spreadsheets / lists / drawings / documentation will be reviewed and validated according to the relevant specifications and engineering principles. All documentation must be presented to Transnet Pipelines for review and acceptance .

4 Equipment Design Requirements

4.1 Switchgear

4.1.1 General

- a. MV and LV switchgear shall consist of grouped assemblies of free-standing, vertical, metal clad enclosures containing single main busbar systems, removable circuit breakers/switching devices, necessary auxiliary control devices, instrument transformers, relays and metering equipment.
- b. MV Switchgear (LV incomers) shall be designed to allow for mechanical interlocking.
- c. MV and LV switchgear is to be included in the SCADA monitoring and control system.
- d. In general the MV and LV switchgear design has to comply with the Transnet Pipelines specification PL 632 and PL 631 respectively.
- e. MV and LV switchgear assemblies for installation in switch rooms or buildings with controlled environments shall be of Transnet Pipelines approved industrial types.
- f. HT Switchgear assemblies for installation outdoors shall have weatherproof, vermin-proof, fully gasketed enclosures, adequate lighting and ventilation shall be provided.
- g. Switchgear assemblies shall be provided with space heaters to prevent internal condensation.

4.1.2 Switchgear / Motor Control Centres

- a. Switchgear shall be in accordance with the requirements of the relevant Transnet Pipelines specifications.
- b. Data sheets shall be prepared for each equipment item, detailing the specific requirements of the subject equipment.
- c. The switchboard shall incorporate incoming units and outgoing units for motor starters, distribution board feeders and feeders to individual consumers.
- d. MV motor starters shall be Circuit Breakers. Protection shall be provided by means of approved electronic motor protection relays, and appropriate auxiliary relays as required.
- e. LV motor starter and outgoing feeder circuits shall comprise Transnet Pipelines approved MCCB's, ammeters, contactors, overloads, auxiliary relays and earth leakage relays, "Local – Auto" selector switches, start push buttons, stop push buttons, control systems interface relays as appropriate for the required circuit duties.
- f. Where indicated on schematic diagrams and as defined by the operating philosophy, incoming and outgoing units shall have facilities for remote control and monitoring by the SCADA system.
- g. Electrical / Control Systems Interface panels shall form part of the 400V LV switchboard arrangement.
- h. The requirements for main lighting distribution boards and motorised valve distribution boards shall be as shown on the 400V LV switchboard / MCC distribution Single Line Diagram.
- i. Distribution boards shall be supplied as integral units in the LV switchboard / MCC arrangement unless specific site requirements (e.g. loads grouped at a significant distance from the substation) warrant the use of field mounted boards.

4.2 Protective Devices

4.2.1 General

- a. The protective relaying system applied to the electrical distribution system shall be based on the use of Transnet Pipelines approved solid-state relaying equipment, supplied by vendor(s) experienced in the design, development and manufacture of such equipment. For medium voltage applications the relays shall be discrete devices. For low voltage applications the relays may either be discrete devices or devices fitted integrally within circuit breakers or other switching devices.
- b. Protection relays shall generally comply with the requirements of IEC 60255.
- c. The protective relaying philosophy shall be based on single contingency planning, so that the relay system will provide graded fault clearing for one of the following occurrences:
 - failure of either the primary or backup relays to function, or failure in either of their associated secondary or control circuits
 - failure of the circuit breaker to interrupt, including a faulty circuit breaker
- d. The protection circuits of all circuit breakers used for automatic disconnection in conjunction with a non-integral protective relaying scheme shall be equipped with hand reset master lock-out relays.

4.2.2 Incoming Supply / Generator Protection

Protection arrangements for incoming supplies derived from local power supply authority networks shall be fully co-ordinated with the protection system in operation on the supply network. As a minimum, incoming supply feeders incorporating a step-down transformer shall be provided

with the following protective devices:

- high set instantaneous and time delayed phase fault over-current relays
- time delayed earth fault over-current relays, except when fuse protection is applied (primary winding)
- differential relays (biased type) – on transformers rated above 2000 kVA
- oil temperature indicator (trip and alarm)
- winding temperature indicator (trip and alarm) - above 1000 kVA
- pressure relief device (trip and alarm) - hermetically sealed type transformers only
- restricted earth fault relays (secondary winding) - resistance earth systems only
- facilities for Buchholz trip and alarm protection to be provided

4.2.3 Motor Circuits

- a. Direct on line starting of MV motors shall be by electrically operated circuit breakers equipped as motor starters.
- b. MV motor protective devices shall be Transnet Pipelines approved electronic protection relays.
- c. MV Variable speed drive applications shall be fed from suitably equipped electrically operated circuit breaker feeders.
- d. Typical Transnet Pipelines LV motor starting philosophy is as follows:
 - LV motors $\leq 15\text{kW}$ DOL starting
 - LV motors $> 15\text{kW}$ –VSD's / Soft Starter application (contractor to provide prices for these options)
- e. Cable lengths, P&ID and load schedules may require the use of VSDs on the complete range of motor ratings, the use of VSD application to avoid using two cables per motor installation.
- f. LV motors (typically operating at 400V) shall be controlled using Transnet Pipelines approved Type 2 coordinated motor starter combinations.
- g. LV motor protective devices shall as a minimum cater for the following:
 - Rated short circuit protection
 - Thermal overload with single phasing protection (motors rated up to 55kW only).
 - Electronic motor protection (motors rated 75kW and above only).

4.2.4 General Purpose Feeder Circuits

Protective devices shall be applied according to the application but shall as a minimum include:

- instantaneous and time delayed over-current protection (MCCB with thermal and magnetic trips)
- time delayed earth fault (circuits rated 60 amps and above only)

4.3 Metering and Control

4.3.1 Main Incoming Supply

Tariff metering and control of an incoming supply from a local power supply authority network shall be as specified by the relevant supply authority. The protection scheme is to include a power analysing relay e.g. Siemens Simeas P.

