Electrical Design Criteria

PL666

Rev.001

AMENDMENT RECORD

REV	REV DATE	CHG REQ NO.	CHANGE SUMMARY	PAGES AFFECTED
001	16.05.2016		Small power wiring requirements in buildings.	34
002	21.10.2019		Updated lighting lux levels	

Contents

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 Symbology 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 Hexafloride (SF_6) for use in Electrical Equipment
IEC 60439	Low voltage Switchboards and Control Assemblies
IEC 60445	Basic and Safety Principals 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	Uninteruptible 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	Metalic 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 Kennzeichung – 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 Bucholz 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 ≤ 15kW DOL starting
   - LV motors > 15kW –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^{o}C. The air conditioning design temperature is selected to provide a margin below the switchgear operating temperatures of 35^{o}C average and 40^{o}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 attached Annexure.

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. Luminares 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 mm^2, except for signal cable to ETM/L panels which shall be 1.5mm^2. 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 mm^2 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 idents shall be of the approved printed lables.

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:

Application	***Sheath Colour***
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	Make
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

DRAWING OFFICE STANDARD (PL100)

DOCUMENT APPROVAL PROCESS

NAME		POSITION/MEETING NO.	SIGNATURE	DATE
Originator:	Zandile Moloi	Drawing Office Manager		20/06/2016
Approver:	Petros Khumalo	Technical Support Manager		30-06-2016
Original date: 15 June 2016				
Effective date: 06 July 2016				

TABLE OF CONTENT

1. INTRODUCTION

The objective of this Drawing Standards Document is to establish a set of approved drawing standards and codes of practise that shall be required to be adhered to by both Contractor and Client in the preparation of Engineering Documentation for and on behalf of Transnet Pipelines, a Division of Transnet Limited. By ensuring comprehensive, consistent and uniform means of presentation of information, these Standards and Codes of Practise are intended to facilitate rapid comprehension by the users of the information, and thus assist in the maintenance and fault finding of installed technology.

2. SCOPE

2.1. General

This document defines as a minimum, the general responsibilities for the provision of all Engineering Documentation, whether it be by the Client or Contractor, for and on behalf of Transnet Pipelines. In this regard, providers of Engineering Documentation are required to familiarise themselves with all applicable Standards and Codes of Practice listed herein, and to ensure compliance in the execution of any work in terms of this document. Failure to comply may render the provider liable for corrections at his own cost.

These Standards and Codes of Practise should be read in conjunction with all other Specifications and drawings as issued for a particular contract. Where discrepancies occur, these must be brought to the attention of Transnet Pipelines in writing before commencement of work. In the event of any conflict between the contents of any documents forming part of a contract (as listed in the Schedule of Contract Documents) and this document, the former shall prevail.

This Drawing Standards Document PL100 incorporates two sections as follows:

Section A - General Standards

Incorporating Standards PL 101 to PL 103, detailing Plant and Equipment Tag Numbering, Symbology and General Drawing Standards to be adhered to in the production of Engineering Documentation for and on behalf of Transnet Pipelines

Section B - Documentation Typicals / Design Documentation

Incorporating typicals of all Drawing and Documentation Types. These typicals have been incorporated into the Standards Document for the purposes of conveying both layout and content requirements to be adhered to in the production of Engineering Documentation for and on behalf of Transnet Pipelines.

Prior to commencement of design, contractors are required to request typicals of all relevant Drawings and Documentation to be produced, and should ensure adherence in both content and layout standards.

Where Contractors wish to deviate from specified typicals, either in layout or information content, approval will be required to be obtained from Transnet Pipelines prior to commencement of work.

Typicals exist for the following types of documentation:

Process Flows/ Diagrams Documentation Standards

- Piping & Instrumentation Diagrams (P&IDs)
- Process Flow Diagrams (PFDs)
- Heating Ventilation & Air Conditioning (HVAC)
- Hazardous Area Classification Diagrams
- Hazop Studies

Metering & Instrumentation Documentation Standards

- Instrument Schedules
- Instrument Data Sheets
- Instrument Hook-up Diagrams
- Loop Reports/ Drawings
- Panel Layout and General Arrangements
- Panel Wiring Diagrams
- Cable Schedules (Refer to Electrical Typicals)
- Cable Block Diagrams (Refer to Electrical Typicals)
- Cable Interface Wiring Diagrams
- Safety Integrity Levels (SILs) Report

Software Documentation Standards

- Plant Input/ Output (I/O) Schedules
- Flow Charts
- Software Listings

Electrical Documentation Standards

- Single Line Diagrams
- Electrical Schematic & Wiring Diagrams
- Panel Layout and General Arrangements
- Cable Schedules
- Cable Block Diagrams
- Cable Interface Wiring Diagrams
- Connection/ Hook-up Diagrams

Mechanical Documentation Standards

- General Arrangement/ 3D CAD views of Piping, Structural Steel & Mechanical, Installations.
- Layout Drawings/ 3D model Isometric views
- Underground Drawings
- Piping – Analysis, Calculations, Studies, Reports

Civil/Site Layout & Survey Documentation Standards

- Trenching and Services Layout Diagrams
- Earthing Reticulation Diagrams
- Cable Routing Reticulation Diagrams
- Structural Arrangement Drawings
- Structural Fire Protection Drawings
- Structural Steel Detail Drawings
- Foundation Drawings
- Pipe/ Ducting Support Drawings
- Weight Reports
- Structural Analysis Design Reports

2.2. Application to Work Activities

The Standards and Codes of Practice contained herein are suitable for use whenever Engineering Documentation is required to be produced and includes amongst others the following:

- Design Sketches
- Technical Data and manufacturer's technical literature
- Equipment Identification and Tagging
- Construction Drawings
- Specifications, both Functional and Technical
- Installation, operating and maintenance instructions, drawings and records

3. REFERENCE DOCUMENTATION

The following standard specifications are to be used for reference purposes and need to be noted by Tenderers in order to signify familiarity and compliance with the requirements. It is expected of Tenderers that they be familiar with the applicable clauses and that these will be adhered to in the execution of any work in terms of this specification.

A. Standards and Recommended Practices for Instrumentation and Control, 11th Edition, Instrument Society of America.

- ANSI/ISA-5.1-2009 : Instrumentation Symbols and Identification
- ISA-S5.3-1983 : Graphic Symbols for DCS/Shared Display Instrumentation, Logic & Computer Systems
- ISA-S5.4-1991 : Instrument Loop Diagrams
- ANSI/ISA-S5.5-1985 : Graphic Symbols for Process Displays

B. Graphical Symbols for Electrical Diagrams NRS 002-2000 second edition

C. International Electro technical Commission Standards for Electrical Drawings

- IEC Publication 27 : Letter Symbols to be used in Electrical Technology
- IEC Publication 50 : International Electro technical Vocabulary
- IEC Publication 617 : Graphical Symbols for Diagrams

D. SANS-10111-1-2011 Engineering Standard

E. TPL-TECH-I-POL-001 - Measurement Policy
F. TPL-TECH-I-POL-002 - Control Policy
G. TPL-TECH-I-POL-003 - Instrumentation Policy

4. ABBREVIATIONS

For the purpose of understanding these Standards, the following abbreviations apply.

ANSI : American National Standards Institute
C & I : Control and Instrumentation
IEC : International Electrotechnical Commission
ISA : Instrument Society of America
SABS : South African Bureau of Standards
ASA : American Standards Association

5. APPENDICES

General Standards

- PL 101 - Plant & Equipment Tag Numbering Standards
- PL 102 - Equipment, Instrument and Electrical Symbology Standards
- PL 103 - General Drawing Standards

6. DOCUMENT CHANGE HISTORY:

The owner of this document is responsible for the revision and control of the document, including updating of the table below, which contains the history of the document with details of each revision.

Date	Previous Rev No.	New Rev No.	Details of Revision
15.01.99	00	01	Document approved for distribution
30.07.99	01	02	Doc Typicals – Typicals and Rev No's added
15.04.01	02	03	Doc Typicals – Changed to On Request basis
12.06.12	03	04	New Transnet Standard Template Adopted
13.04.16	04	05	Document review & New Template

This table summarises what has been changed in the document so that it is easy to keep track of the effected changes.

DRAWING OFFICE STANDARD (PL101)

DOCUMENT APPROVAL PROCESS

NAME		POSITION/MEETING NO.	SIGNATURE	DATE
Originator:	Zandile Moloi	Drawing Office Manager		20/06/2016
Approver:	Petros Khumalo	Technical Support Manager		30-06-2016
Original date: 15 June 2016				
Effective date: 06 July 2016				

TABLE OF CONTENT

1. INTRODUCTION

The purpose of this standard is to establish a uniform means of designating and identifying plant and equipment installed on the respective pump station sites within Transnet Pipelines, a Division of Transnet Limited. The designation systems detailed below have been designed to cater for both technical as well as financial/management requirements and are proposed to be integrated on both the AutoCAD P&ID (technical) and SAP R3 (financial/management) platforms throughout Transnet Pipelines. (For details of integration onto the SAP R3 platform, the reader is referred to Addendum No.1 attached).

By ensuring a comprehensive, consistent and uniform means of plant and equipment designation, it is hoped that this Standard will assist in the rapid identification of plant and equipment installed at the respective Transnet Pipelines sites, assimilation of design information associated with the plant and equipment installed, and assistance with the maintenance and fault finding history of installed technology.

2. SCOPE

2.1. General

This document defines identification and tag numbering standards to be adhered to in the tagging and identification of the following instrumentation, plant & equipment as installed on the respective Transnet Pipelines Pump Station sites:

- Process Plant (e.g. receivers, strainers etc.)
- Process Equipment (e.g. valves, pumps, motors etc.)
- Electrical Distribution Equipment (e.g. transformers, breakers, etc.)
- Instrumentation
- Electrical and Instrument Panels (Switchgear, DB Boards, PLC Panels, Junction Boxes)
- Electrical & Instrument Cabling
- Process Piping

These Standards are required to be adhered to by both Client and Contractor alike, for and on behalf of Transnet Pipelines. Both Client and Contractor will be required to familiarise themselves with all applicable Standards and Codes of Practise listed herein, and to ensure compliance in the execution of any work in terms of this document. Failure to comply may render the provider liable for corrections at his own cost.

These Standards should be read in conjunction with all other specifications and drawings as issued for a particular contract. Where discrepancies occur, these must be brought to the attention of Transnet Pipelines in writing before commencement of work. In the event of any conflict between the contents of any documents forming part of a contract (as listed in the Schedule of Contract Documents) and this document, the former shall prevail.

2.2. Application to Work Activities

The Standards contained herein are suitable for use whenever plant and equipment are required to be identified or tagged, for the purposes of engineering design or installation on any of the respective Transnet Pipelines Pump Station Sites. These Standards thus cover designation of the following plant and equipment:

- Process Plant (e.g. receivers, strainers etc.)
- Process Equipment (e.g. valves, pumps, motors etc.)
- Electrical Distribution Equipment (e.g. transformers, breakers, etc.)
- Instrumentation
- Electrical and Instrument Panels (Switchgear, DB Boards, PLC Panels, Junction Boxes)
- Electrical & Instrument Cabling
- Process Piping

3. REFERENCE DOCUMENTATION

3.1. Plant and Equipment can be identified on Transnet Pipelines Sites using two forms of Identifiers; namely, by Function using the Function Designation System (identified by the prefix " = "), or by Location using the Location Designation System (identified by the prefix " + "). In this regard the following documentation included in the Appendices (Appendix 1) attached details each Standard:

FUNCTIONAL DESIGNATION	PL 118736	Plant & Equipment
	PL 118737	Instrumentation
	PL 118738	Panels
	PL 118739	Cabling
	PL 118740	Process Piping
LOCATION DESIGNATION	PL 118741	Panels

3.2. The following standard specifications are to be used for reference purposes and need to be noted by Tenderers in order to signify familiarity and compliance with the requirements. It is expected of Tenderers that they be familiar with the applicable clauses and that these will be adhered to in the execution of any work in terms of this specification.

A. Standards and Recommended Practices for Instrumentation and Control, 11th Edition, Instrument Society of America.

- ANSI/ISA-5.1-2009 : Instrumentation Symbols and Identification
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- IEC Publication 27 : Letter Symbols to be used in Electrical Technology
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D. SANS-10111-1-2011 Engineering Standard

E. TPL-TECH-I-POL-001 - Measurement Policy
F. TPL-TECH-I-POL-002 - Control Policy
G. TPL-TECH-I-POL-003 - Instrumentation Policy

4. ABBREVIATIONS

For the purpose of understanding these Standards, the following abbreviations apply.

ANSI : American National Standards Institute
C & I : Control and Instrumentation
IEC : International Electrotechnical Commission
ISA : Instrument Society of America
SABS : South African Bureau of Standards
ASA : American Standards Association

5. PLANT & EQUIPMENT IDENTIFIERS

The following types of plant and equipment may be identified by use of Plant and Equipment Identifiers, which are allocated to unique pieces of plant and equipment installed at functional locations within a Transnet Pipelines Site:

- Process Plant (e.g. receivers, strainers etc.)
- Process Equipment (e.g. valves, pumps, motors etc.)
- Electrical Distribution Equipment (e.g. transformers, breakers, etc.)

[Composition of Process Plant & Equipment Identifiers conform to the Ops Code Standard as adopted by Transnet Pipelines and as detailed in Control and Instrumentation Policy No. C&I 700/94/001 April 1994. Composition of Electrical Distribution Equipment Identifiers conform to HT Distribution Equipment Identification Schemas as determined by Transtel Control (SARS Distribution)].

The reader is referred to the following Plant & Equipment Identification Standard as is included in the Appendices:

FUNCTIONAL DESIGNATION PL 118736 Plant & Equipment

5.1. Process Plant Identifier Assignment Rules

Used to identify process plant installed on the respective Transnet Pipelines Pump Station sites. Note that Process Plant usually comprises of a **grouping of process vessels, equipment, and**

instrumentation that combine to perform a common function e.g. piping, valves and instrumentation that combine to form a piece of process plant called a Receiver.

Assignment Rules

1. Each Plant item shall be identified by means of a two digit Station Identifier (and prefix "="), followed by a three digit alphanumeric Function Identifier (Ops Code) in compliance with PL 118736.

2. The first letter of the Ops Code Identifier shall convey the function of the equipment in the plant.

3. The second and third characters of the Ops Code Identifier shall comprise of a double-digit consecutive number used to uniquely identify the particular piece of process plant and shall be allocated per Pump station on a consecutive basis. (e.g. where three Auxiliary Pumps exist these shall be identified as X01, X02, X03 irrespective of their function).

In multiproduct dedicated manifolds, the third letter may be used to identify the product type associated with the particular piece of process plant as follows:

3 Diesel - 500ppm
6 ULP - 95 Octane
8 Avtur
14 ULP - 93 Octane
33 Diesel 50ppm
76 Crude oil

4. VALVES, ACTUATORS & SWITCHBOXES

Valve actuators and switchboxes are identified by the addition of a prefix to indicate function (in full compliance with ISA Standard S5.1), as follows:

CV ANN Modulating/Control Valve Actuator
XV ANN On/Off Valve Actuator
ZV ANN Hand Valve with Switchbox
HV ANN Hand Valve without Switchbox

Process Plant Examples: (Allocated on a Pump Station basis).