4.3.2 Generator plant incoming supply

The following metering equipment shall be provided on generator control panel / generator circuit breaker panel:

- voltmeter and phase selector switch
- ammeter and phase selector switch
- kilo-watt meter
- power factor indicator
- frequency meter
- hours run counter
- synchro-scope

4.3.3 LV Switchboard / MCC

- a. The LV switchgear shall comply with Transnet Pipelines Specification PL 631.
- b. Incoming supply circuit breakers or isolators shall be equipped as a minimum with the following metering equipment:
 - Line side voltmeter and phase selector switch
 - Busbar voltmeter and phase selector switch
 - off maximum demand ammeters (1 per phase)
- c. Outgoing feeder circuit breakers or switches, feeding major load centres, shall be equipped as a minimum with an ammeter connected in the (Y) phase.
- d. LV motor starters shall be equipped with an ammeter connected in the (Y) phase.
- e. The ammeter shall have a compressed upper scale calibrated up to six times motor full load current.
- f. LV motor starters of 15kW and larger shall provide a 4-20mA feedback circuit for current to the control system.
- g. LV contactor and switched feeder outgoing circuits shall be equipped with an ammeter connected in the (Y) phase when process or other considerations require indication of operating current.

4.3.4 Motor Control Stations

- a. Start / stop pushbutton control stations mounted local to motors shall be of the weatherproof industrial duty type. Where appropriate, they shall be designed and certified for installation and use as appropriate for the designated area classification.
- b. Start / stop control stations shall normally be installed onto suitable steel supports adjacent to their respective motors. Lock-off type emergency stop push buttons shall be located adjacent to the motor in all cases where the control station is remote from the motor.

- c. Motors that can be started from more than one position or started automatically, controlled by a level switch, pressure switch or temperature switch etc., shall in addition, be controlled by a 'Local-Auto' selector switch mounted on the individual motor starter compartment
- d. Field mounted ammeters shall only be provided where specifically required and essential for process or operational purposes.
- e. No field mounted motor starter installation are allowed.

4.4 Power Transformers

- 4.4.1** Power Transformers shall be in accordance with the requirements of SANS 780 and SANS IEC 60076 sections 1 through to 10.
- 4.4.2** Transformers shall comply with the requirements of the project specification 2684358-U-A00-EL-SP-007.
- 4.4.3** Data sheets shall be prepared for each equipment item, detailing the specific requirements of the subject equipment.
- 4.4.4** Transformer standard kVA ratings shall be selected as defined in SANS standards. Transformers shall be rated to carry at least 125% of the estimated dual redundant maximum demand of the switchboard it is supplying. The rating shall be based on the naturally cooled full load temperature rise limits defined in the data sheets / specification. (See Sections 3.1.4 and 3.1.5).
- 4.4.5** Transformer nominal impedance shall preferably be selected from 'standard' values defined to result in the most economical design commensurate with:
 - limiting through fault short circuit current values to permit use of switchgear with standard certified short circuit current ratings
 - permitting the starting of the largest connected induction motors, direct-on-line whilst remaining within the voltage regulation requirements of sections 3.4.2 and 3.4.3.

4.5 Battery Charger Systems

4.5.1 General

Battery Charger systems shall be in accordance with the requirements of the Transnet Pipelines specifications: PL 647 and PL 648.

Data sheets shall be prepared for each equipment item, detailing the specific requirements of the subject equipment.

4.5.2 Switchgear Closing and Tripping Supply Unit

- a. The switchgear tripping supply nominal output voltage shall be 110V DC.
- b. Battery tripping equipment shall be located in the substation in close proximity to the switchboard serviced.
- c. Battery tripping systems shall be designed for a standby time of 24 hours.
- d. The rectifier and battery system shall be rated to supply the following loads:
 - Switchgear standing load, plus battery charging load, plus closing of two circuit breakers simultaneously - applies to rectifier only.

- Switchgear standing load for 24 hours plus tripping of all circuit breakers and latched switching devices twice in succession at the end of the 24 hours period - applies to battery system only.
- e. The battery shall be of the sealed type.

4.6 UPS System

4.6.1 General

UPS systems, shall be in accordance with the requirements of Transnet Pipelines specifications PL 720 and IEC 62040.

Data sheets shall be prepared for each equipment item, detailing the specific requirements of the subject equipment.

4.6.2 Station Control System UPS System

- a. The UPS system for plant control system / SCADA and communications equipment shall be located in the substation building.
- b. SCADA / Control system UPS shall be determined by the technical requirements of the Control System in terms of type, make, model and size.
- c. The UPS will require a serial communication interface to the control system to achieve an orderly shutdown of the control system.
- d. The UPS system supplying uninterruptible AC power to the plant control and information systems shall comprise a single train rectifier / inverter / battery system with the rectifier/inverter rated to supply 100% of the calculated system load. The system shall incorporate a bypass supply and static switch changeover system.
- e. Battery systems shall be designed with a standby minimum time of 30 minutes and shall be of the sealed lead-acid gas recombination type to SANS 1632.
- f. The nominal output voltage of the system shall be 220V, 50 Hz.
- g. Both the mains and bypass power supplies to the UPS system shall be derived directly from the station 400 V switchboard / MCC with a back-up supply from the standby diesel generator system. A 400 V / 230 V constant voltage transformer is required in the bypass supply link.

4.7 Electric Motors

4.7.1 General

- a. Motors shall normally be 3-phase squirrel cage induction type machines, totally enclosed, fan cooled and adequately rated for the duty required by the driven equipment. Motors shall be certified for use within hazardous areas. Motors for use in hazardous areas shall be Ex 'd' rated (Explosion proof), even if located in a Zone 2 area and shall have a minimum degree of protection of IP 55.
- b. Motors shall, whenever possible, be purchased as part of the driven equipment package.
- c. Data sheets shall be prepared for each motor, detailing the specific requirements of the subject machine.
- d. Where variable speed motors are employed with varying frequency inverter systems, the motors shall be designed and rated in a manner that the temperature rise of the motor under operating conditions will remain within safe limits over the entire speed range of the drive.
- e. The insulation levels of the motors are to be rated for use with VSD systems

with specific reference to the peak voltage levels. In addition, this added insulation requirement needs to be applied to the VSD cable ratings, primary and secondary.

- f. The design shall take into account the heating effect of harmonics generated by the rectifier inverter system and the decrease in cooling effect of fan cooling at reduced speeds.
- g. Where drives of this type are supplied for installation within hazardous areas, the motors shall be appropriately certified by the SANS (or a SANS recognised **local** test authority) as being suitable for use in combination with a variable speed drive unit within the designated hazardous area applicable to the locality of the proposed installation, i.e. it shall meet all requirements in respect of zone classification, gas grouping and temperature class for safe operation over the full speed range and respective load duty.

4.7.2 MV Motors

- a. Motors shall generally be in accordance with the requirements of project specification 2684358-U-A00-EL-SP-010, and IEC requirements IEC 60034 series.
- b. Motors shall be designed for operation on 3300V, 6600V or 11000V, 3 phase, 50 Hz power supply systems having an earthed neutral via NER. The NER shall be rated for 50 to 300A for 30 seconds. Final values will be determined by means of a system study.
- c. MV motors fed from vacuum circuit breakers shall be fitted with Zork surge suppression devices.
- d. MV motors shall be fitted with space heaters. Leads for space heaters shall be terminated in a box separate from the motor main power termination box.

4.7.3 LV Motors

- a. Motors shall generally be in accordance with the requirements of project specification 2684358-U-A00-EL-SP-005.
- b. Motors shall be designed for operation on a 400V, 3 phase, 50 Hz power supply system having a solidly earthed neutral.

4.8 Standby Generator

- 4.8.1** Where required standby diesel engine driven generator sets shall be supplied in accordance with Transnet Pipelines specifications PL 622H and IEC Specification IEC60034-22 - AC Generators for reciprocating internal combustion engine driven generating sets.
- 4.8.2** Alternators shall have continuous capacity 5 % higher than the base rating of the diesel engine driver at power factor from 0.80 lagging to 0.95 leading.
- 4.8.3** Alternators shall be totally enclosed, fan cooled, unless installed within a building or purpose-built container type enclosure, in which case an open ventilated drip-proof machine may be used.
- 4.8.4** Alternator stator winding shall be suitable for star connection with both ends of each phase winding brought out to the terminal housing.
- 4.8.5** Alternator exciter shall be a rotating brushless type, mounted on or coupled to the alternator shaft.
- 4.8.6** Alternators larger than 120 kVA shall be equipped with RTD (Resistance Temperature Detector) elements.
- 4.8.7** Alternators shall be equipped with space heaters.
- 4.8.8** A free-standing generator control panel shall be furnished for installation in the electrical substation. Electrical protection equipment shall be located in the generator circuit breaker or contactor cubicle.
- 4.8.9** The selected rating of diesel generators must ensure that the continuous running load on the generator will not be less than 50% of the engine rated output power in order to avoid problems associated with engine choking and resultant loss of reliability. (Note: The minimum rating of diesel generator sets shall be 60 kVA per Transnet Pipelines specification PL622H.
- 4.8.10** The day tank capacity shall cater for 12 hours run time fully loaded.

5 Facilities Design Requirements

5.1 Control and Administration Buildings

5.1.1 General

Buildings shall be located in non-hazardous areas to permit the use of industrial type equipment. A minimum distance of 15 meters from any source of hazard shall be allowed to the nearest point of any building. Buildings shall be conventional site built, single storey construction and shall be furnished with electrical services. Cable entries to the building shall be arranged for underground cables entering through the floor or in preformed cable trenches. In addition the substation buildings shall have concrete roofs.

5.2 Substation Buildings

5.2.1 General

- a. Electrical substation buildings shall be of brick construction with a concrete

roof.

- b. Substation buildings shall be located in non-hazardous areas to permit the use of standard industrial type switchgear. A minimum distance of 15 meters from any source of hazard shall be allowed to the nearest point of any substation building.
- c. Substations floors shall be elevated from grade to provide for a cable entry basement or preformed trenching access.
- d. Sleeved underground cable entries to the building shall be arranged for cable access. Draw boxes shall be provided to facilitate cable installation.
- e. Substations shall be pressurised to provide a dust free atmosphere. Where specified, air conditioning equipment shall be provided to maintain the temperature within the building at a maximum of 30°C. The air conditioning design temperature is selected to provide a margin below the switchgear operating temperatures of 35°C average and 40°C maximum.
- f. MV and LV switchgear equipment will not be located in the same room.
- g. Tripping Batteries shall be Valve Regulated Lead Acid type.
Note: Open rack Lead Acid mounted batteries, shall only be employed with Transnet Pipelines approval and shall be installed in a separately ventilated room, furnished to suit the special corrosive and hazardous environments.
- h. VSD equipment shall be located in a separate air conditioned room.
- i. Substations shall have a double door with a removable door panel to facilitate equipment removal at one end of the building and a personnel door at each end. Each personnel door is to be fitted with panic bar, and shall open outward.
- j. Diesel generator sets shall be located within a separate room of the substation building.
- k. Power transformers shall be located along the outside of the substation building in fenced enclosures a distance away from buildings.
- l. Transformers shall be mounted on a concrete foundation surrounded by a pebble filled / or grated pit, the capacity of which shall be at least equal to the volume of the oil in the transformer. The pit shall either drain into an oily water sewer or a sump be provided from which spillage can be pumped.
- m. Firewalls shall be provided between transformer bays whenever more than one transformer is installed, extending at least 300 mm above and 600 mm beyond the transformer. A minimum clearance of 800 mm shall be maintained between transformer extremities and the firewall.
- n. All safety labels to be installed within the various areas of plant equipment eg. HV, MV and LV Subs; LV generator rooms; pump house; etc.