Main Pump	P01	Main Line Pump No. 1
	P02	Main Line Pump No. 2
	P03	Main Line Pump No. 3
	P04	Main Line Pump No. 4
Accumulator Pump	A01	Accumulator Pump No. 1
	A02	Accumulator Pump No. 2

Booster Pump	B01	Booster Pump No. 1
	B02	Booster Pump No. 2
Auxiliary Pumps	X01	Sump Pump
	X02	Sump Pump
	X03	Lube Pump
	X04	Lube Pump
	X05	Inhibitor Pump
	X06	Inhibitor Pump
	X07	Petrol Blend Pump
	X08	Diesel Blend Pump
	X09	Petrol Prover Transfer Pump
	X10	Diesel Prover Transfer Pump
	X11	ULP Blend Pump
	X12	ULP Prover Transfer Pump
	Q01	Purge Air Fan 1
	Q02	Purge Air Fan 2
	Q03	Pressurisation Fan 1
	Q04	Pressurisation Fan 2
Meters	M01	Turbine/Positive Displacement Meter No 1.
	M02	Turbine/Positive Displacement Meter No 2.
Strainers	S01	Main Line Strainer
	S02	Main Line Strainer
	S03	Main Line Strainer
	S04	Main Line Strainer
	S05	Petrol Header Strainer (Delivery Station)
	S06	Petrol Header Strainer (Delivery Station)
	S07	Diesel Header Strainer (Delivery Station)
	S08	Diesel Header Strainer (Delivery Station)
	S09	ULP Header Strainer (Delivery Station)
	S10	ULP Header Strainer (Delivery Station)

5.2. Equipment Identifier Assignment Rules

Used to identify unique pieces of process equipment (e.g. valves, motors, actuators etc.) installed at functional locations within the respective Transnet Pipelines sites.

Assignment Rules.

1. Each Plant item shall be identified by means of a two digit Station Identifier (and prefix "= "), followed by a three digit alphanumeric Function Identifier (Ops Code) in compliance with PL 118736.

2. The first letter of the Ops Code Identifier shall convey the function of the equipment in the plant. Thus all equipment associated with the operation of the Receiver for example, shall be assigned the first letter "R".

   For Example:

   The Inlet Valve on Meter Prover Y01 shall be designated Y1A.
   The Discharge Valve on Launcher L02 shall be designated L2E.

3. The second letter of the Ops Code Identifier shall comprise of a single digit consecutive alphanumeric used to uniquely identify a particular piece of equipment. This character may be used to identify either the product type or origination (company from where the product was supplied) associated with the particular piece of equipment as follows:

   - 3 Diesel 500ppm
   - 6 ULP - 95 Octane
   - 8 Avtur
   - 14 ULP - 93
   - 33 Diesel - 50ppm
   - 73 Crude oil
   - C Caltex
   - S Shell
   - BP British Petroleum
   - R Sasol
   - T Total
   - M Engen
   - E Petro SA
   - U Zenex
   - W Vopak

   For Example:

   A Consignee Valve supplying Caltex shall be identified as CC1.
   A Header valve on a ULP (95 Octane) manifold shall be identified as H6A.

4. The third letter of the Ops Code Identifier shall convey additional information regarding the function of the designated equipment.

   For Example:
   Receiver Inlet Valve shall be identified as R1A, with A indicating functionality (Inlet).

   Where two Prover Drain valves exist on Meter Prover Y01, these shall be identified as Y1W and Y2W respectively, function as denoted by the third character taking precedence over the second alphanumeric indicating product type or origination.

5.3. Electrical Distribution Equipment Identifier Assignment Rules

Used to identify unique pieces of electrical distribution equipment (e.g. transformers, alternators, breakers, links etc.) installed at functional locations within the respective Transnet Pipelines sites.

Assignment Rules.

1. Each Plant item shall be identified by means of a two digit Station Identifier (and prefix "= "), followed by a three digit alphanumeric Function Identifier (Control Code) in compliance with PL 118736.

2. The first letter of the Control Code Identifier shall convey the function of the equipment in the plant.

   For Example:
   Main Incomer Transformer shall be designated M1.
   Incomer Breaker feeding the 3.3 kV MV Panels shall be designated F11.

3. The second and third characters of the Control Code Identifier shall comprise of a double-digit consecutive number used to uniquely identify the particular piece of process plant and shall be allocated per Pump station on a consecutive basis.

   The second and third characters may be used to convey additional information such as supply voltage in the case of Breakers and Links, where:

   50 – 59 denotes 11 kV supply upwards
   10 – 19 denotes 3.3 kV supply
   30 – 39 denotes 380 V supply

Electrical Distribution Equipment Examples: (Allocated on a Pump Station basis).

3.3 kV Main Incomer Transformer No. 1		M1
3.3 kV Main Incomer Transformer No. 2		M2
380 V Aux Transformer No. 1		A1
380 V Aux Transformer No. 2		A2
3.3 kV Incomer Breaker No. 1	(MV Panel)	F11
3.3 kV Incomer Breaker No. 2	(MV Panel)	F12
380 V Incomer Breaker No. 1	(LV Panel)	F31
380 V Incomer Breaker No. 2	(LV Panel)	F32
Incomer Supply No. 1 / 2	(3.3 kV AC)	E01/E02
Auxiliary Supply No. 1 / 2	(380 V AC)	E03/E04
Control & Tripping Supply	(110/50 V DC)	E05
Standby Generator	(380 V AC)	E06

6. INSTRUMENT IDENTIFIERS

Instrumentation may be identified by use of Instrument Identifiers, which are allocated to instrumentation installed at functional locations within a Transnet Pipelines Site.

Composition of these Identifiers conforms to the ISA Standard ANSI/ISA-S5.1-1984 Instrument Symbols and Identification.

The reader is referred to the following Plant & Equipment Identification Standard as included in the Appendices.

FUNCTIONAL DESIGNATION PL 118737 Instrumentation

6.1. Assignment Rules

1. Each Plant item shall be identified by means of a two digit Station Identifier (and prefix "= "), followed by a four digit alphanumeric Function Identifier (ISA Standard S5.1) and three digit unique Item Identifier.

2. The Function Identifier shall comprise of a first letter, which is used to indicate the primary function of the instrument / equipment item (i.e. the measured or initiating variable), and one or more succeeding letters, covering the functions of the instrument. Where no identifiable functions exist, these succeeding letters may be omitted.

3. The Function Identifier shall be made according to function and not construction. Thus a differential pressure recorder used for flow measurement, shall be identified as FR and not PDR.

4. When used as part of an instrument loop, the first letter of the functional identifier shall be selected according to the measured or initiating variable and not according to the manipulated variable. Thus a control valve varying flow according to the dictates of a level controller shall be denoted LCV and not FCV.

5. The succeeding letters of the functional identifier shall be used to designate one or more readout or passive functions and one or more output functions or both. A modifying letter may be used, if required, in addition to the succeeding letters, to denote alarming features, provided that these alarm signals constitute separate signals fed back to the control system/controller. In the event of alarm signals being derived from within a control system/controller itself, this alarm functionality may be denoted by the attachment of alarm prefixes to the outside the device symbol bubble itself. (i.e. has no impact on the device tag number).

6. The sequence of identification letters shall thus begin with the first letter (denoting primary function). Readout or passive function letters shall follow these in any sequence, and finally output letters in any sequence except for the output letter C (Control), that shall precede output letter V (Valve). All modifying letters, if used shall be interposed so that they immediately follow the letters they modify.

7. A multiple function device may be symbolised on a diagram by as many multiple device bubbles as there are measured variables, outputs and/or functions. Thus a Coriolis Mass Flowmeter with dual outputs of flow and temperature and located on the Diesel LP Manifold, may be identified with two tangent bubbles, inscribed FT 821 and TT 821 respectively.

8. The number of functional letters grouped for one instrument should be kept to a minimum according to the judgement of the user. The total number of letters within one group shall not exceed four.

9. The unique Item Identifier shall comprise of a three-digit numeral, the first two digits indicating the Device Group to which the instrument belongs and the third letter a consecutive number unique to the device. Device Group selection shall be selected according to function and not location. Thus a densitometer located remotely from a launcher (e.g. near a receiver) and used for Interface Control shall be assigned the Launcher Device Group number and not the Receiver Device Group number.

10. Item Identification digit allocations as detailed in Standard PL 118737 have been designed to cater for all applications as currently existing on Transnet Pipelines Pump Station Sites.

11. Item Identifiers shall be allocated on an individual instrument/equipment basis and not on an instrument/equipment loop basis. (This represents a deviation from recommendations as contained in the ISA Standard S5.1.).

12. Where two devices or sensors form part of a single measurement entity, and consequently have been assigned the same functional identification, a suffix may be appended to the Tag number to identify the respective devices or sensors.

    For Example: Where dual turbine meter pickups return dual pulse trains 90 degrees out of phase for the purposes of calculating product flow, and where the resultant flow measurement has been assigned the Tag number FT 811, the dual pickup sensors may be identified as FE 811A and FE 811B respectively.

13. PUMP STATION IDENTIFICATION.
    As per ISA Standard S5.1, and in order to assist in integration with both the AutoCAD P&ID and SAP R3 Business Management Platforms, Tag numbers for all Instrumentation and Equipment carry a prefix, used to identify the Transnet Pipelines Pump Station at which the equipment is located. Integration into the SAP R3 Platform requires the identification of managerial/cost centres and consequently the Pump Station identifier comprises of a four digit alpha numeric prefix, whereas integration into the AutoCAD P&ID Platform requires the identification of only the Pump Station at which the equipment is installed and thus the identifier comprises of a two digit integer prefix.

14. SOFTWARE MNEUMONIC DESIGNATION. In order to assist in the identification of more than one signal fed back to a control system/controller from a unique instrument or piece of equipment, a three digit alphanumeric suffix may be appended to the Tag Number and used for both software mneumonic identification as well as core identification numbering of the respective signals.

Suffixes defined to date are as follows:

Actuated Valve signals

OP	Valve Open Feedback
CL	Valve Closed Feedback
SL	Valve in Local/Off
O	Open Valve command
C	Close Valve command

Pump Starter signals

IRC	Start Pump command
IRT	Stop Pump command
PTR	Pressure Trip command
TVR	Mechanical Trip command
TOP	Thermal Overload Trip feedback
ELP	Earth Leakage Trip feedback
ERP	Electronic Protection Relay Failure feedback
FBL	Fuse Blown Trip feedback
SLO	Switchgear in Local/Off
PON	Pump Running feedback
POF	Pump Stopped feedback
RES	Remote Emergency Stop Trip feedback
MTR	Master Trip Relay Active feedback
SPH	Max Starts per Hour Exceeded Trip feedback
VT	Control Voltage Failure feedback
VSF	VSD Fault f/b (equivalent to ERP)
VSR	VSD Ready f/b (equivalent to MTR)

Fan signals

IRC	Start Fan command
IRT	Stop Fan command
TOP	Thermal Overload Trip feedback
FON	Fan Running feedback
FOF	Fan Stopped feedback

HV/MV Incomer signals

OP	Breaker/Link Open f/b
CL	Breaker/Link Closed f/b
SLO	Breaker in Local f/b
TCF	Trip Circuit Faulty f/b

MTR	Master Trip Relay f/b
BRS	Breaker Racked Out f/b
OCP	Over Current Trip f/b
ELP	Earth Fault Trip f/b
BEF	Balanced Earth Fault Trip f/b
BGF	Buchholtz Gas Fail Alarm f/b
OTP	Oil Temp Hi Alarm f/b
ERP	Electronic Protection Relay Fail f/b

Other signals

FB	Fault Bit
SB	Status Bit
PV	Process Variable
SP	Setpoint Variable
AHH	Process Trip High
AH	Process Alarm High
ALL	Process Trip Low
AL	Process Alarm Low

Instrument Identifier Examples:

PT	121	Pressure Transmitter located on HP Manifold (Routing Device Group)
PI	121	Pressure Gauge located on HP Manifold (Routing Device Group)
TE	121	Temperature Probe or primary measuring element
TT	121	Temperature Transmitter located on HP Manifold (Routing Device Group)
DX	811	Densitometer Source (Radioactive) located on Petrol LP Manifold.
DE	811	Densitometer Detector (Ionisation Chamber) located on Petrol LP Manifold.
FE	121	Flow element located on the HP manifold (Routing Device Group)
FT	121	Flow measurement located on the HP manifold (Routing Device Group)
ZI	101	Sphere detector located on the Receiver.

7. PANEL IDENTIFIERS

Electrical & Instrument Panels shall be identified by use of unique Panel Identifiers (both by Function and Location), allocated to panels installed at functional locations within a Transnet Pipelines Site.

Composition of these Identifiers conforms to the International Electrotechnical Commission Standards IEC Publication 750 Table 1.

The reader is referred to the following Plant & Equipment Identification Standard as included in the Appendices.

FUNCTIONAL DESIGNATION	PL 118738	Panels
LOCATION DESIGNATION	PL 118741	Panels

7.1. Assignment Rules – Functional Designation

1. Each Panel (and components thereof) shall be identified by means of a Functional and Location Identifier. The Functional Identifier shall comprise of a two digit Station Identifier (and prefix " = "), followed by a five digit alphanumeric Panel Identifier. Panel components may be uniquely identified by the addition of a three digit alphanumeric suffix and design typicals identified by the addition of a four digit alphanumeric suffix.

2. The first three characters of the Panel Identifier shall be is used to indicate the primary function of the panel (e.g. LV will indicate that the panel's primary function is that of LV Distribution, JB will indicate that the panel's primary function is that of Instrument marshalling etc.).

3. The last two digits of the Panel Identifier shall comprise of a two digit number used to uniquely identify the Panel in question. In all cases other than Instrument Junction Boxes and Control Panels, this unique integer number shall fall within the range as indicated in the Standard PL 118738, and shall be numbered in a consecutive manner. In the case of Instrument Junction Boxes and Control Panels however, this integer number shall be the same as the Instrument Group Identifier, thus identifying the Instrument Group to which the J/B has been associated. (Note that Instrumentation are marshalled in Junction Boxes on the basis of Device Groups).

4. Where Panels comprise of separate cubicles/tiers that contain equipment or marshalling unique to an individual piece of Process Plant/Equipment, these separate cubicles/tiers may be uniquely identified by means of an equipment identifier of the same format as detailed in Section 5 of this standard.

For example, an LV Panel LV 01 containing a cubicle housing a starter for auxiliary motor X01, may be uniquely identified by the Functional Identifier "= LV01 X01". In cases where only one LV Distribution Panel is likely to exist on the Station, this identifier may be shortened to read "= LV X01". In the case where an MV panel tier houses a starter for mainline pump set P01, the tier may be uniquely identified by the Functional Identifier "= MV01 P01". In cases where only one MV Distribution Panel is.

5. Equipment components within panels may be uniquely identified using an additional Component Identifier, comprising of an alphanumeric first character (to identify component function) followed by a two digit integer number (used to uniquely identify the component). Component Identification is indicated by the addition of a minus sign "-" as a suffix to the identifier. Composition of these Identifiers conforms to the International Electrotechnical Commission Standards IEC Publication 750 Table 1.

6. Where identical or typical design schemas exist, these may optionally be indicated by an additional Document Typical Identifier, comprising of an alphanumeric first character (to

identify document type) followed by a two digit integer number (used to uniquely identify the design schema standard. Design Typical Identifiers are indicated by the addition of a full stop sign "." as a suffix to the identifier. Note that Document Typical Identifiers may only appear in Documentation Headers i.e. may never form part of the Panel or Component Identifier.

Panel Identifier Examples:

LV 01	LV Distribution Panel 01
LV 21	Control Voltage Distribution Panel (may reside in Panel LV01 as a separate cubicle)
LV01 X01	Sub Distribution Cubicle of Panel LV01 containing Aux Motor Starter X01 OR
LV X01	Sub Distribution Cubicle of Panel LV01 containing Aux Motor Starter X01
MV01	MV Incomer Panel 01
MV01 F11	Sub Distribution Cubicle of Panel MV01 containing Incomer Breaker F11 OR
MV F11	Sub Distribution Cubicle of Panel MV01 containing Incomer Breaker F11
MV01 P01	Sub Distribution Cubicle of Panel MV01 containing Motor Starter P01 OR
MV P01	Sub Distribution Cubicle of Panel MV01 containing Motor Starter P01
ETM 01	PLC Remote I/O Distribution Panel associated with MV Switchgear P01
ETL 01	PLC Remote I/O Distribution Panel associated with LV Panel LV01
DH 11	Density Hut Control Panel associated with Launcher Device Group 11
JB 10	Instrument Junction Box associated with Receiver Device Group 10
JB P01	Instrument Junction Box associated with Mainline Pumpset P01
FH01	Fire Hut Control Panel 01

7.2. Assignment Rules – Location Designation

Each Panel (and components thereof) shall be identified by means of a Functional and Location Identifier. The Location Identifier shall comprise of the Functional Identifier as detailed in Section 7.1 above (and prefix "+ "), followed by a three digit alphanumeric Tier/Row Identifier. Tier/Row Identification shall be indicated by the addition of a full stop sign "." as a suffix to the identifier.