5.2.2 Space Allocation

- a. Minimum working clearances around electrical equipment shall be as follows:
 - 1000 mm minimum from top of equipment to bottom of ceiling
 - 2500 mm between lines of switchgear
 - 1200 mm between rear of the equipment and wall
- b. 25 % spare space (or minimum one equipment enclosure tier) shall be allowed within substation buildings at each end of switchboard arrangements sufficient for the extension of the same.
- c. Extra space is reserved for operation and maintenance of electrical equipment in accordance with the manufacturer's requirements.

5.3 Earthing Installations

5.3.1 General

- a. A common earthing system shall be provided for electrical system equipment earthing, static protection and lightning protection. The earthing shall be in accordance with the requirements of the IP Model Code of Safe Practice - Part 1: Electrical 1991, SANS 10313, PL 727 and typical earthing drawing PL 727 except where further defined or modified by the requirements of the following sections.
- b. A ground resistivity survey shall be carried out to provide data on the ground conditions and the results applied to the related earthing system design.
- c. Major electrical equipment such as switchgear, transformers, distribution boards, floodlight towers or poles, control panels, and metallic frameworks for supporting same, shall be directly connected to the earthing system.
- d. Static earthing protection shall be provided by connecting steel structures, towers, vessels, tanks, and similar items to the common earthing system.
- e. Earthing connections to equipment shall be at purpose designed termination studs. Anchor bolts shall not be used.

5.3.2 Earthing Systems

- a. Earthing system shall be designed on the ring principle with interconnecting conductors as necessary. This ring shall be connected to earth electrodes or as required by the design parameters.
- b. Earthing system installations shall be carried out using PVC sheathed (green/yellow) stranded copper conductor earthing cable both above and below grade. The minimum size shall be 70 mm² except for branch conductors to equipment, which may be a minimum of 35 mm².
- c. Earthing conductors shall be run underground at a minimum depth of 500 mm below grade in unpaved areas. In paved areas, conductors may be run on rough grade, under paving. In general, earthing conductors shall be run on the same routes as power and other cable systems.
- d. Earthing conductors rising through paving or other concrete work shall be run in suitable protective sleeves, which shall project 75 mm above finished grade level.
- e. Earth electrode design shall take account of soil and sub-soil conditions at the respective pipeline facilities site locations. Earth electrodes shall, wherever possible, consist of driven rods and shall be directly connected to an earth busbar mounted above grade, by a short length of 70 mm² cable, PVC sheathed coloured green / yellow.
- f. Earth electrodes paralleled in a group, to reduce the earth resistance to the permissible value, shall be spaced apart a distance at least equal to the length of the buried electrode.
- g. The resistance of the common earthing system to the general mass of earth, measured at any point on the plant site, shall not exceed 1 ohm.

5.3.3 Electrical System Earthing

The method of system earthing at each voltage level shall be as defined in section 3.2.1 of this specification. The points at which system earth connections are to be applied shall be defined on the single line diagrams and earthing layout drawings.

The neutrals of alternators and transformers shall be connected to an adjacent earth electrode directly or through an earthing resistor, as required.

5.3.4 Electrical Equipment Earthing

- a. Frames of MV motors shall be connected to the earthing grid via a separate single core 70mm² PVC green earth wire run with the motor power cable.
- b. Frames of LV motors shall be connected to the earthing system within the motor terminal box by utilising the fourth core of the motor power cable.
- c. Note : For cable core sizes greater than 70mm², three core power cable shall be installed and a separate single core 70mm² PVC green earth wire run with the cable to the motor.
- d. A copper conductor, 70 mm² minimum, shall be solidly tied into an earth electrode system for earthing substation equipment in a ring formation.
- e. A main earthing ring conductor system shall be provided within substation buildings and other rooms containing electrical equipment e.g. control room. The earthing ring shall comprise a number of strategically positioned earthing busbars interconnected by at least a 70 mm² PVC sheathed conductor. The earthing ring shall also be interconnected with the common plant earthing system at a minimum of two separate points.

5.3.5 Static Bonding Connections

- a. Plant equipment items supplied as assembled units shall be connected to the plant earthing system by a minimum of two separate bonding conductors.
- b. Flanges of metallic piping systems that have insulated linings shall be bonded to ensure electrical continuity. A bond shall also be applied at any equipment connection. Flanged joints in other metallic piping systems shall be considered to be inherently electrically continuous.
- c. Pipelines shall only be connected to the earthing system where they enter and leave the battery limits. The requirements of cathodic protection systems shall be observed.
- d. Road and rail vehicle bonding facilities shall be installed at points in the plant, where classified hazardous products are loaded or unloaded from vehicles. Bonding facilities may also be required in non-hazardous areas if the product being handled is likely to give rise to a build up of static electricity in the vehicle, e.g. bulk powder loading / unloading. Bonding equipment shall incorporate integral local alarm facilities to alert operating personnel if the bonding connection becomes accidentally disconnected.

5.3.6 Computer / Instrumentation

- a. Appropriately sized earth ring and equipment connections shall be installed in control rooms and other instrumentation equipment rooms as appropriate, for Computer / Instrumentation earthing. The earthing ring used for equipment / enclosure earthing shall be connected to the common earthing system by a minimum of two separate conductors.
- b. An insulated earth ring shall be installed in the control room for an 'instrument high quality earth' of less than 1 ohm. This system shall be isolated from common earthing systems and building structures. It shall be connected to the substation main earth bar.
- c. Additional earthing systems shall be installed for earthing of intrinsically safe type equipment. Requirements shall be as for the 'clean' earth system.

5.3.7 Lightning protection

A lightning study shall be carried out to provide data on the lightning conditions and the results applied shall be applied to the related lightning protection system design after having been reviewed and accepted by Transnet Pipelines.

Where applicable, tall or isolated structures shall be protected against lightning in accordance with SANS 10313.

- a. Where applicable, tall or isolated structures shall be protected against lightning in accordance with SANS 10313.
- b. Down conductors from air terminals or lightning poles shall be provided with an individual earth electrode as well as a connection to the common earthing system. The resistance to the general mass of earth at individual earth electrodes shall be a minimum of 1 ohms.
- c. Provided they are electrically continuous, tall steel structures such as towers or structure columns shall be considered inherently protected against lightning by their connection to the plant earthing system. Bonds across joints may be used to ensure electrical continuity wherever necessary.