Panel Identifier Examples:

LV01 X01.3F2	Aux Motor Starter Cubicle located in LV Panel LV01, Tier 3, Row 2
MV01 F11.1F	3.3 kV Incomer Breaker F11 located in MV Panel MV01, Tier 1

8. ELECTRICAL & INSTRUMENT CABLE IDENTIFIERS

Electrical & Instrument Cabling may be identified by use of Cable Identifiers, which are allocated to cabling installed at functional locations within and outside of Transnet Pipelines Pump Station confines.

The reader is referred to the following Plant & Equipment Identification Standard as included in the Appendices.

FUNCTIONAL DESIGNATION PL 118739 Cabling

8.1. Assignment Rules

1. Each Cable shall be identified by means of a Cable Identifier comprising of the following components:
   - single digit Type Identifier used to identify whether the cable is used for power or control purposes
   - a Functional Descriptor of the equipment to which the cable is terminated (either source or destination)
   - a Signal Type Identifier which may be used to indicate additional information under the following circumstances only:
     - on Instrument Multicores to indicate signal type (discrete or analogue)
     - on Electrical Cables running to motors, to differentiate between functions (heater versus emergency stop)

2. For details on Functional Descriptors, the reader is referred to Transnet Pipelines Specification PL727 “Cabling, Racking, Trenching & Earthing Installation Codes of Practice” Section 8.5.

9. PROCESSING PIPING IDENTIFIERS

Process Piping may be identified by use of Piping Identifiers, which are allocated to piping installed at functional locations within and outside of Transnet Pipelines Pump Station confines.

The reader is referred to the following Plant & Equipment Identification Standard as included in the Appendices.

FUNCTIONAL DESIGNATION PL 118740 Process Piping

9.1. Assignment Rules

1. Each Plant item shall be identified by means of a two digit Station Identifier (and prefix “= “), followed by a nine digit alphanumeric Function Identifier.

2. The Function Identifier shall comprise of a first letter used to denote Pressure Rating, followed by a three digit ID used to identify Line Size, followed by a two digit ID used to identify Material Composition, followed by a three digit number used to uniquely identify the pipe in question.

3. Process Piping Identifiers shall be allocated to P & ID Diagrams below the process line where drawn on the horizontal, and to the right of process lines were drawn vertically.

10. APPENDICES

Plant and Equipment can be identified on Transnet Pipelines Sites using two forms of Identifiers; namely, by Function using the Function Designation System (identified by the prefix "= "), or by Location using the Location Designation System (identified by the prefix "+ "). In this regard the following documentation attached details each Standard:

FUNCTIONAL DESIGNATION	PL 118736	Plant & Equipment
	PL 118737	Instrumentation
	PL 118738	Panels
	PL 118739	Cabling
	PL 118740	Process Piping
LOCATION DESIGNATION	PL 118741	Panels

ADDENDUM No 1

EQUIPMENT, ELECTRICAL AND INSTRUMENT TAG NUMBERING STANDARDS - INTEGRATION INTO THE SAP/R3 BUSINESS MANAGEMENT PLATFORM.

Equipment/Electrical/Instrument Tag Numbering Standards have been integrated into a Structure **Indicator** defined within the SAP R3 Business Management platform and used for the purposes of equipment, electrical and instrument identification, specification, historic tracking and management reporting functionality. This Structure Indicator, as utilised by SAP R3, comprises of two separate parts, namely, a **Functional Location Identifier** which describes the specific location in the plant at which the equipment is installed, and an **Equipment/Instrument/Electrical Identifier** as defined in the respective Tag Numbering Standards attached. Incorporation of the Equipment, Instrument and Electrical Tag Numbering Systems into the Structure Indicator ensures integration between the AutoCAD P&ID Design and SAP R3 Business Management platforms.

Table A1. Structure Indicator.

STRUCTURE INDICATOR

FUNCTIONAL LOCATION IDENTIFIER — EQUIPMENT IDENTIFIER

X - X - XXXX - X - XXX - X - XXX - XXXXXXXXX

1 2 3 4 5 6 7 8

where

1. **Company Code** P for Transnet Pipelines.
2. **District Code** H for Head Office, N for Northern District, S for Southern District.
3. **Depot Code** Refer to Table A2 below.
4. **Depot Sub-Code** O for Operational, N for Non Operational cost allocation.
5. **Pipeline Code** Currently under investigation. PL1 for Multiproducts (12 inch), PL2 for Gas (18 inch), PL3 for Crude (16 inch), PL11 for NMPP (24 inch), SHR for Shared.
6. **Line Function Code** M for Mechanical, E for Electrical, C for Civil, I for Instrument, S for Services, T for Info Tech etc.
7. **Process/Plant Code** Refer to Table A3 below.
8. **Equipment Identifier** Refer to Tag Numbering Standards attached.

P - N - ALR1 - O - PL1 - M - R01 - XVR1A
P - N - ALR1 - O - PL1 - I - P01 - TT011
P - S - HWK - O - PL2 - E - X01 - K01
P - S - HTP1 - O - PL11 - I - P01 - PT011

A.1 FUNCTIONAL LOCATION IDENTIFIER.

The Functional Location Identifier is used to define the exact location of equipment/ instrumentation on a Transnet Pipelines Pump Station site. As such the Identifier has been split ito several parts called **codes** defined below.

A.1.1 Company Code

Used to identify the company to which the equipment belongs. This code is usually given the letter "**P**" to denote Transnet Pipelines.

A.1.2 District Code

Used to identify the District responsible for the management and maintenance of the equipment. The following options have currently been defined:

N for Northern Districts
S for Southern Districts
H for Head Office

A.1.3 Depot Code

Used to identify the Depot to which the equipment belongs. This code has been defined on managerial/cost centre basis. The following options have currently been defined:

Table A2. Depot Codes

Depot Name	Operations SAP R3	Technical SAP R3	M & I SAP R3	M & I AutoCAD P&ID
Airport	APT1			21
Alrode	ALR1	ALR2	ALR3	18
Benoni	BIR1			Not Allocated
Bethlehem	BEM1			13
Bethlehem TOP	BHT1			12
Coalbrook	CBK1	CBK2		17
Durban	DNR1			02
Duzi	Duzi			
Empangeni	EMG1	EMG2		32
Fort Mistake	FTM1			
Fynnlands	FYN1			01
Hillcrest	HLR1			03 (DJP) , 04 (DWP)
Hilltop	HTP1			
Howick	HWR1			07 (DJP) , 08 (DWP)
Jameson Park-1438	JMP			
Jameson Park TPL-1475	JMP1			
Klerksdorp	KRP1			20
Kendal	KDL1			36

Table 2. Continued

Depot Name	Operations SAP R3	Technical SAP R3	M & I SAP R3	M & I AutoCAD P&ID
Kroonstad	KRO1	KRO2		14
Ladysmith	LAY1	LAY2		09 (DJP) , 10 (DWP)
Ladysmith TOP	LST1			Not Allocated
Langlaagte	LLA1			24
Magdala	MGA1			15
Mahlabatini	MAT1			33
Mnambithi	MBT1			
Mngeni	MGN1			
Mooi River	MRR1			
Newcastle	NCS1			28
Pietermaritzburg	PZB1	PZB2		05
Pietermaritzburg TOP	PMT1			06
Potchefstroom	PCM1			19
Pretoria West	PWT			23
Quagga	QGA1			35
Rustenburg	RTR1			26
Sasolburg	SBG1			16
Scheepersnek	SCN1	SCN2		34
Secunda	SEC1			31
Standerton	SNR1	SNR2		30
Tarlton	TLR1	TLR2		25
Twini	TNI1			
Van Reenen	VRN1			11
Villiers	VLR1			
Volksrust	VRR1			29
Vrede				
Waltloo	WAO1			22
Warden	WDN1			
Wilge	WIL1			
Witbank	WIR1			27
Transnet Pipelines Head Office	PHO9			Not Allocated
Transnet Pipelines Northern District	NDO9			Not Allocated
Transnet Pipelines Southern District	SDO9			Not Allocated

A.1.4 **Depot Sub Code**

Used to assign equipment costs into operational and non-operational cost categories. The following two options are available:

O for operational costs
N for non-operational costs

A.1.5 Pipeline Code

Used to assign equipment to particular pipelines. Currently under evaluation by Transnet Pipelines. An initial proposal has been defined as follows:

PL1 for the Multiproducts (12 inch) pipeline
PL2 for the Gas (18 inch) pipeline
PL3 for the Crude (16 inch) pipeline
PL11 for the NMPP (24 inch) pipeline
SHR for shared equipment

A.1.6 Line Function Code

Used to define the Line Function responsible for the maintenance of the equipment. The following options have currently been defined:

C for Civil
E for Electrical
F for Fire and Effluent
G for General
I for Metering and Instrumentation
M for Mechanical
S for Services
T Information Technology

A.1.7 Process Plant Code

Used to define the location of process plant installed on the respective Transnet Pipelines sites. Note that Process Plant is defined as a **grouping of equipment and instrumentation that combine to perform a common function** e.g. piping, valves and instrumentation that combine to form a piece of process plant called a Receiver. Identification of Process Plant conforms to the Ops Code standard as adopted by Transnet Pipelines and detailed in PL 101 Section 5.1.

Table A3. Ops Code Definition (Process Plant)

X	X	X

OPERATIONAL CODE TABLE					
A	Accumulator	A		A	Inlet
B	Booster	B		B	
C	Consignee/or	C	Caltex	C	
D	Distributor	D		D	
E		E	Petro SA	E	Discharge
F	ProverTransfer	F		F	
G	Blender	G		G	
H	Header	H		H	
I	Isolation	I		I	
J		J		J	Control
K		K		K	Bypass
L	Launcher	L		L	
M	Meter	M	Engen	M	
N	Reverse Pump	N	BP	N	Transfer
O		O		O	
P	Main Pumps	P		P	
Q	Fans	Q		Q	
R	Receiver	R	Sasol	R	Reverse
S	Strainer	S	Shell	S	
T	Tank	T	Total	T	
U	Lube System	U		U	
V		V		V	Vent
W		W	Vopak	W	Drain
X	Aux Pumps	X		X	Launch
Y	Meter Prover	Y		Y	
Z		Z		Z	
		1			
		2			
		3	Diesel 500ppm		
		4			
		5			
		6	ULP-95 Octane		
		7			
		8	Avtur		
		9			
		14	Ulp -93 Octane		
		33	Diesel 50ppm		
		76	Crude Oil		

Note: For an adequate understanding of the Table above, please refer to the Assignment Rules below.

Assignment Rules.

1. Each Plant item shall be identified by means of a three digit alphanumeric identifier in compliance with Table 1.

2. The first letter shall convey the **functional location** of the equipment in the plant.

3. The second and third characters shall comprise of a double-digit consecutive number used to uniquely identify the particular piece of process plant and shall be allocated per Pump station on a consecutive basis. (E.g. where three Auxiliary Pumps exist these shall be identified as X01, X02, X03 irrespective of their function).

   In multiproduct dedicated manifolds, the third letter **may** be used to identify the product type associated with the particular piece of process plant as follows:

   3 Diesel 500ppm
   6 ULP - 95 Octane
   8 Avtur
   14 ULP - 93
   33 Diesel - 50ppm
   73 Crude oil

4. No separators (e.g. Dashes) shall be used to separate characters in the identifier.

Process Plant Examples: (Allocated on a Pump Station basis).

Main Pump	P01	Main Line Pump No. 1
	P02	Main Line Pump No. 2
	P03	Main Line Pump No. 3
	P04	Main Line Pump No. 4
Accumulator Pump	A01	Accumulator Pump No. 1
	A02	Accumulator Pump No. 2
Booster Pump	B01	Booster Pump No. 1
	B02	Booster Pump No. 2
Auxiliary Pumps X01	Sump Pump	
	X02	Sump Pump
	X03	Lube Pump
	X04	Lube Pump
	X05	Inhibitor Pump
	X06	Inhibitor Pump
	X07	Petrol Blend Pump
	X08	Diesel Blend Pump
	X09	Petrol Prover Transfer Pump
	X10	Diesel Prover Transfer Pump
	X11	ULP Blend Pump
	X12	ULP Prover Transfer Pump

	Q01	Purge Air Fan 1
	Q02	Purge Air Fan 2
	Q03	Pressurisation Fan 1
	Q04	Pressurisation Fan 2
Meters	M01	Turbine/Positive Displacement Meter No 1.
	M02	Turbine/Positive Displacement Meter No 2.
Strainers	S01	Main Line Strainer
	S02	Main Line Strainer
	S03	Main Line Strainer
	S04	Main Line Strainer
	S05	Petrol Header Strainer (Delivery Station)
	S06	Petrol Header Strainer (Delivery Station)
	S07	Diesel Header Strainer (Delivery Station)
	S08	Diesel Header Strainer (Delivery Station)
	S09	ULP Header Strainer (Delivery Station)
	S10	ULP Header Strainer (Delivery Station)

11. DOCUMENT CHANGE HISTORY:

The owner of this document is responsible for the revision and control of the document, including updating of the table below, which contains the history of the document with details of each revision.			
Date	Previous Rev No.	New Rev No.	Details of Revision
15.01.99	00	01	Document approved for distribution.
23.05.00	01	02	Phase II revisions added.
15.04.01	02	03	Instrument Group ID Allocations revised. Plant & Equip Identification Stds clarified.
01.08.07	03	04	Transnet Pipelines logo added.
12.06.2012	04	05	New Transnet Standard Template Adopted Updating the Reference Documentation
25.05.2016	05	06	Document review & update & New Template

This table summarises what has been changed in the document so that it is easy to keep track of the effected changes.

DRAWING OFFICE STANDARD (PL102)

DOCUMENT APPROVAL PROCESS

NAME		POSITION/MEETING NO.	SIGNATURE	DATE
Originator:	Zandile Moloi	Drawing Office Manager		20/06/2016
Approver:	Petros Khumalo	Technical Support Manager		30-06-2016
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TABLE OF CONTENT

1. INTRODUCTION

The purpose of this standard is to establish a uniform means of designating plant, equipment, instrumentation and electrical switchgear as installed on the respective pump station sites within Transnet Pipelines, on technical drawings and in documentation. By ensuring a comprehensive, consistent and uniform means of representing plant, equipment and instrumentation on technical drawings and in documentation, it is hoped that this Standard will assist in the rapid identification of equipment and instrumentation, as well as correct interpretation of information presented.

2. SCOPE

2.1. GENERAL

This document defines graphical symbology standards to be adopted when representing all plant, equipment, instrumentation and electrical switchgear on technical drawings and in documentation. Plant, equipment and instrumentation symbology has been based on the Instrument Society of America Standards ISA S5.1-1984 and ISA S5.3-2009 respectively, and supplemented to include Transnet Pipelines specific equipment. Electrical Switchgear symbology has been based on the International Electrotechnical Commission Standards IEC Publication 60617 as adopted by SABS/NRS 002-2000.

It is not the intent of these Standards to mandate the usage of each type of symbol for each occurrence of a generic device within the overall control system, which may result in undue complexity, but rather to enable the designer the facility to use internationally recognised symbology to convey the level of detail required to accurately reflect the process.

In this regard, symbology and rules of usage as defined within this Standard are required to be adhered to by Client and Contractor alike, for and on behalf of Transnet Pipelines, a Division of Transnet Ltd. Both Client and Contractor will be required to familiarise themselves with all applicable Standards and Codes of Practice listed herein, and to ensure compliance in the execution of any work in terms of this document. Failure to comply may render the provider liable for corrections at his own cost.

These Standards should be read in conjunction with all other specifications and drawings as issued for a particular contract. Where discrepancies occur, these must be brought to the attention of Transnet Pipelines in writing before commencement of work. In the event of any conflict between the contents of any documents forming part of a contract (as listed in the Schedule of Contract Documents) and this document, the former shall prevail.

2.2. APPLICATION TO WORK ACTIVITIES

The Standards contained herein are suitable for use whenever plant, equipment, instrumentation or electrical switchgear are required to be represented in technical drawings and in documentation. These Standards thus cover designation of plant, equipment, instrumentation and electrical switchgear in the following types of documentation:

- Flow Diagrams, process and mechanical
- Piping and Instrumentation diagrams
- Instrumentation system diagrams
- Electrical switchgear diagrams
- Specifications, purchase orders, manifests and other lists
- Construction Drawings
- Technical Papers, literature and discussions
- Tagging of Instruments
- Installation, operation and maintenance instructions, drawings and records

3. REFERENCE DOCUMENTATION

The following standard specifications are to be used for reference purposes. It is expected of Tenderers that they be familiar with the applicable clauses and that these will be adhered to in the execution of any work in terms of this specification.

A. Standards and Recommended Practices for Instrumentation and Control, 11th Edition, Instrument Society of America.

ANSI/ISA-S5.1-2009	Instrument Symbols and Identification
ANSI/ISA - S 5.2-1992	Binary Logic Diagrams for Process Operations
ANSI/ISA-S5.3-1983	Graphic Symbols for Distributed Control, Shared Display Instrumentation, Logic and Computer Systems
ANSI/ISA - S 5.5-1985	Graphic Symbols for Process Displays

B. Graphical Symbols for Electrical Diagrams NRS 002-2000 second edition.

C. International Electrotechnical Commission Standards for Electrical Drawings

IEC Publication 27	Letter Symbols to be used in Electrical Technology
IEC Publication 50	International Electrotechnical Vocabulary
IEC Publication 617	Graphical Symbols for Diagrams

D. American Society of Mechanical Engineers (ASME)

ASME Y32.11 - 1961	Graphical Symbols for Process Flow Diagrams
ASME Y32.2.3 - 1994	Graphical Symbols for Pipe Fittings, Valves & Piping.

4. ABBREVIATION

For the purpose of understanding these Standards, the following abbreviations apply.

ANSI	:	American National Standards Institute
C & I	:	Control and Instrumentation
IEC	:	International Electrotechnical Commission
ISA	:	Instrument Society of America
SABS	:	South African Bureau of Standards
ASA	:	American Standards Association

5. EQUIPMENT & INSTRUMENT SYMBOLOGY STANDARD

Equipment / Instrument Symbols as defined in the tables contained in Appendix A conform to the following standards:

A. Standards and Recommended Practices for Instrumentation and Control, 11th Edition, Instrument Society of America.

ANSI/ISA-S5.1-2009	Instrument Symbols and Identification
ANSI/ISA - S 5.2-1992	Binary Logic Diagrams for Process Operations
ANSI/ISA-S5.3-1983	Graphic Symbols for Distributed Control, Shared Display Instrumentation, Logic and Computer Systems
ANSI/ISA - S 5.5-1985	Graphic Symbols for Process Displays

B. American Society of Mechanical Engineers (ASME)

ASME Y32.11 - 1961	Graphical Symbols for Process Flow Diagrams
ASME Y32.2.3 - 1994	Graphical Symbols for Pipe Fittings, Valves & Piping.

The symbol descriptions listed to the right of each symbol are intended to serve as guidelines for applicability and have been supplemented by comments where further clarity may be required.

5.1. SYMBOL DEFINITIONS (Refer to Appendix A)

Table 1	General Instrument or Function Symbols
Table 2	Interlock and Math Functionality
Table 3	Line Symbology
Table 4	Fire System Symbology
Table 5	General Symbology
Table 6	Pump Symbology
Table 7	Valve Symbology
Table 8	Mechanical Symbology
Table 9	Equipment Symbology
Table 10	Tank Symbology

5.2. RULES FOR USAGE

5.2.1 . Individual pieces of equipment and instrumentation shall be uniquely identified on technical drawings and documentation via means of the symbols defined above. Where pieces of equipment / instrumentation have easily defined or recognisable relationships, these need not be individually tagged on a diagram. For example, an orifice plate need not be separately tagged to the differential pressure transmitter, for the purposes of flow measurement. Also, where there is a primary element connected to another instrument on a diagram, use of a symbol to represent the primary element on the diagram is optional.

5.2.2 . Where an instrument/equipment has more than one function and denotation of these are necessary to gain a full understanding of the process, these functions may be individually reflected by symbols located alongside one another and tagged separately. Use of contiguous symbols may thus be used to reflect the following additional functionality:

- Interfacing between associated instruments e.g. hardwiring, internal system links, backup.
- Instrument integrated multiple functions.

5.2.3. Brief explanatory notation may be added adjacent to the symbol or line to clarify instrument functionality e.g. a lead analyser may have the letters Pb placed adjacent to the symbol to indicate the function of the analyser; a temperature probe may have the letters PT100 placed adjacent to the symbol to indicate the element type.

5.2.4. Where math functionality is performed within an instrument (e.g. square root extraction) such functionality may be indicated by means of explanatory notation placed adjacent to the instrument symbol.

5.2.5. Orientation and sizing of symbology should be selected with neatness and legibility in mind. Function Block designation and Tag Numbers should always be drawn on the horizontal.

5.2.6. Electrical, pneumatic or other power supply to an instrument need not be shown, unless it is essential to an understanding of the function or operation of an instrument or loop.

5.2.7. The sequence in which instruments or functions are connected on a diagram should reflect the functional logic and need not necessarily correspond to the signal connection sequence. For example, an analogue instrument using voltage feedback requires parallel wiring whereas an instrument using current feedback requires series wiring, although both are represented in documentation using identical symbology.

5.2.8. The degree of detail to be applied to each document or drawing lies is entirely at the discretion of the user. For example, sketches and technical papers usually contain simplified symbology whereas P & ID Diagrams and Process Flow Diagrams may show all in-line components. In all cases, consistency should be exercised for each document /drawing type, and in this regard the reader is required to familiarise himself with examples of drawings included in the Drawing Standards Document in order to ascertain degree of detail requirements.

5.2.9. Interlocking Functionality. For the sake of clarity and in order to prevent technical drawings from becoming cluttered, only hardwired interlocking functionality need be reflected on technical drawings produced for and on behalf of Transnet Pipelines. All other interlocking functionality shall be defined in Software Documentation and Functional Design Specifications accompanying the installation of Control Systems technology.

5.2.10. Where graphical symbols are similar in nature and may cause misinterpretation, cautionary notes should be added to the document/drawing, in order to assist in interpretation.

5.2.11. Alarm and Trip Functionality. All derived tags (alarm and trip functionality) shall be represented by the placement of additional notation alongside the instrument symbol on a drawing. In this regard the following notation has been derived to date:

PAHH	Press Trip High
PAH	Press Alarm High
PALL	Press Trip Low
PAL	Press Alarm Low
dP/dT	Rate of Change
PDA	Deviation from Setpoint

6. EQUIPMENT & INSTRUMENT SYMBOLOGY STANDARD

Electrical Switchgear Symbology used shall conform to the International Electrotechnical Commission Standards IEC Publication 60617 as adopted by SABS/NRS 002-2000 (Amended 1994).

Lists of the more commonly used symbols have been included in Appendix B for reference purposes. The symbol descriptions listed to the right of each symbol are intended to serve as guidelines for applicability and have been supplemented by comments where further clarity may be required.

7. APPENDICES
APPENDIX A

Equipment & Instrument Symbol Tables

Table 1
General Instrument or Function Symbols

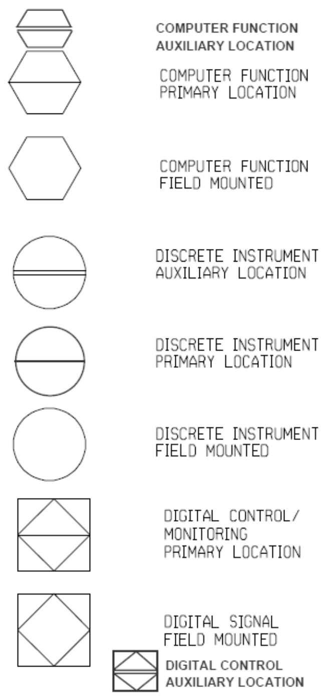


Table 2
Interlock and Math Functionality

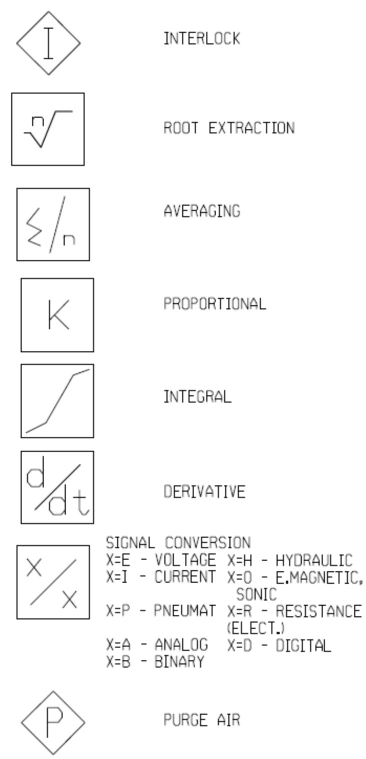
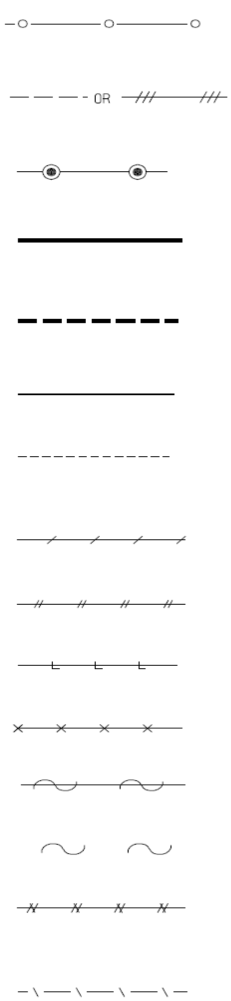
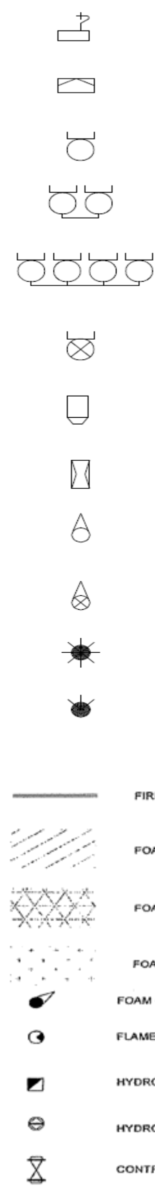


Table 3
Line Symbology



- INTERNAL SYSTEM LINK
- ELECTRIC SIGNAL
- MECHANICAL LINK
- PRIMARY PROCESS LINK
- PRIMARY PROCESS LINK (UNDERGROUND)
- SECONDARY PROCESS LINK
- SECONDARY PIPING LINK (UNDERGROUND)
- UNDEFINED SIGNAL
- PNEUMATIC SIGNAL
- HYDRAULIC SIGNAL
- CAPILLARY TUBE
- ELECTROMAGNETIC SIGNAL (GUIDED)
- ELECTROMAGNETIC SIGNAL (UNGUIDED)
- PNEUMATIC BINARY SIGNAL
- ELECTRIC BINARY SIGNAL

Table 4
Fire System Symbology



- BALL PRESSURE PROPORTIONER
- BURSTING DISK
- FIRE HYDRANT SINGLE
- FIRE HYDRANT DOUBLE
- FIRE HYDRANT QUADRUPLE
- HYDRANT FOAM
- FOAM POURER
- HIGH BACK PRESS. GENERATOR
- OSC MONITOR
- FIXED MONITOR
- SPRINKLER NOZZLE
- TANK DRENCHING NOZZLE
- FIRE LINES
- FOAM CANNON COVERAGE
- FOAM POURER COVERAGE
- FOAM SPRINKLER COVERAGE
- FOAM CANNON
- FLAME DETECTOR
- HYDROCARBON LIQUID DETECTOR
- HYDROCARBON GAS DETECTOR
- CONTROL VALVE

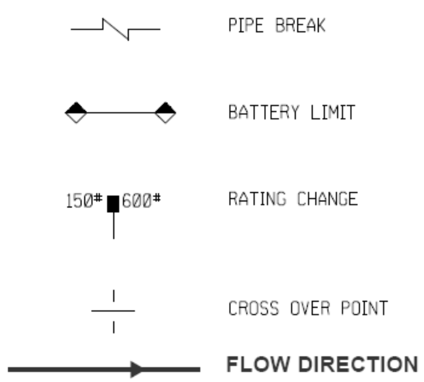
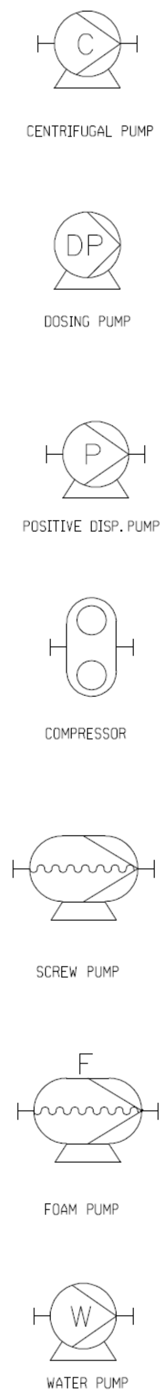
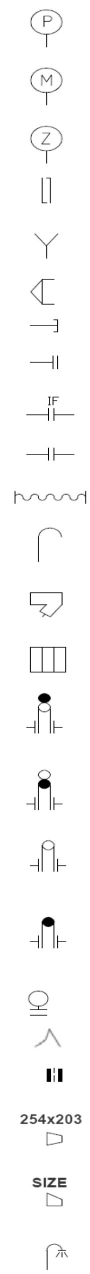
<table>
<tr><th>Table 5
General Symbology</th><th>Table 6
Pump Symbology</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Table 7
Valve Symbology

3-WAY VALVE
4-WAY VALVE
BALL VALVE
BUTTERFLY VALVE
CHECK VALVE
CONTROL VALVE
DIAPHRAGM VALVE
EXPANDING PLUG VALVE
PLUG VALVE
NEEDLE VALVE
GATE-PARALLEL VALVE
GATE-WEDGE VALVE
GLOBE VALVE
PRESSURE SUSTAINING VALVE
PRESSURE RELIEF VALVE
THERMAL RELIEF VALVE
UNSPECIFIED VALVE
SPHERE HANDLING VALVE
SPHERE RELEASE FINGER

Table 8
Mechanical Symbology



ACTUATOR - PNEUMATIC
ACTUATOR - ELECTRIC
MANUAL VALVE WITH POSITION FEEDBACK
SAFETY END CLOSURE
DRIP CUP
DRY BRAKE COUPLING
END CAP
FLANGE BLIND
FLANGE INSULATING
FLANGE SET
FLEXIBLE HOSE
GOOSE NECK
SLOP INJECTOR
JAIL BARS
SPECTACLE LINE BLIND - OPEN
SPECTACLE LINE BLIND - CLOSED
SPADE LINE BLIND - OPEN
SPADE LINE BLIND - CLOSED
STOPPLE FITTING
LOADING ARM
ORIFICE PLATE
CONCENTRIC REDUCER
ECCENTRIC REDUCER
EYE WASH & EMERGENCY SHOWER