5.4 Lighting

5.4.1 Lighting Facilities

- a. Lighting facilities shall generally consist of: All designs to comply with Transnet energy efficiency strategy. LED technology shall be employed.

- A system for supplying "switched" lighting circuits and 230V switched socket outlet circuits that will be permanently energized under normal operating conditions.
- An outdoor lighting system that is only energized at night and which is controlled by a light sensitive switch/photocell (or timer when specified) and contactor arrangement. (Note: in remote stations this facility may additionally be switched).
- Perimeter and mid-area lighting poles shall be mid-hinged.
- The above mentioned systems shall also contain a percentage of lights designated to transfer from the normal to the emergency / diesel generator standby power system whenever the main power supply fails.

- b. The facilities of each system shall as a minimum consist of:

- A Low Voltage distribution switchboard located within the 400V switchboard / MCC within the substation building.
- Miscellaneous sub distribution boards as may be required.
- An area lighting distribution board containing 3 phase, and single phase double pole circuit-breakers located within the 400V switchboard / MCC in the substation building.

Note: The area lighting distribution board shall contain an automatic mains fail change over system which shall transfer designated lighting circuitry onto the emergency / diesel generator backup supply in the event of a mains failure. This distribution board shall also contain an area lighting day - night contactor panel which shall switch on the area lighting at night. The contactor control may be affected by a light sensitive switch or a 24 hour timer. A maintenance by-pass switch shall be installed in the distribution board for the purposes of checking the lighting during the daytime.

(Note: in remote stations this facility may additionally be switched and the lights left off during the times when the station is unmanned).

- Transnet Pipelines approved light fittings, switched socket outlets, junction boxes, mid – hinged poles and fixture support structures.

5.4.2 Lighting Fittings

- a. For the purpose of standardization of the various types of fixtures throughout the various Transnet Pipelines sites of hazardous areas and floodlight fixtures, Transnet Pipelines will select the preferred manufacturer of these items. Specific details will be shown on the lighting layout drawings and / or will be stipulated in the RFP or Contract documentation.
- b. In general, luminaires for illumination at grade and on operating platforms shall be energy efficient type.
- c. Lighting fixtures for installation within hazardous areas shall be appropriately certified industrial type from a Transnet Pipelines approved supplier.
- d. Lighting fixtures for switch rooms shall be energy efficient type, surface mounted industrial type.
- e. Lighting fixtures for station offices and / or Control rooms shall be surface or flush mounted commercial type.
- f. Lighting fixture type to be approved by Transnet Pipelines prior procurement.

5.4.3 Illumination levels

- a. The illumination levels attained for normal lighting shall conform to the requirements of the OHS Act, as scheduled in the associated environmental regulations for work places, and any subsequent modifications to the schedule made by the Chief Inspector by notice in the Government Gazette.
- b. The recommended illumination levels shall be used for design purposes as the minimum maintained levels. Initial lighting level designs must make allowance for a maintenance-ageing factor.
- c. In all respects, lighting installations shall be in conformance with SANS 10098, SANS 10114, Part 1 and SANS 10142.
- d. Lighting on rotating machinery must be such that the hazard of stroboscopic effects is eliminated.
- e. Glare in any workplace shall be reduced to a level that does not impair vision. The use of antiglare lamps in computer and control rooms shall also be evaluated and considered during the design.
- f. The final illumination levels shall be measured at the elevations listed above grade or at floor level and between two adjacent lighting fixtures.
- g. Illumination levels and glare index shall be in accordance with the recommendations made in the SANS codes of practice. Typical minimum values applicable to Transnet Pipelines projects are given in the table below. Refer also to the Specification 2684358-U-A00-EL-SP-011: Lighting Installations.

<u>Location</u>	<u>Luminance (Lux)</u> <u>Horizontal Plane</u>
<u>General and Operating Areas</u>	
Pump rows, valves, manifolds	100
Mainline Pumps	100
Platforms (General area)	40

Operating Platforms	75
Gangways, catwalks, stairways (at floor level)	20
Ladders and stairs	50
General areas	25 at grade
Security fence	5 at grade
Pump station main entrances/exits	50
Marshalling yards	10

Pump station and Buildings

Instrument Panel	200 (vertical)
Console	300 at 750 mm
Back of Panel	200 (vertical)
General Area	300 – 400
Control room	200
Emergency (Control Room only)	20 at ground level
Pump house/room	100
Control laboratories and testing	200
Standby generator room	100
Battery and charging equipment rooms	100
Purge air/pressurisation fan rooms	100

Substation Buildings and Yard Areas

General Area - Indoor	150
General Area - Outdoor	25
General Area - Emergency	10
HV yard and transformer terrain	20
HT and LT switchgear rooms	150
Relay and telecommunications rooms	100
Transformer rooms	75

Buildings

Workshops (rough work)	300 + local lights for fine work
Locker Rooms and Toilets	100
Laboratories and Offices	300
General rooms/offices	300
Stairs and corridors	100

Workshops and Machine Shops

General work areas	100
Tool rooms and work benches	250
Medium soldering, brazing and welding	300
Fine soldering and spot welding	500
Repair of fine work e.g. instrumentation	500
Inspection and calibration areas	500

Storage Tank Areas

Tank - stairs, ladders	50
External Apron	20
Pump and manifold areas	75
General area (where required)	25