Table 9
Equipment Symbology

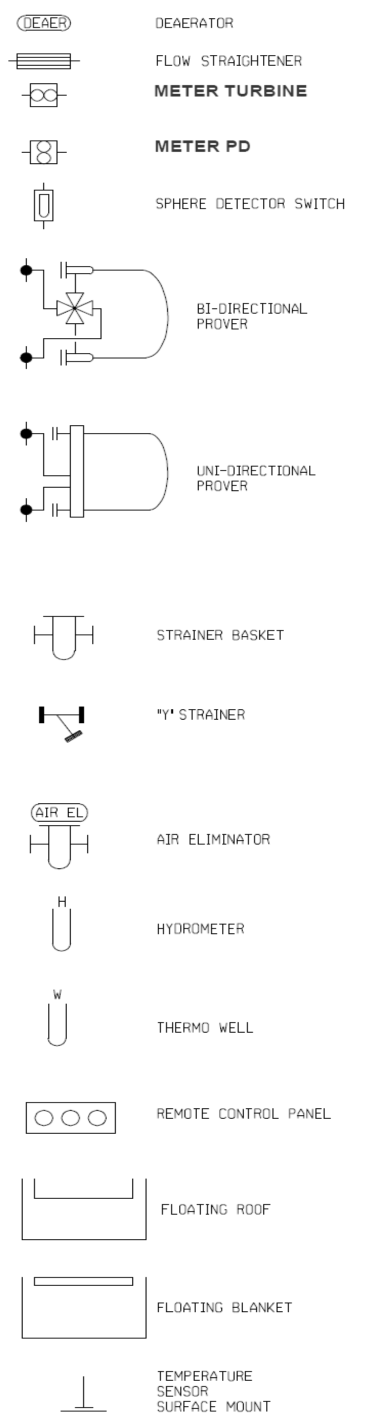
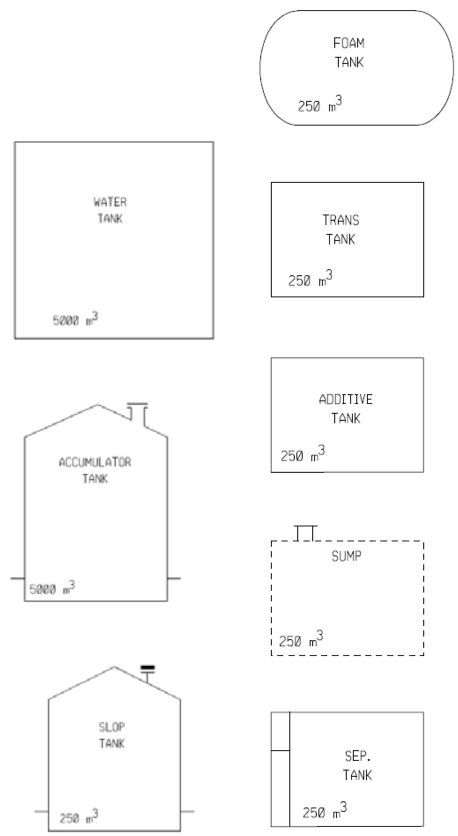


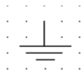
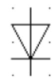
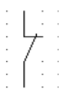
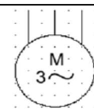
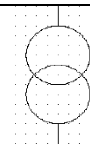
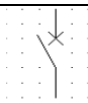
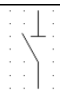
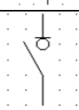
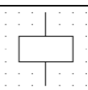
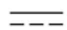
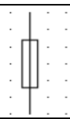
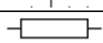
Table 10
Tank Symbology



APPENDIX B

Electrical Switchgear Symbol Tables

Graphical Symbols for Electrical Diagrams NRS 002-2000 second edition.

	Earth general symbol Earthing, general symbol, Ground (US) general symbol; Grounding (US) general symbol		Coil, general symbol, Winding general symbol Inductor; Choke
	Make contact, general symbol, switch, general symbol		Semiconductor diode, general symbol
	Break contact		Induction motor, three phase, squirrel cage
	Change-over break before make contact		Transformer with two windings, general symbol (form 1)
	Circuit Breaker		Rectifier
	Disconnector, Isolator		Primary cell
	Switch-disconnector, On-load isolating switch		Lamp, general symbol lamp Signal lamp, general symbol
	Operating device, general symbol; Relay coil, general symbol Operating coil of a selector (form 1)		Direct current
	Fuse, general symbol		Alternating current
	Resistor, general symbol		
	Capacitor, general symbol		

8. DOCUMENT CHANGE HISTORY:

The owner of this document is responsible for the revision and control of the document, including updating of the table below, which contains the history of the document with details of each revision.

Date	Previous Rev No.	New Rev No.	Details of Revision
15.01.99	00	01	Document approved for distribution.
12.06.12	01	02	New Transnet Standard Template Adopted
26.05.16	02	03	Document review and update & New Template

This table summarises what has been changed in the document so that it is easy to keep track of the effected changes.

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NRS 002:2000

Second edition

Rationalized User Specification

GRAPHICAL SYMBOLS FOR ELECTRICAL DIAGRAMS

Preferred requirements for applications in the Electricity Supply Industry

N R S

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This Rationalized User Specification is
issued by the NRS Project
on behalf of the
User Group given in the foreword
and is not a standard as contemplated in the Standards Act, 1993 (Act 29 of 1993).

Rationalized user specifications allow user organizations to define the performance and quality requirements of relevant equipment.

Rationalized user specifications may, after a certain application period, be introduced as national standards.

Amendments issued since publication

Amdt No.	Date	Text affected

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Contents

Contents (continued)

Contents (concluded)

Foreword

This specification has been prepared by the NRS Project Management Agency for use in the Electricity Supply Industry in South Africa as a compilation of a subset of internationally accepted symbols: it has not been specifically approved by a technical committee or user group. It is intended to be a ready source of reference for the industry.

This second edition of NRS 002 has been prepared to incorporate amendments to the relevant parts of IEC 60617 that have been published since the first edition of NRS 002 was prepared.

The specific contribution of Dott Browse of Eskom in the compilation of this specification is acknowledged.

Comments are invited from interested parties and correspondence should be directed to the NRS Standardization Manager, c/o the Electrotechnical Standards Manager, SABS, Private Bag X191, Pretoria, 0001.

Introduction

The objective of this specification, which details preferred symbols for use on electrical diagrams and drawings, is to reduce the number of variations in symbols.

The numbering of symbols is in accordance with the IEC reference numbers.

In an attempt to establish a degree of uniformity and in order to standardize,

a) the choice of alternative symbols has been rationalized;

b) the letter "V" for voltage/volts is used throughout in preference to the alternative "U";

c) the symbol "θ" for temperature is used throughout in preference to the alternative "t";

d) a black dot, symbol 03-02-01, is used for all connections;

e) a small circle is used throughout to represent the hinge-point of symbols representing contacts and switchgear; and

f) the line representing the moving contact part of switchgear is drawn thicker than the other lines.

The symbols have been created in electronic format for use in a computer-aided design (CAD) cell library and are available, on disks, with this edition of NRS 002. The cells were developed in Microstation SE® and can be used with various drawing software packages through conversion.

The symbols have been selected from different parts of IEC 60617. The graphical symbols for diagrams used are those that are most common. Certain graphical symbols for reticulation system plans have been added.

SPECIFICATION

Graphical symbols for electrical diagrams

Preferred requirements for applications in the Electricity Supply Industry

1 Scope

This specification contains graphical symbols, typically for use in electrotechnical diagrams for heavy current equipment and associated control equipment.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this specification. At the time of publication, the editions indicated were valid. All standards and specifications are subject to revision, and parties to agreements are encouraged to investigate the possibility of applying the most recent editions of the normative documents listed below. Information on currently valid national and international standards and specifications can be obtained from the South African Bureau of Standards.

IEC 60027-1:1995, *Letter symbols to be used in electrical technology – Part 1: General.*

IEC 60050:(all parts), *International Electrotechnical Vocabulary (IEV).*

IEC 60076-1:1993, *Power Transformers – Part 1: General.*

IEC 60375:1972, *Conventions concerning electric and magnetic circuits.*

IEC 60445:1988, *Identification of equipment terminals and of terminations of certain designated conductors, including general rules of an alphanumeric system.*

IEC 60617-2:1996, *Graphic symbols for diagrams – Part 2: Symbol elements, qualifying symbols and other symbols having general application.*

IEC 60617-8:1996, *Graphic symbols for diagrams – Part 8: Measuring instruments, lamps and signalling devices.*

IEC 60617-11:1966, *Graphic symbols for diagrams – Part 11: Architectural and topographical installation plans and diagrams.*

ISO/IEC 646:1991, *Information technology – ISO 7-bit coded character set for information interchange.*

3 Definitions

For the purposes of this specification, the following definitions apply:

3.1 block symbol: A simple graphical symbol, representing an assembly of items and intended to indicate the function of the assembly, neither giving details about the items nor taking account of all connections.

NOTE Block symbols are generally used in diagrams where a single-line representation is applied. They may also be used in diagrams with all input connections shown.

3.2 general symbol: A symbol, usually simple, common to a whole family of items, and characteristic of that family.

3.3 graphical symbol: A figure, mark or character conventionally used on a diagram or other document to represent an item or a concept.

3.4 qualifying symbol: A symbol added to another to provide additional information.

NOTE 1 Qualifying symbols cannot normally be used on their own but a general symbol may sometimes be used for qualifying purposes. Thus the general symbol for an auto-transformer may be added to that for a motor starter to produce the symbol for an auto-transformer starter.

NOTE 2 The term "supplementary symbol" has been used in the past with the same meaning as qualifying symbol.

3.5 symbol element: A simple figure with a defined meaning, which has to be combined with other figures to form the complete symbol for a device or a concept.

For example, the symbol for a d.c. compound wound generator is assembled from symbol elements representing the machine, series and shunt field windings, bushes and terminals. When symbol elements are combined in this way, their arrangement is not necessarily related to the physical structure of the device symbolized.

4 General

4.1 General structure

Clause 5, which has the general heading *Symbols*, is structured as follows:

5.1 Symbol elements, qualifying symbols and other symbols having general application

It relates to outlines and enclosures, qualifying symbols for types of current and voltage, variability, direction of force, motion and flow, etc., mechanical controls, earth and frame connections.

5.2 Conductors and connecting devices

It relates to conductors, flexible, screened or twisted, coaxial, terminals, junctions, plugs, sockets and cable sealing ends.

5.3 Passive components

It relates to resistors, capacitors, inductors and delay lines.

5.4 Semiconductors

It relates to diodes, transistors and thyristors.

5.5 Production and conversion of electrical energy

It relates to windings, generators, motors, transformers and power converters.

5.6 Switchgear, controlgear and protective devices

It relates to contacts, switches, temperature-sensitive and touch-sensitive switches, proximity switches, switchgear and controlgear, motor starters, all-or-nothing relays, measuring relays, fuses, gaps and arresters.

5.7 Measuring instruments, lamps and signalling devices

It relates to indicating, integrating and recording instruments, thermocouples, telemetering devices, clocks, lamps, horns and bells.

5.8 Architectural and topographical installation plans and diagrams

It relates to generating stations, substations, conductors, wiring, socket outlets, switches, lighting outlets and fittings, light poles, ducts and water mains.

4.2 Terminology

Whenever possible, the names of the devices and concepts symbolized in this specification correspond to those used in IEC 60050.

4.3 Presentation of symbols

The symbols in this specification have been drawn to a size convenient for comprehension, but efforts have also been made to give them suitable sizes relative to each other. The symbols are laid out in such a way that the distance between connecting lines is a multiple of a certain modulus. The multiple of the modulus has been chosen to provide enough space for the usual terminal designations.

In most cases, the symbols are directly applicable on a diagram and they can be put on a grid in a CAD system (see Introduction).

Although the symbols are presented without a background grid, a grid was used in their preparation.

4.4 Numbering of symbols

Each symbol has a serial number, which is the same number as the corresponding symbol in IEC 60617. This number is composed of three groups:

a) the first group (two digits) identifies the part number of IEC 60617 in which that symbol is specified. Numbers for symbols not specified in any part of IEC 60617 start with the digits "00";

b) the second group (two digits) identifies the number of the section in that part; and

c) the third group (two digits) identifies the number of the symbol in that section.

Each one of these groups is separated from the next group by a hyphen.

In each part of IEC 60617, the sections are numbered from 01 to 99.

In each section, the symbols are numbered from 01 to 99 (not always consecutively, since some symbols of IEC 60617 have not been included).

Example:

03 – 02 – 05

Part 3
Section 2
Symbol 5

Some symbols have serial numbers with a suffix, for example, "-A" or "-02A". This suffix identifies a symbol that does not appear in IEC 60617, but that is related to the symbols adjacent to it.

NOTE Such symbols are included because they are used at present, but their further use should be avoided if possible.

4.5 Use of symbols

The list of symbol elements, qualifying symbols and general symbols has been made as complete as possible, but only a limited number of examples of combined symbols are given. If the symbol for a particular device or design cannot be found in this specification, it should be possible to produce it by an appropriate combination of accompanying symbols or by further reference to IEC 60617.

The sizes of symbols relative to one another may be changed to suit the circumstances of a given diagram or application, for example different symbol sizes are often used for power transformers and measuring transformers. Also, if a symbol is used to qualify another, its size is often reduced. The relative proportions of the symbols should be retained when they are reduced or enlarged.

Different line thicknesses may be used for conductor symbols. The minimum size of symbol and line thickness shall conform to microfilm standards and shall be the minimum permitted by the reproduction method used, as in the case of technical publications.

Symbols may be turned or mirror-imaged if this does not affect their meaning. Unless otherwise stated, the orientation shown in this specification is not mandatory.

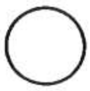
For clarity, symbols are usually shown with connecting lines. Unless otherwise stated, the arrangement shown is only one example of the ways in which connecting lines may be drawn.

Supplementary information can be added to most symbols. This specification gives examples of this practice only in those cases where there is a recommended method for the presentation of such information.

5 Symbols

5.1 Symbol elements, qualifying symbols and other symbols having general application

5.1.1 Symbol elements – Outlines and enclosures

IEC No.	Symbol	Description	Remarks
02-01-01	Form 1 	Item Equipment Functional Unit	Suitable symbols or legends shall be inserted in or added to the symbol outline to indicate the item, equipment or function.
02-01-02	Form 2 		
02-01-03	Form 3 		
02-01-04	Form 1 	Envelope (tank) Enclosure	An outline of another shape may be used. If the enclosure has special protective features, attention may be drawn to these by a note. The use of the envelope symbol is optional. It may be omitted if no confusion will arise. The envelope shall be shown if there is a connection to it. If necessary, the envelope may be split.
02-01-05	Form 2 		
02-01-06		Boundary line	Used to indicate items associated physically, mechanically or functionally. Any combination of short and long strokes may be used.
02-01-07		Screen (shield)	The screen may be drawn in any convenient shape.

5.1.2 Qualifying symbols

5.1.2.1 Types of current and voltage

IEC No.	Symbol	Description	Remarks
02-02-03	Form 2 ⎓	Direct current	Symbol 02-02-01 and 02-02-02 shall not be used.
02-02-04	∼	Alternating current	The numerical value of the frequency or frequency range may be added at the right-hand side of the symbol.
02-02-05	∼ 50 Hz	Alternating current of 50 Hz	
02-02-06	∼ 100 kHz to 600 kHz	Alternate current of frequency range 100 kHz to 600 kHz	The voltage may also be indicated at the right-hand side of the symbol.
02-02-07	3/N ∼ 400/230 VHz	Alternating current: three-phase with neutral, 50 Hz, 400 V (230 V between phase and neutral) 3N may be replaced by 3 + N	The number of phases and the presence of a neutral may be indicated at the left-hand side of the symbol.

5.1.2.1 (concluded)

IEC No.	Symbol	Description	Remarks
		Alternating current, different frequency ranges The following symbols may be used when it is necessary on a given drawing to distinguish between the different frequency ranges.	
02-02-09	$\sim$	Relatively low frequencies (example: power frequencies or sub-audio frequencies)	
02-02-10	$\approx$	Medium frequencies (example: audio)	
02-02-11	≋	Relatively high frequencies (example: super audio, carrier and radio frequencies)	
02-02-13	+	Positive polarity	
02-02-14	—	Negative polarity	
02-02-15	N	Neutral	
02-02-16	M	Mid-wire	

5.1.2.2 Variability

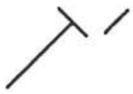
Variability is non-inherent when the variable quantity is controlled by an external device, for example, when the resistance is controlled by a regulator.