Loading Racks

General Area	50
Road Car - loading points	150
Rail Car - loading points	100

Street Lighting

Heavy Traffic (main)	25
Light Traffic (secondary)	5

5.4.4 General Requirements

- a. Lighting to be energy efficient as a rule.
- b. For general area and perimeter lighting, it is preferred not to use high mast light poles, e.g. hoisting cable mechanism; only different lengths of mid-hinged poles.
- c. Luminaires shall be spaced to provide uniform lighting distribution on the working surfaces, and in general be arranged for a symmetrical appearance.
- d. A maintenance factor of 70 % shall be used in design calculations and the lumen output of lamps shall be the "average through life" value.
- e. The sub-circuit loading on each lighting distribution board shall be as follows:
 - Maximum current per circuit = 10 amps (with 16 amp protective device).
 - Loading for discharge lamps (including fluorescent) = Rated lamp (watts) plus ballast load.
- f. Emergency lighting shall be provided as follows:
 - Skeleton lighting in Control and Substation buildings.
 - Anti-stumble lighting in operating areas.
 - Local lighting at critical process points and local instrument panels.
 - Stairways and escape routes
- g. It is the purpose of the emergency lighting to allow safe movement of personnel rather than provide a high level of illumination. The emergency lighting system shall thus provide for a safe minimum illumination level in all working areas within the station.
- h. The Environmental Regulations for Work Places of the OHS Act requires that emergency escape lighting be installed in all indoor work places without natural lighting. The level of luminance for emergency installations within buildings shall not be less than 20 lux at ground level.
- i. Emergency light sources shall last long enough to ensure the safe shutdown of the plant and possible evacuation of the workplace.
- j. All single-phase circuit-breakers, supplying 230V socket outlet circuits, shall be provided with earth leakage protection.
- k. When feeding installations within hazardous areas, circuit-breakers shall be double-pole to isolate both phase and neutral in accordance with SANS 10089.
- l. The installation methods for lighting fixtures shall be designed for the environment and hazardous area classification in which they are installed.
- m. All lighting fixtures shall be rigidly mounted and firmly fixed to their supports. Installations shall be arranged for ease of maintenance.
- n. Lighting circuits shall be protected by 16 Amp, single-pole breakers. The maximum load on any branch circuit shall not exceed 12 Amps.
- o. Floodlighting fixtures shall be mounted on Transnet Pipelines approved reinforced concrete or galvanised steel poles.
- p. Where floodlights are mounted on poles (or high masts) at a height in excess of 8m, or where the poles are located in areas inaccessible to

vehicle mounted hydraulic work platforms, raising and lowering gear for maintenance of the floodlights or hinged type scissor masts shall be provided.

- q. When economically viable to do so the use of floodlighting shall be maximized in operating areas, to eliminate the requirement for several locally mounted fluorescent fixtures.
- r. All metallic components of light fittings shall be securely bonded to the station safety earth.

5.4.5 Operating Plant Lighting

- a. Luminaires in operations areas shall be solidly fixed and not suspended by means of items such as chains and conduits. They shall be mounted such that routine operations and reasonable maintenance can be conducted with safety and without the use of temporary scaffolding.
- b. Luminaires for illumination at grade shall be mounted at a minimum height of 2200 mm to underside of luminaires, unless specific conditions require otherwise. Typical installation standard detail drawings shall be prepared and defined on layout drawings for each luminaire location.
- c. Use shall be made of floodlights for general lighting of outdoor open areas. Floodlighting luminaires shall be mounted at sufficient elevation and directed so as not to be objectionable or dazzling to operating personnel. Plant structures shall be used where possible for mounting such floodlights, but where poles or towers are used, safe access and a working platform shall be provided for re-lamping and servicing.
- d. Luminaires for general illumination shall be located as close as possible to items such as instruments and gauges so that special lighting is unnecessary.
- e. The site area lighting shall be controlled by 24 hour timers with manual switching where required and over-ride facilities.
- f. Local lighting switches shall generally only be provided in enclosed buildings or as detailed in section 5.4.5(g).
- g. Lighting switches and MCB distribution boards shall normally be located in the nearest substation. Where necessary: fused cut-outs or MCB units shall be provided on each floodlight pole.

5.4.6 Road Lighting

- a. Road lighting shall be provided on all permanent metalled roads within the site plot limits only when it is not possible to provide adequate illumination using area and / or perimeter fence floodlighting.
- b. Road lighting installations shall comply with the relevant SANS standards.
- c. Lighting poles shall support luminaires at a minimum clear height of 6 metres above the finished road surface. Poles to present minimum obstruction to the movement of wide equipment packages on plant roadways.
- d. Luminaire types and pole spacing shall be selected to achieve the required levels of illuminance and provide the most economic installation.
- e. Power distribution from the station main substation to lighting poles shall be at 400 V, 3 phase, 4 wire, 50 Hz. A junction arrangement shall be provided in the base of each lighting pole, which shall incorporate a MCB and looping terminals suitable for the termination of 4-core power supply cables. The power supply shall be derived directly from a feeder in the 400 V, 3 phase, 4-wire switchboard from the dedicated area lighting distribution board. The arrangement selected shall be the most cost

effective, taking account of the number and rating of feeders required. The power supply to street lighting circuits shall be switched by a 24 hour timer. Manual switching facilities and a manual override shall be provided.

- f. Wherever possible lighting poles shall be sited in areas classified as non-hazardous. In the event that poles have to be sited in hazardous areas the selection of the luminaire shall be made accordingly and the fused cut-out shall be replaced by a MCB unit certified for installation and use as appropriate to the area classification.

5.4.7 Perimeter/Security Lighting

- a. Lighting provided to illuminate perimeter security fences shall be fed from the permanent power supply via an area lighting day-night contactor controlled distribution system.
- b. Lighting poles shall support luminaires at a minimum clear height of 6 metres above grade.
- c. Luminaire types and pole spacing shall be selected to achieve the required levels of illuminance and provide the most economic installation.
- d. Power distribution from the plant main substation to lighting pole shall be at 400 V, 3 phase, 4 wire, 50 Hz. A MCB shall be provided in the base of each lighting pole, which shall incorporate, looping terminals for termination of a 4-core power supply cable. The power supply shall be derived either directly from a feeder(s) in the 400 V plant switchboard or from a dedicated distribution board. The arrangement selected shall be the most cost effective, taking account of the number and rating of feeders required. The power supply to perimeter lighting circuits shall be switched by a 24 hour timer. Manual switching facilities and a manual override shall be provided.
- e. Wherever possible lighting poles shall be sited in areas classified as non-hazardous. In the event that poles have to be sited in hazardous areas the selection of the luminaire MCB unit and installation materials shall be suitable for installation in the hazardous area.