Variability is inherent when the variable quantity depends on qualities of the device itself, for example, when the resistance changes with change of voltage or with change of temperature.

The sign for variability should be drawn across the main symbol at about 45° to the centre line of the symbol.

IEC No.	Symbol	Description	Remarks
02-03-01		Variability, non-inherent	
02-03-02		Variability, non-inherent, non-linear	
02-03-03		Variability, inherent	Information on the controlling quantity, e.g. voltage or temperature, may be shown near the symbol.
02-03-04		Variability, inherent, non-linear	The remark on symbol 02-03-03 applies.
02-03-05		Pre-set adjustment	Information on the conditions under which adjustment is permitted may be shown near the symbol.
02-03-06	 $I=0$	Pre-set adjustment permitted only at zero current	

5.1.2.2 (concluded)

IEC No.	Symbol	Description	Remarks
02-03-07		Variability in steps Stepping action	A figure indicating the number of steps may be added.
02-03-08		Variability, non-inherent in five steps	
02-03-09		Continuous variability	
02-03-10		Pre-set adjustment, continuously variable	

5.1.2.3 Direction of force or motion

An arrow may be used to indicate the direction in which the movable part of a symbol has to move to give a required effect (see, for example, symbol 02-04-02).

An arrow may also indicate the direction of a force or the direction of motion of the physical part symbolized. In such cases, a note to indicate the viewpoint may be required.

The effect caused by movement may be explained by means of symbols or text.

IEC No.	Symbol	Description	Remarks
02-04-01		Rectilinear force or motion in the direction of the arrow	
02-04-02		Bidirectional rectilinear force or motion Frequency is increased when wiper 3 is moved towards terminal 2	
02-04-03		Unidirectional rotation in the direction of the arrow, e.g. clockwise	

5.1.2.3 (concluded)

IEC No.	Symbol	Description	Remarks
02-04-04		Bidirectional rotation	
02-04-05		Bidirectional rotation, limited in both directions	
02-04-06		Reciprocating motion	

5.1.2.4 Direction of flow

IEC No.	Symbol	Description	Remarks
02-05-01		Propagation, energy flow, signal flow, one way, e.g. of energy, signal, information	
02-05-02		Propagation, both ways, simultaneously Simultaneous transmission and reception	
02-05-03		Propagation, both ways, not simultaneously Alternate transmission and reception	
02-05-04		Transmission	The dot may be omitted if the sense is unambiguously given by the arrowhead in combination with the symbol to which it is applied.
02-05-05		Reception	The dot may be omitted if the sense is unambiguously given by the arrowhead in combination with the symbol to which it is applied.

5.1.2.4 (concluded)

IEC No.	Symbol	Description	Remarks
02-05-06		Energy flow from the busbars	
02-05-07		Energy flow towards the busbars	
02-05-08		Bidirectional energy flow	

5.1.2.5 Operational dependence on a characteristic quantity

IEC No.	Symbol	Description	Remarks
02-06-01	$>$	Operating when the characteristic quantity is higher than the setting value	
02-06-02	$<$	Operating when the characteristic quantity is lower than the setting value	
02-06-03	$\gtrless$	Operating when the characteristic quantity is either higher than a given high setting or lower than a given low setting	
02-06-04	$=0$	Operating when the value of the characteristic quantity becomes zero	
02-06-05	≈ 0	Operating when the value of the characteristic quantity differs from zero by an amount that is very small compared with the normal value	

5.1.2.6 Effect or dependence

IEC No.	Symbol	Description	Remarks
02-08-01		Thermal effect	
02-08-02		Electromagnetic effect	
02-08-04		Magnetic field effect or dependence	
02-08-05		Delay	

5.1.2.7 Radiation

Arrows pointing towards a symbol denote that the device symbolized will respond to incident radiation of the indicated type.

Arrows pointing away from a symbol denote the emission of the indicated type of radiation by the device symbolized.

Arrows located within a symbol denote a self-contained radiation source.

IEC No.	Symbol	Description	Remarks
02-09-01		Radiation, non-ionizing, electromagnetic (e.g. radio waves, visible light or light emission)	
02-09-02		Coherent radiation, non-ionizing (e.g. coherent light)	

5.1.2.8 Signal waveforms

IEC No.	Symbol	Description	Remarks
02-10-01		Positive-going pulse	
02-10-02		Negative-going pulse	
02-10-03		Pulse of alternating current	
02-10-04		Positive-going step function	
02-10-05		Negative-going step function	
02-10-06		Sawtooth wave	

5.1.3 Other symbols having general application

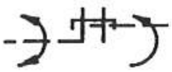
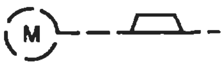
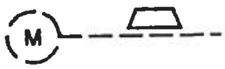
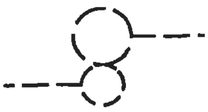
5.1.3.1 Mechanical controls

IEC No.	Symbol	Description	Remarks
02-12-01	Form 1	Mechanical connection (link) Pneumatic connection (link) Hydraulic connection (link)	
02-12-02		Mechanical connection with indication of force or motion	
02-12-03		Mechanical connection with indication of direction of rotation	The arrow is assumed to be placed in front of the connection symbol.
02-12-04	Form 2		Symbol 02-12-04 is to be used if the space is too restricted to permit the use of 02-12-01.

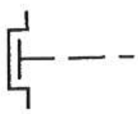
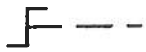
5.1.3.1 (continued)

IEC No.	Symbol	Description	Remarks
02-12-05	Form 1 	Delayed action	Delayed action in the direction of movement from the arc towards its centre ("Parachute" effect).
02-12-06	Form 2 		
02-12-07		Automatic return	The triangle is pointed in the return direction.
02-12-08		Detent Non-automatic return Device for maintaining a given position	
02-12-09		Detent, disengaged	
02-12-10		Detent, engaged	
02-12-11		Mechanical interlock between two devices	
02-12-12		Latching device, disengaged	
02-12-13		Latching device, engaged	
02-12-14		Blocking device	
02-12-15		Blocking device engaged, movement to the left is blocked	
02-12-16		Clutch Mechanical coupling	

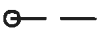
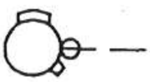
5.1.3.1 (concluded)

IEC No.	Symbol	Description	Remarks
02-12-17		Mechanical coupling, disengaged	
02-12-18		Mechanical coupling, engaged	
02-12-19		Bidirectional and rotating coupling devices (free wheel)	
02-12-20		Brake	
02-12-21		Electric motor with brake applied	
02-12-22		Electric motor with brake released	
02-12-23		Gearing	

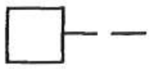
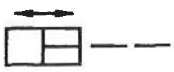
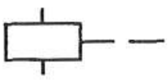
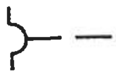
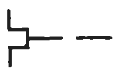
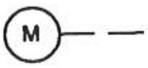
5.1.3.2 Operating devices and methods

IEC No.	Symbol	Description	Remarks
02-13-01		Manually operated control, general case	
02-13-02		Manually operated control with restricted access	
02-13-03		Operated by pulling	
02-13-04		Operated by turning	

5.1.3.2 (continued)

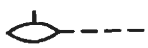
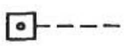
IEC No.	Symbol	Description	Remarks
02-13-05		Operated by pushing	
02-13-06		Operated by proximity effect	
02-13-07		Operated by touching	
02-13-08		Emergency switch (mushroom-head safety feature)	
02-13-09		Operated by handwheel	
02-13-10		Operated by pedal	
02-13-11		Operated by lever	
02-13-12		Operated by removable handle	
02-13-13		Operated by key	
02-13-14		Operated by crank	
02-13-15		Operated by roller	
02-13-16		Operated by cam	If desired, a more detailed drawing of the cam may be shown. This applies also to a profile plate.
02-13-17		Cam profile	
02-13-18		Profile plate Cam profile (developed representation)	
02-13-19		Operated by cam and roller	

5.1.3.2 (concluded)

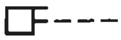
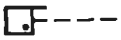
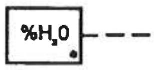
IEC No.	Symbol	Description	Remarks
02-13-20		Operated by stored mechanical energy	Information showing the form of stored energy may be added in the square.
02-13-21		Operated by pneumatic or hydraulic control, single acting	
02-13-22		Operated by pneumatic or hydraulic control, double acting	
02-13-23		Operated by electromagnetic actuator	
02-13-24		Operated by electromagnetic over-current protection	
02-13-25		Operated by thermal actuator, e.g. thermal relay, thermal over-current protection	
02-13-26		Operated by electric motor	
02-13-27		Operated by electric clock	

5.1.3.3 Control by non-electrical quantities

Letter symbols from IEC 60027-1 may be used to denote operating quantities other than those shown below (for example, pressure or speed). They should be enclosed in a rectangle if ambiguity could otherwise arise.

IEC No.	Symbol	Description	Remarks
02-14-01		Control by fluid level	
02-14-02		Control by number of events Control by a counter	

5.1.3.3 (concluded)

IEC No.	Symbol	Description	Remarks
02-14-03		Control by flow	
02-14-04		Control by gas flow	
02-14-05		Control by relative humidity	

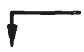
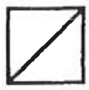
5.1.3.4 Earth and frame connections, equipotentiality

IEC No.	Symbol	Description	Remarks
02-15-01		Earth	General symbol. Supplementary information may be given to define the status or the purpose of the earth if this is not readily apparent.
02-15-02		Noiseless earth	
02-15-04		Frame Chassis	

5.1.3.5 Miscellaneous

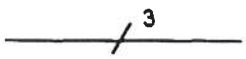
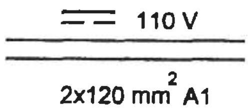
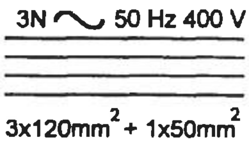
IEC No.	Symbol	Description	Remarks
02-17-01		Fault (indication of assumed fault location)	
02-17-02		Flashover Breakthrough	
02-17-03		Permanent magnet	

5.1.3.5 (concluded)

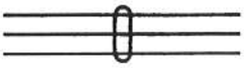
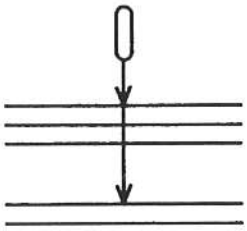
IEC No.	Symbol	Description	Remarks
02-17-04		Moving (e.g. sliding) contact	
02-17-05		Test point indicator	
02-17-06		Changer Converter	General symbol. If the direction of change is not obvious, it may be indicated by an arrow-head on the outline of the symbol, e.g. see symbol 06-14-06. A symbol or legend indicating the input or output quantity, waveform, etc., may be inserted in each half of the general symbol to show the nature of the change (see 5.5). The diagonal line from this symbol is used in the form of a solidus to show a converting function.
02-17-08	∩	Identifier of analogue signals	The symbol shall be used only when it is necessary to distinguish between analogue and digital signals.
02-17-09	⌗	Identifier of digital signals	Digital. This symbol shall be used only when it is necessary to distinguish between digital and other forms of signals and connections See also clause 1 in ISO/IEC 646.

5.2 Conductors and connecting devices

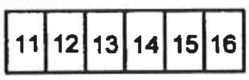
5.2.1 Conductors

IEC No.	Symbol	Description	Remarks
03-01-01		Conductor Group of conductors Line Cable Circuit Transmission path	Single-line representation of conductors. When a single line represents a group of conductors, their number may be indicated by adding either small strokes or one stroke and a figure.
03-01-02	Form 1 	*Example:* Three conductors	Additional information may be indicated as follows: *Above the line:* type of current, system of distribution, frequency and voltage.
03-01-03	Form 2 		*Below the line:* the number of conductors of the circuit followed by a multiplication sign and the cross-sectional area of each conductor. If different sizes of conductors are used, their particulars should be separated by a plus sign. The conductor material may be indicated by its chemical symbol.
03-01-04		*Examples:* Direct current circuit, 110 V, two aluminium conductors of 120 mm²	
03-01-05		Three-phase circuit, 50 Hz, 400 V, three conductors of 120 mm² with neutral of 50 mm²	
03-01-06		Flexible conductor	
03-01-07		Screened conductor	

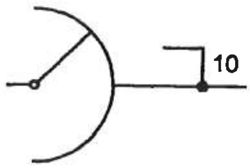
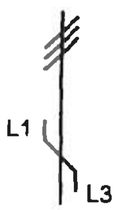
5.2.1 (concluded)

IEC No.	Symbol	Description	Remarks
03-01-08		Twisted conductors, two conductors shown	
03-01-09		Conductors in a cable, three conductors shown	
03-01-10		*Example:* Two conductors out of five in a cable	If several conductors are in a cable (or twisted together or in a screen) but the lines representing them on a diagram are not adjacent to each other, the method shown below may be used.
03-01-11		Coaxial pair	If the coaxial structure is not maintained, the tangential line should be drawn on the coaxial side only.
03-01-12		*Example:* Coaxial pair connected to terminals	
03-01-13		Coaxial pair with screen	

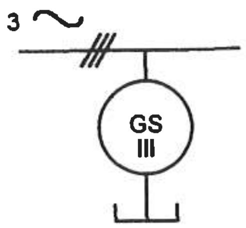
5.2.2 Terminals and connections of conductors

IEC No.	Symbol	Description	Remarks
03-02-01	•	Connection of conductors	
03-02-02	o	Terminal	Used on schematic and key diagrams.
03-02-03		Terminal strip (examples shown with terminal markings) Terminal markings may be added	Used on wiring and cabling diagrams.

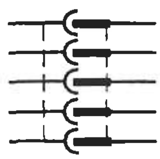
5.2.2 (continued)

IEC No.	Symbol	Description	Remarks
03-02-04		T- connection	
03-02-05		Symbol 03-02-04 shown with junction symbol	Other than at a terminal.
03-02-06		Junction of conductors at a terminal	
03-02-07	Form 1 	Double junction of conductors	Other than at a terminal.
03-02-08	Form 2 	Form 2 shall only be used if required by layout considerations	
03-02-09		Connection common to a group of similar items "n" shall be replaced by the total number of circuits	The total number of similar items may be indicated by a figure near the common connection symbol.
03-02-10		*Example:* Multiplied uniselector banks shown for 10 banks	Deleted. Transferred to annex A: 03-A1-02 (see IEC 60617)
03-02-11		Interchange of conductors, change of phase sequence or inversion of polarity, shown for n conductors in single-line representation	The interchanged conductors may be indicated.
03-02-12		*Example:* Change phase of sequence	For the identification of the conductors, IEC 60445 applies.

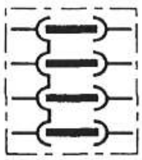
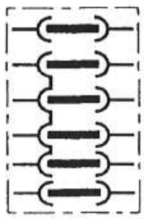
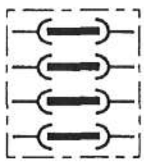
5.2.2 (concluded)

IEC No.	Symbol	Description	Remarks
03-02-13 03-02-14	 	Neutral point Point at which multiple conductors are connected together to form the neutral point in a multi-phase system *Example:* Synchronous generator, three-phase, both leads of each phase brought out, shown with external neutral point	

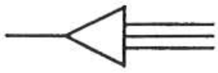
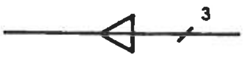
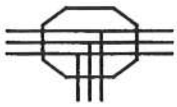
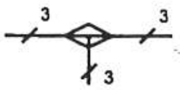
5.2.3 Connecting devices

IEC No.	Symbol	Description	Remarks
03-03-01		Socket (female) Pole of a socket	
03-03-03		Pole of a plug Plug (male)	
03-03-05		Plug and socket (male and female)	
03-03-07 03-03-08	 	Multipole plug and socket, shown with six poles: multi-line representation Single-line representation	
03-03-15		Coaxial plug and socket	If the coaxial plug or socket is connected to a coaxial pair, the tangential line(s) should be appropriately extended.