5.4.8 Building Lighting

Lighting requirements in plant buildings located in non-hazardous areas are defined above in paragraph 5.4.3.

Lighting for control room instrument panels and similar installations shall be designed to illuminate the vertical panel with glare free uniform intensity.

5.5 Cable and Wiring System

5.5.1 General

- a. Electric Cables shall comply with the relevant SANS Specifications.
- b. Cable and wiring design to comply with Transnet Pipelines specification PL 727. No cable joints are allowed.
- c. Low voltage cables for operation at 600 V or below and used for items such as power, control, and distribution board feeders shall have stranded copper conductors, PVC insulation, extruded PVC bedding, steel wire armour and PVC sheath overall, except for single-core cables which shall

have non-magnetic armour. Minimum conductor size shall be 2.5 mm², **except for signal cable to ETM/L panels which shall be 1.5mm²**. Cables shall be flame retardant and UV resistant.

- d. Sub-circuit cables for lighting, socket outlets, and other circuits may be run above ground in similar cable to that detailed in Section 5.5.1.2 of this specification. Minimum conductor size for lighting circuits shall be 2.5 mm² stranded copper.
- e. Cables shall be installed in directly buried sleeves, suitably sized for the cable, with adequate free space to ease the installation of the cable. The sleeves shall be of a material that can tolerate hydro-carbon contamination or adverse soil conditions (e.g. sulphate reducing bacteria).
- f. Due regard shall be paid to the routing of power cables with respect to electronic instrumentation and other similar low power systems to avoid interference. A minimum separation of 600 mm. shall be allowed between long parallel runs of power and control systems cabling. Where cable routes cross at 90 degrees, a vertical separation of 150 mm minimum shall be acceptable.
- g. Small power reticulation in buildings shall consists of conduit or trunking with the respective colour coding: Raw Power(orange); UPS Power (purple); Data(blue); Fire(red).
- h. The wire shall be general purpose house wire 1000v rating and shall comply to SANS 10142-1 for the current capacity requires of intended use.

5.5.2 Cable Sizing and Selection

- a. The short time maximum current carrying capacity of cables shall be considered in conjunction with the current time setting of the electrical network protective system, to ensure that cables do not suffer damage under maximum through fault conditions. The cross-sectional areas of cross-linked polyethylene (XLPE) or EPR insulated cables relative to prospective fault currents shall be assessed from manufacturer's data.
- b. Cables shall be sized according to the procedures and requirements set out in the SANS 1507 and SANS 10142 considering the following parameters:
 - Continuous current rating
 - Voltage drop restrictions
 - Short circuit current rating
 - Earth loop impedance
- c. Manufacturer's data and rating tables shall be used, when available, for the specific cable type, however in the absence of such information, the ratings etc given in the respective parts of ERA Report 69/30 shall be used.
- d. Appropriate rating factors as tabled in manufacturer's data shall be applied in all cases for the following installation parameters:
 - Depth of laying
 - Ground temperature
 - Air temperature
 - Grouping of cables

- e. The above parameters shall be determined for the installation from either site-measured data or established published data for similar installation conditions.
- f. The voltage drop on distribution network cables shall comply with the parameters defined in section 3.4.

5.5.3 Underground Installations

- a. Cables run underground shall be installed in sleeving with draw boxes provided at suitable intervals to facilitate the installation of the cables. 25% spare sleeving shall be provided to facilitate future additions.
- b. The routing and arrangement of underground cables, particularly in areas adjacent to substations and control houses, shall be planned concurrently with main pipe routes and vehicle access ways, to give as far as possible, unimpeded direct routes.
- c. Medium Voltage distribution cables to on-plot substations shall be installed in separate / segregated trenches and arranged in a single layer. Depth of trench shall be 1000 mm. Pilot and control cables shall be laid alongside their respective feeder cable. Spacing between centres of feeder cables shall be minimum 225 mm.
- d. 400 V cables may be installed in a trench with up to two layers. Minimum depth to top side of LV cables shall be 750 mm.
- e. Spacing between continuous current carrying LV cables shall be 150 mm. Care shall be taken to locate loaded and unloaded cables alternately where possible to minimise the effects of group de-rating factors.
- f. Cables shall be laid on 75 mm of sand and covered with 75 mm of sand. The sand shall be screened to remove sharp objects and compacted to eliminate voids. Two layers of marker tape shall be installed over the cables as indicated on the standard drawings. The sand provided shall have been selected for the most favourable thermal grading available.
- g. Motor control cables shall be laid alongside their respective motor power cable.
- h. Single-core cables shall be run in trefoil formation held in place by suitable strapping. Where metal sheathed single core cables are used, the metal sheath shall be bonded at the switchboard end only.
- i. No cables shall be run directly beneath pipes that follow the same direction as the cables, whether the pipes are laid directly in the ground or above ground.
- j. Cable routes in unpaved areas shall be marked with reinforced concrete marker posts, located at each change of direction of the route and at no more than 25 m spacing on straight sections. In paved areas, marker discs embedded in the paving shall identify the trench route.

5.5.4 Above Ground Installations and Support Systems

- a. Cable trays or ladder racks supported from structures shall be used for overhead multiple cable runs and cables shall be adequately secured in a single layer. Individual cables may be clipped and supported directly to structures, but where such structures are fireproofed, cables shall be clipped to cable tray or supported clear of fireproofing.
- b. Cable clips for securing PVC sheathed cables to the tray shall be purpose or site fabricated from PVC sheathed stainless steel strips.