5.2.3 (concluded)

IEC No.	Symbol	Description	Remarks
03-03-17	Form 1 	Connecting link, closed	
03-03-46	Form 2 	Connecting link, open	Vertical representation.
03-03-47			Horizontal representation.
03-03-20		Plug and socket type connector, e.g. U-link: male-male *Example of test blocks:*	
03-03-48		Four-way test block with auxiliary short-circuiting contacts	Used in current transformer circuits.
03-03-49		Six-way test block with auxiliary short-circuiting contacts on four of the ways	Used in current transformer circuits.
03-03-50		Four-way test block	Used in voltage circuits. The dotted lines drawn between the socket symbol examples denote an auxiliary short-circuiting device that operates on the withdrawal of the plug from the socket.

5.2.4 Cable fittings

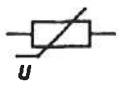
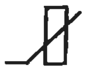
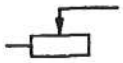
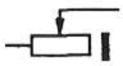
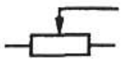
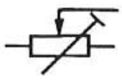
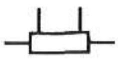
IEC No.	Symbol	Description	Remarks
03-04-01		Cable sealing end, shown with one three-core cable	Multi-line representation.
03-04-50			Single-line representation.
03-04-03		Straight-through joint box, shown with three conductors	Multi-line representation.
03-04-04			Single-line representation.
03-04-05		Junction box, shown with three conductors with T-connections	Multi-line representation.
03-04-06			Single-line representation.

5.3 Passive components

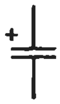
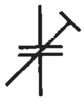
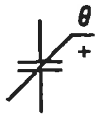
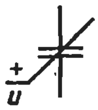
5.3.1 Resistors

IEC No.	Symbol	Description	Remarks
04-01-01		Resistor	General symbol.
04-01-03		Variable resistor Adjustable resistor	
04-01-04		Voltage dependent resistor Varistor (Resistor with inherent non-linear variability, voltage dependent)	Metrosil.

5.3.1 (concluded)

IEC No.	Symbol	Description	Remarks
04-01-49		Temperature dependent resistor with negative resistance-temperature coefficient	Thermistor.
04-01-50		Temperature dependent resistor with positive resistance-temperature coefficient	Ballast resistor. Vertical representation.
04-01-05		Resistor with sliding contact	
04-01-06		Resistor with sliding contact and off-position	
04-01-07		Potentiometer with sliding contact	
04-01-08		Potentiometer, pre-set	
04-01-09		Resistor with fixed tappings (taps), two shown	
04-01-10		Shunt Resistor with separate current and voltage terminals	
04-01-11		Carbon-pile resistor	
04-01-12		Heating element	

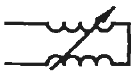
5.3.2 Capacitors

IEC No.	Symbol	Description	Remarks
04-02-01		Capacitor	General symbol.
04-02-03		Lead-through capacitor Feed-through capacitor	
04-02-05		Polarized capacitor, e.g. electrolytic	
04-02-07		Variable capacitor Adjustable capacitor	
04-02-09		Capacitor with pre-set adjustment	
04-02-15		Temperature dependent polarized capacitor, where deliberate use is made of the temperature coefficient, e.g. ceramic capacitor	
04-02-16		Voltage dependent polarized capacitor where deliberate use is made of the voltage dependent characteristic, e.g. semiconductor capacitor	

5.3.3 Inductors

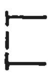
IEC No.	Symbol	Description	Remarks
04-03-01		Inductor Coil Winding Choke NOTE If it is desired to show that the inductor has a magnetic core, a single line may be annotated to indicate non-magnetic materials and it may be interrupted to indicate a gap in the core *Examples:*	For transformer windings, see 5.5.
04-03-03		Inductor with magnetic core	
04-03-04		Inductor with gap in magnetic core	

5.3.3 (concluded)

IEC No.	Symbol	Description	Remarks
04-03-05		Continuously variable inductor, shown with magnetic core	
04-03-06		Inductor with fixed tappings, two shown	
04-03-07		Inductor with moving contact, variable in steps	
04-03-08		Variometer	

5.4 Semiconductor devices

5.4.1 Symbol elements

IEC No.	Symbol	Description	Remarks
05-01-01		Semiconductor region with one ohmic connection	The horizontal line is the semiconductor region and the vertical line is the ohmic connection.
05-01-02	Form 1 	Semiconductor region with several ohmic connections, example shown with two ohmic connections	
05-01-03	Form 2 		
05-01-04	From 3 		
05-01-05		Conduction channel for depletion type devices	
05-01-06		Conduction channel for enhancement devices	
05-01-07		Rectifying junction	

5.4.1 (continued)

IEC No.	Symbol	Description	Remarks
		Junction than influences a semi-conductor layer by means of an electric field, e.g. in a junction field effect transistor	
05-01-09		P-region that influences an N-layer	
05-01-10		N-region that influences a P-layer	
		Indication of the conductivity type of the channel for insulated gate field effect transistors (IGFETS)	
05-01-11		N-type channel on a P-type substrate, shown for a depletion type IGFET	
05-01-12		P-type channel on an N-type substrate, shown for an enhance-ment type IGFET	
05-01-13		Insulated gate	For an example with multi-ple gates, see symbol 05-05-17.
		Emitter on a region of dissimilar conductivity type	
05-01-14		P-emitter on N-region	The slanting line with arrow represents the emitter.
05-01-15		Several P-emitters on N-region	
05-01-16		N-emitter on P-region	
05-01-17		Several N-emitters on P-region	

5.4.1 (concluded)

IEC No.	Symbol	Description	Remarks
05-01-18		Collector on a region of dissimilar conductivity type	The slanting line represents the collector.
05-01-19		Several collectors on a region of dissimilar conductivity type	
05-01-20		Transition between regions of dissimilar conductivity types, either P to N, or N to P	The short slanting line indicates the point of change along the horizontal from P to N, or from N to P. No ohmic connection shall be made to the short slanting line.
05-01-21		Intrinsic region separating regions of dissimilar conductivity type thus giving either a PIN or a NIP structure	The intrinsic region lies between the linked slanting lines. Any ohmic connection to the region 1 shall be made between the short slanting lines and not to them.
05-01-22		Intrinsic region between regions of similar conductivity type giving either a PIP or a NIN structure	
05-01-23		Intrinsic region between a collector and a region of dissimilar conductivity type giving either a PIN or a NIP structure	The connection to the collector is made to the long slanting line.
05-01-24		Intrinsic region between a collector and a region of similar conductivity type giving either a PIP or a NIN structure	

5.4.2 Qualifying symbols particular to semiconductor devices

If necessary, a special function or property essential for circuit operation may be indicated by a qualifying symbol placed adjacent to, or forming part of the symbol of, the device.

IEC No.	Symbol	Description	Remarks
05-02-01		Schottky effect	
05-02-02		Tunnel effect	
05-02-03		Unidirectional breakdown effect	
05-02-04		Bidirectional breakdown effect	
05-02-05		Backward effect (unitunnel effect)	

5.4.3 Examples of semiconductor diodes

IEC No.	Symbol	Description	Remarks
05-03-01		Semiconductor diode	General symbol.
05-03-02		Light-emitting diode (LED)	General symbol. See also symbol 08-10-01.
05-03-03		Temperature testing diode Diode where use is made of its temperature dependence	
05-03-04		Variable capacitance diode	Varactor.
05-03-05		Tunnel diode	
05-03-06		Breakdown diode, unidirectional Voltage regulator diode	Esaki diode. Zener diode.
05-03-07		Breakdown diode, bidirectional	

5.4.3 (concluded)

IEC No.	Symbol	Description	Remarks
05-03-08		Backward diode	Unitunnel diode.
05-03-09		Bidirectional diode	Diac. Varistor.

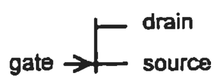
5.4.4 Examples of thyristors

IEC No.	Symbol	Description	Remarks
05-04-01		Reverse blocking diode thyristor	
05-04-02		Reverse conducting diode thyristor	
05-04-03		Bidirectional diode thyristor	Diac.
05-04-04		Triode thyristor, type unspecified	This symbol is used to represent a reverse blocking triode thyristor, if it is not necessary to specify the type of gate.
05-04-05		Reverse blocking triode thyristor, N-gate	Anode-side controlled.
05-04-06		Reverse blocking triode thyristor, P-gate	Cathode-side controlled.
05-04-07		Turn-off triode thyristor, gate not specified	
05-04-08		Turn-off triode thyristor, N-gate	Anode-side controlled.
05-04-09		Turn-off triode thyristor, P-gate	Cathode-side controlled.
05-04-10		Reverse blocking thyristor, tetrode type	
05-04-11		Bidirectional triode thyristor	Triac.

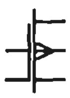
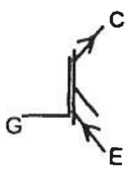
5.4.4 (concluded)

IEC No.	Symbol	Description	Remarks
05-04-12		Reverse conducting triode thyristor, gate not specified	
05-04-13		Reverse conducting triode thyristor, N-gate	Anode-side controlled.
05-04-14		Reverse conducting triode thyristor, P-gate	Cathode-side controlled.

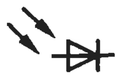
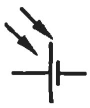
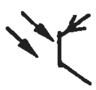
5.4.5 Examples of transistors

IEC No.	Symbol	Description	Remarks
05-05-01		PNP transistor	
05-05-02		NPN transistor with collector connected to the envelope	
05-05-03		NPN avalanche transistor	
05-05-04		Unijunction transistor with P-type base	
05-05-05		Unijunction transistor with N-type base	
05-05-06		NPN transistor with transverse biased base	
05-05-07		PNIP transistor with ohmic connec-ion to the intrinsic region	
05-05-08		PNIN transistor with ohmic connec-tion to the intrinsic region	
05-05-09		Junction field effect transistor with N-type channel	The gate and source connections shall be drawn in line. 

5.4.5 (concluded)

IEC No.	Symbol	Description	Remarks
05-05-10		Junction field effect transistor with P-type channel	
05-05-11		IGFET, enhancement type, single gate, P-type channel without substrate connection	For an example with multiple gates, see symbol 05-05-17.
05-05-12		IGFET, enhancement type, single gate, N-type channel without substrate connection	
05-05-13		IGFET, enhancement type, single gate, P-type channel with substrate connection brought out	
05-05-14		IGFET, enhancement type, single gate, N-type channel with substrate internally connected to source	
05-05-15		IGFET, depletion type, single gate, N-type channel without substrate connection	
05-05-16		IGFET, depletion type, single gate, P-type channel without substrate connection	
05-05-17		IGFET, depletion type with two gates, N-type channel with sub-strate connection brought out	In the case of multiple gates, the primary gate and the source connection shall be drawn in line.
05-05-18		Insulated gate bipolar transistor (IGBT), enhancement type, P-channel	The letters E, G and C which represent the ter-minal names "emitter", "gate", and "collector" res-pectively, may be omitted unless confusion is likely.

5.4.6 Examples of photosensitive and magnetic field sensitive devices

IEC No.	Symbol	Description	Remarks
05-06-01		Light dependent resistor Photoconductive device with asymmetrical conductivity	
05-06-02		Photodiode Photoconductive device with symmetrical conductivity	
05-06-03		Photovoltaic cell	
05-06-04		Phototransistor, PNP type shown	

5.5 Production and conversion of electrical energy

5.5.1 Qualifying symbols for winding interconnections

5.5.1.1 Separate windings

IEC No.	Symbol	Description	Remarks
06-01-01	|	One winding	The number of separate windings should be indicated: - either by the number of strokes drawn, or - by adding a figure to the symbol. Symbol 06-01-01 may also be used to represent windings that can be externally connected in various ways.
		Examples:	
06-01-02	|||	Three separate windings	
06-01-03	| 6	Six separate windings	
06-01-04	||| 3 $\sim$	*Examples:* Three-phase winding, phases not interconnected	
06-01-05	| $^{m}/_{m}\sim$	*m*-phase winding, phases not interconnected	
06-01-06	L	Two-phase winding, four-wire	

5.5.1.2 Internally connected windings

The method of connecting transformer windings may also be indicated by codes (see IEC 60076-1).

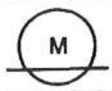
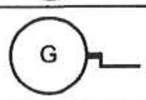
IEC No.	Symbol	Description	Remarks
06-02-05		Three-phase winding, delta	This symbol may be used to symbolize a multiphase polygon connection of windings by adding a figure to denote the number of phases.
06-02-06		Three-phase winding, open delta	
06-02-07		Three-phase winding, star	This symbol may be used to symbolize a multiphase star connection of windings by adding a figure to denote the number of phases.
06-02-08		Three-phase winding, star, with neutral brought out	
06-02-09		Three-phase winding, zigzag or interconnected star	
06-02-10		Six-phase winding, double delta	
06-02-11		Six-phase winding, polygon	
06-02-12		Six-phase winding, star	
06-02-13		Six-phase winding, fork with neutral brought out	

5.5.2 Machines

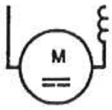
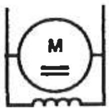
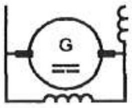
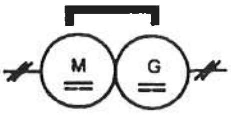
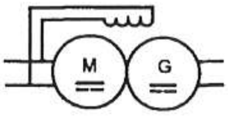
5.5.2.1 Elements of machines

IEC No.	Symbol	Description	Remarks
		Differentiation between windings having different functions	
06-03-01		Commutating or compensating winding	
06-03-02		Series winding	
06-03-03		Shunt winding or separate winding	
06-03-04		Brush (on slip ring or commutator)	Brushes are shown only if necessary. For example of application, see symbol 06-05-03.

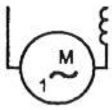
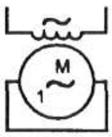
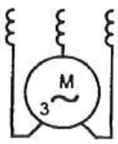
5.5.2.2 Types of machines

IEC No.	Symbol	Description	Remarks
06-04-01		Machine The asterisk* shall be replaced by a letter designation as follows: C: Rotary converter G: Generator GS: Synchronous generator M: Motor MG: Machine capable of use as a generator or motor MS: Synchronous motor	General symbol. Symbol 02-02-04 may be added, as shown in 5.1.2.1.
06-04-02		Linear motor	General symbol.
06-04-03		Stepping motor	General symbol.
06-04-04		Hand generator (magneto caller)	

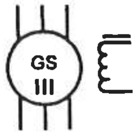
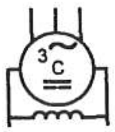
5.5.2.3 Examples of direct current machines

IEC No.	Symbol	Description	Remarks
06-05-01		Series motor, DC	
06-05-02		Shunt motor, DC	
06-05-03		Generator, DC, compound excited (short shunt), shown with terminals and brushes	
06-05-04		Rotary converter, d.c. to d.c. with common permanent magnet field	
06-05-05		Rotary converter, d.c. to d.c. with common field winding	Rotary converter, d.c. to d.c. with common exitation winding.

5.5.2.4 Examples of alternating current commutator machines

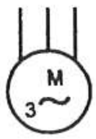
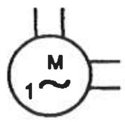
IEC No.	Symbol	Description	Remarks
06-06-01		Series motor, single-phase	
06-06-02		Repulsion motor, single-phase	
06-06-03		Series motor, three-phase	

5.5.2.5 Examples of synchronous machines

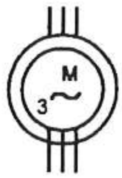
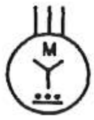
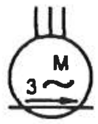
IEC No.	Symbol	Description	Remarks
06-07-01		Synchronous generator, three-phase, permanent magnet	
06-07-02		Synchronous motor, single-phase	
06-07-03		Synchronous generator, three-phase, star-connected, with neutral brought out	
06-07-04		Synchronous generator, three-phase, both leads of each phase winding brought out	
06-07-05		Synchronous rotary converter, three-phase, shunt excited	

5.5.2.6 Examples of induction type (asynchronous) machines

The general symbol for a machine (06-04-01) should be used to represent an asynchronous machine if no external connections to the rotor exist, for example, in a squirrel cage motor. An inner circle, representing the rotor, should be shown in those cases where external connections exist (see, for example, symbol 06-08-03).