- c. Overhead cables shall not be routed close to steel pipelines. A minimum distance of 500 mm shall be maintained between pipes and cables.
- d. Overhead cable tray / ladder rack shall be hot-dipped galvanised steel.
- e. Tray / ladder rack shall be run vertically only.
- f. Straight sections and fittings shall have the provision for covers to be fitted when required for a specific installation.
- g. Cable tray / ladder rack proprietary accessories shall be used if available to limit the amount of site fabrication.
- h. Proprietary tray / ladder rack factory supplied fabricated sections e.g. bends, tees, joint kits etc., shall be selected from a manufacturers component system and shall be identical to straight sections in materials, rung spacing, and strength.
- i. Cable tray / ladder rack installation shall be connected to the common earth system in compliance with Transnet Pipelines specification PL 727.
- j. The maximum straight section length of cable tray, when fully loaded in accordance with the manufacturer's recommendation, shall have a minimum safety factor of 1.5.

5.5.5 Cable Terminations

- a. All cable terminations shall use compression type cable glands complying with the requirements of SANS 1213. Glands shall be manufactured in brass and shall be fitted with sealing washers as appropriate to installation conditions. Glands installed on classified electrical equipment installed in hazardous areas shall be suitably certified. The installation requirements of the respective protection class and certification shall be observed. Cable glands having dual EEx d / EEx e certifications are preferred.
- b. Medium voltage terminations shall use terminal box designs suitable for the following alternative termination types:
 - 'Raychem' heat shrink termination kits or equal.
 - 'Elastimold' connectors and bushings or equal.
 - 'Cold Shrink' terminations or equal.
- c. The cable conductors of all terminations shall be fitted with properly sized crimped wire pins, or cable lugs selected on the basis of conductor size and terminal type. Bare copper wire terminations will not be allowed.

5.5.6 Cable Identification and Schedules

- a. Power cables shall be identified at each end, and where they enter or leave underground ducts, by permanent stainless steel identification tags, bearing the cable reference number allocated on the cable schedules.
- b. Cores of both multi-core and single-core cables shall be suitably marked at their termination point with ferrules in accordance with the wire or terminal identification shown on connection diagrams. Core ids shall be of the approved printed labels.
- c. Cable terminations at motors and starters shall be made following the positive identification sequence (1-2-3) or (R-Y-B) of the conductors in accordance with the specified phase rotation sequence of the power supply.
- d. Cables, except sub-circuits for lighting and socket outlets, shall be identified in accordance with cable schedules. To indicate the service for

which the cable is to be utilised, the overall sheath will be coloured as follows:

<i>Application</i>	<i>Sheath Colour</i>
11 kV / 6.6 kV and 3.3 kV Cables	Black
600 / 1000V Cables	Black
Communication	Brown

- e. Cables will be allocated a cable type reference, which shall also be used as a drum number prefix. Details shall be included on the project cable schedule.

5.6 Electric Surface Heating Systems

- a. Electric trace heating systems shall be designed and installed in accordance with Transnet Pipelines approved designs.
- b. Electric trace heating systems for winterisation (freeze protection) shall be applied to piping systems, vessels, etc. as defined on P & ID drawings and the piping line list.
- c. Heaters applied to pipelines / equipment for winterisation purposes shall preferably be of the self-limiting type.
- d. Electric surface heaters and all components and accessories to be installed in a designated classified area shall be certified, as a system, for installation within the designated Zone classification.
- e. Heater circuits shall be controlled by air thermostat(s) set to switch 'ON' and 'OFF' between project specified temperature limits. Thermostats used to control heater circuits shall be provided with manual override, except when used as high temperature limiting cut-outs for the purposes of complying with hazardous area certification requirements.

5.7 Socket Outlets

5.7.1 General

Socket outlets of the types outlined in the following sections shall be provided for maintenance and inspection purposes.

5.7.2 Welding Socket Outlets

- a. Outlets shall be provided and distributed in plant areas for portable welding supplies and other power requirements. Socket outlets shall be of a Transnet Pipelines approved single standardised type for installation in non-hazardous areas only, such that plugs used on portable equipment will be of a common pattern.
- b. 63 amps, 400V, 3-phase, 3-wire plus earth, EEx d certified switched socket units shall be used. No more than two outlets shall be connected to any single circuit, which shall in turn be supplied from a 63 amp MCCB / residual current feeder circuit breaker on the station LV switchboard.

5.7.3 Switched Socket Outlets

- a. 230V switched socket outlets shall be provided in the operating areas located on the basis of being accessible by use of a 25 m extension lead. Socket outlets shall be of a single standardised type in both hazardous and non-hazardous areas such that plugs used on portable equipment will be of a common pattern.
- b. Not more than eight outlets shall be served from a single circuit derived from a 16 amp MCB / residual current circuit breaker on a distribution board in the substation.
- c. The socket outlets shall be 16 amps, 230V, 3-pin (double pole and earth), EEx 'd' certified switched or unswitched as required for the application.
- d. Matching plugs shall be supplied on the basis of one for each outlet.

5.7.4 Cathodic Protection

- a. Cathodic protection shall be provided for underground structures, submerged structures, tankage and other metallic structures as and where required.
- b. A Transnet Pipelines approved contractor shall be appointed to conduct soils surveys, recommend, engineer, design and implement the necessary cathodic protection systems.
- c. Bonding Wire and cable for the cathodic protection systems shall be PVC insulated and coloured red for conductors at the +VE potential and black for the conductors at the -VE potential. In process areas susceptible to chemical contamination, such cables shall be PVC insulated and be jacketed with a nylon oversheath.

Preferred Equipment List

HV Yard Equipment

	<u>Make</u>
Links	Actom
Primary Circuit Breakers	Actom
Voltage Transformers	Actom
Current Transformers	Actom
Main Distribution Transformers	Actom

MV Substation Equipment

Switchgear	ABB/Siemens
Protection Relays	ABB/Siemens
Variable Speed Drives	ABB
Battery Charger	Blue Ginger
Power and Check Metering	Schneider

LV Equipment

Auxiliary Distribution transformers	Powertech
LV MCC's/Panels	ABB/Siemens
Actuators	Rotork
Standby Generators	Cummins with Stanford Alternators / Generator Controls
UPS	Eaton

3.3kV MV Motors

Mainline Motors	ABB/Acton
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