IEC No.	Symbol	Description	Remarks
06-08-01		Induction motor, three-phase, squirrel cage	
06-08-02		Induction motor, single-phase, squirrel cage	

5.5.2.6 (concluded)

IEC No.	Symbol	Description	Remarks
06-08-03		Induction motor, three-phase, with wound rotor	
06-08-04		Induction motor, three-phase, star-connected, with automatic starter in the rotor	
06-08-05		Linear induction motor, three-phase, movement limited to one direction	

5.5.3 Transformers and reactors

Two forms of symbol are shown for the same type of transformer:

Single-line form – Form 1
Multi-line form – Forms 2 and 3

Forms 1 and 3 use a circle to represent each winding. Its use is preferably restricted to single-line representation. Symbols for transformer cores are not used with this form.

Form 2 uses symbol 04-03-01 to represent each winding. The number of half circles may be varied to differentiate between certain windings.

Form 3 is an alternative symbol form for three-phase transformers and induction regulators.

For the representation of transformer cores, see note to symbol 04-03-01.

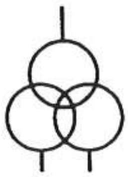
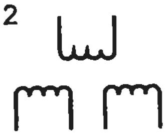
In the case of symbols for current and pulse transformers, straight lines, representing windings, may be used with either form (see 5.5.3.5).

IEC 60375 gives a method of indicating the instantaneous voltage polarities of coupled electric circuits. For an example of application, see symbol 06-09-03.

The strokes on the leads on the single-line form may be omitted if so desired.

The appropriate vector symbols for transformer winding connections are used in accordance with IEC 60076-1.

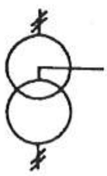
5.5.3.1 General symbols

IEC No.	Symbol	Description	Remarks
06-09-01	Form 1 	Transformer with two windings The instantaneous voltage polarities may be indicated in form 2 of the symbol. *Example:* Transformer with two windings, shown with instantaneous voltage polarity indicators	Single-line form.
06-09-02	Form 2 		Multi-line form.
06-09-03			Instantaneous currents entering the marked ends of the windings produce aiding fluxes.
06-09-04	Form 1 	Transformer with three windings	Single-line form.
06-09-05	Form 2 		Multi-line form.
06-09-06	Form 1 	Auto-transformer	HV side. Single-line form. LV side.
06-09-07	Form 2 		Multi-line form.
06-09-08	Form 1 	Choke Reactor	Single-line form.
06-09-09	Form 2 Use symbol 04-03-01		Multi-line form.

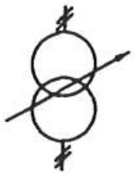
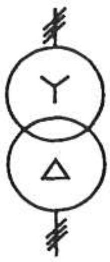
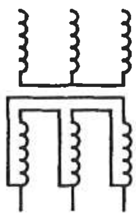
5.5.3.1 (concluded)

IEC No.	Symbol	Description	Remarks
06-09-10	Form 1 	Current transformer Pulse transformer	Single-line form.
06-09-11	Form 2 		Multi-line form.

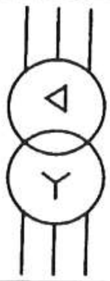
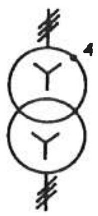
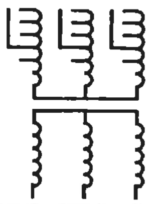
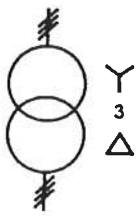
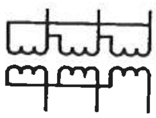
5.5.3.2 Examples of transformers with separate windings

IEC No.	Symbol	Description	Remarks
06-10-01	Form 1 	Single-phase transformer with two windings and screen	Single-line form
06-10-02	Form 2 		Multi-line form
06-10-03	Form 1 	Transformer with centre tapping on one winding	Single-line form.
06-10-04	Form 2 		Multi-line form.

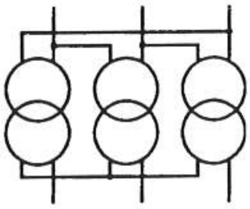
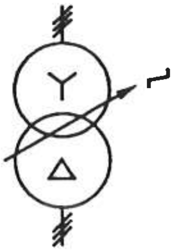
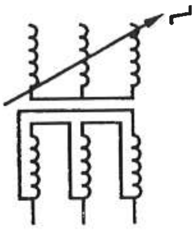
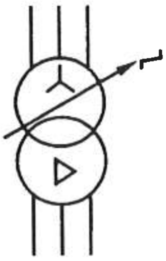
5.5.3.2 (continued)

IEC No.	Symbol	Description	Remarks
06-10-05	Form 1 	Transformer with variable coupling	Single-line form.
06-10-06	Form 2 		Multi-line form.
06-10-07	Form 1 	Three-phase transformer, connection star-delta Yd 11	Single-line form.
06-10-08	Form 2 		Multi-line forms.

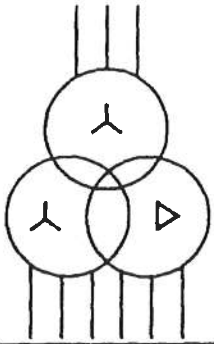
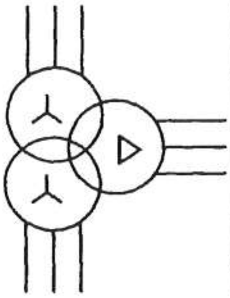
5.5.3.2 (continued)

IEC No.	Symbol	Description	Remarks
06-10-50	Form 3 		Multi-line forms.
06-10-09	Form 1 	Three-phase transformer without four tappings (taps), connection star-star	Each primary winding is shown with four available connection points in addition to those at winding ends.
06-10-10	Form 2 		
06-10-11	Form 1 	Three-phase bank of single-phase transformers, connection star-delta	
06-10-12	Form 2 		

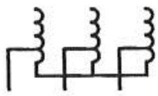
5.5.3.2 (continued)

IEC No.	Symbol	Description	Remarks
06-10-49			Multi-line forms.
06-10-13	Form 1 	Three-phase transformer with on-load tap changer, connection star-delta	
06-10-14	Form 2 		
06-10-48	Form 3 		Multi-line form.
06-10-15	Form 1 		Single-line form.

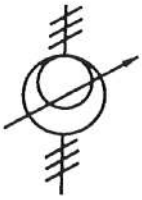
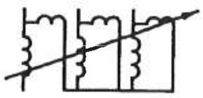
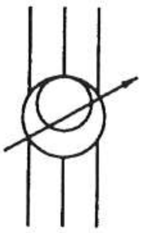
5.5.3.2 (concluded)

IEC No.	Symbol	Description	Remarks
06-10-47		Three-phase transformer, connection star-star-delta	Alternative to symbol 06-10-18
06-19-46			Alternative to symbol 06-10-47

5.5.3.3 Examples of auto-transformers

IEC No.	Symbol	Description	Remarks
06-11-01	Form 1 	Auto-transformer, single-phase	HV side. Single-line form. LV side.
06-11-02	Form 2 		Multi-line form.
06-11-03	Form 1 	Auto-transformer, three-phase, connection star	Single-line form.
06-11-04	Form 2 		
06-11-05	Form 1 	Auto-transformer, single-phase with voltage regulation	Single-line form.
06-11-06	Form 2 		Multi-line form.

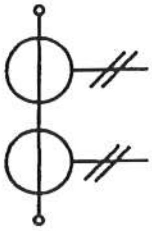
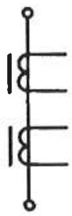
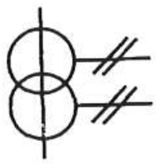
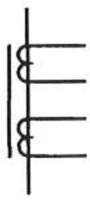
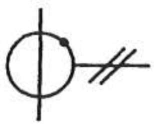
5.5.3.4 Examples of induction regulators

IEC No.	Symbol	Description	Remarks
06-12-01	Form 1 		Single-line form.
06-12-02	Form 2 	Three-phase induction regulator	
06-12-50	Form 3 		Multi-line form.

5.5.3.5 Examples of measuring transformers and pulse transformers

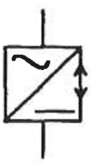
IEC No.	Symbol	Description	Remarks
	Use appropriate symbol in 5.5.3.1	Voltage transformer	
06-13-01	Form 1 	Voltage transformer	
06-13-50	Form 2 		

5.5.3.5 (concluded)

IEC No.	Symbol	Description	Remarks
06-13-02	Form 1 	Current transformer with two cores with one secondary winding on each core	The terminal symbols shown at the end of the primary circuit indicate that only a single device is represented. The terminal symbols may be omitted if terminal designations are used. In form 2, core symbols may be omitted.
06-13-03	Form 2 		
06-13-04	Form 1 	Current transformer with two secondary windings on one core	In form 2, the core symbol shall be drawn.
06-13-49	Form 2 		
06-13-05	Form 1 	Current transformer with one secondary winding with one tapping	Single-line form.
06-13-06	Form 2 		Multi-line form.

5.5.4 Power converters

The symbols 06-14-02 to 06-14-06 (inclusive) are shown in the horizontal representation. For vertical representation, the connecting lines are to be drawn in a vertical plane, without the symbol. For an example of application, see symbol 06-14-06A.

IEC No.	Symbol	Description	Remarks
06-14-01		Converter	General symbol.
06-14-02		D.C./D.C. converter	
06-14-03		Rectifier	
06-14-04		Rectifier in full wave (bridge) connection	
06-14-05		Inverter	
06-14-06		Rectifier/inverter	Horizontal representation.
06-14-50			Vertical representation.

5.5.5 Primary cells and accumulators

IEC No.	Symbol	Description	Remarks
06-15-01		Primary cell and accumulator Secondary cell Battery of primary or secondary cells	The longer line represents the positive pole, the shorter one the negative pole.

5.6 Switchgear, controlgear and protective devices

5.6.1 General

Subclauses 5.6.2 and 5.6.3 give preferred symbols for contact units and switchgear. Each symbol depicts the function of a contact or a switching device, without necessarily being related to the construction of the device it represents.

The movement of all two-position contacts, switches and controlgear from the unoperated to the operated position is from left to right for the vertical representation shown. For horizontal representation, the symbol is rotated counter-clockwise through 90°, the movement then being from below to above, or clockwise.

The line representing the moving contact is drawn thicker for clarity.

5.6.2 Contacts

5.6.2.1 Qualifying symbols

IEC No.	Symbol	Description	Remarks
07-01-01		Contact function	
07-01-02	×	Circuit-breaker function	
07-01-03	—	Disconnector (isolator) function	
07-01-04		Switch-disconnector (isolating-switch) function	
07-01-05	■	Automatic release function	
07-01-06		Position switch function Limit switch function	This qualifying symbol can be applied to simple contact symbols to indicate position or limit switches if there is no need to show the means of operating the contact. In complicated cases, where it is desirable to show the means of operation, symbols 02-13-16 to 02-13-19 should be used instead. This symbol is placed on both sides of the contact symbol when the contact is mechanically operated in both directions.

5.6.2.1 (concluded)

IEC No.	Symbol	Description	Remarks
07-01-07	◁	Spring-return function	This symbol may be used to indicate spring-return function. When this convention is invoked, its use should be appropriately referenced. This symbol should not be used together with qualifying symbols 07-01-01, 07-01-02, 07-01-03 and 07-01-04. In many cases, symbol 02-12-07 may be used.
07-01-08	o	Non-spring-return (stay put) function	This symbol may be used to indicate non-spring-return function. When this convention is invoked, its use should be appropriately referenced. This symbol should not be used together with qualifying symbols, 07-01-01, 07-01-02, 07-01-03 and 07-01-04. In many cases, symbol 02-12-08 may be used.

5.6.2.2 Contacts with two or three positions

IEC No.	Symbol	Description	Remarks
07-02-01	Form 1 	Make contact	
07-02-02	Form 2 		This symbol is also used as the general symbol for a switch.
07-02-03		Break contact	
07-02-04		Change-over break-before-make contact	
07-02-05		Change-over contact with off-position in the centre	

5.6.2.2 (concluded)

IEC No.	Symbol	Description	Remarks
07-02-06	Form 1 	Change-over make-before-break contact (bridging)	
07-02-07	Form 2 		
07-02-08		Contact with two makes	
07-02-09		Contact with two breaks	

5.6.2.3 Passing contacts with two positions ("fleeting" contacts)

IEC No.	Symbol	Description	Remarks
07-03-01		Passing make contact closing momentarily when its operating device is actuated	
07-03-02		Passing make contact closing momentarily when its operating device is released	
07-03-03		Passing make contact closing momentarily when its operating device is actuated or released	

5.6.2.4 Early and late operating contacts

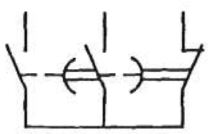
IEC No.	Symbol	Description	Remarks
07-04-01		Make contact (of a multiple contact assembly), which is early to close relative to the other contacts of the assembly	
07-04-02		Make contact (of a multiple contact assembly), which is late to close relative to the other contacts of the assembly	

5.6.2.4 (concluded)

IEC No.	Symbol	Description	Remarks
07-04-03		Break contact (of a multiple contact assembly), which is late to open relative to the other contacts of the assembly	
07-04-04		Break contact (of multiple contact assembly), which is early to open relative to the other contacts of the assembly	

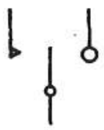
5.6.2.5 Examples of contacts with intentional delay

For the sake of uniformity, the qualifying symbols 02-12-05 and 02-12-06 shall be placed on the left-hand side of the appropriate make or break contact symbol.

IEC No.	Symbol	Description	Remarks
07-05-01		Make contact, delayed when the device containing the contact is being activated	
07-05-02		Make contact, delayed when the device containing the contact is being deactivated	
07-05-03		Break contact, delayed when the device containing the contact is being activated	
07-05-04		Break contact delayed when the device containing the contact is being deactivated	
07-05-05		Make contact, delayed both when the device containing the contact is being activated and when it is being deactivated	
07-05-06		*Example:* Contact assembly with one make contact not delayed, one make contact delayed when the device containing the contact is being activated and one break contact delayed when the device containing the contact is being deactivated	

5.6.2.6 Examples of spring-return and non-spring-return (stay put) contacts

The remarks on symbols 07-01-07 and 07-01-08 apply. Other qualifying symbols shall be placed on the left-hand side of the main symbol.

IEC No.	Symbol	Description	Remarks
07-06-01		Make contact with automatic return	
07-06-02		Make contact without automatic return Stay put make contact	
07-06-03		Break contact with automatic return	
07-06-04		Two-way contact with off-position in the centre and automatic return from one position (shown to the left), and without automatic return in the opposite position	

5.6.3 Switches, switchgear and starters

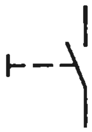
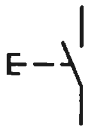
Devices with "push" or "pull" operation normally have automatic return. It is therefore not necessary to show the automatic return symbol (02-12-07). On the other hand, a detent symbol (02-12-08) should be shown in those cases where non-return exists.

Devices operated by turning do not usually have automatic return. It is therefore not necessary for the detent symbol (02-12-08) to be shown. On the other hand, the automatic return symbol (02-12-07) should be shown in those cases where an automatic return exists.

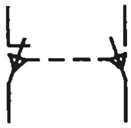
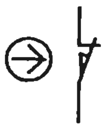
The use of symbol 02-12-04 (form 2) is preferred in conjunction with symbols for single-pole switches.

Qualifying symbols shall be placed on the left-hand side of the main symbol.

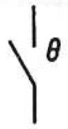
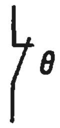
5.6.3.1 Single-pole switches

IEC No.	Symbol	Description	Remarks
07-07-01		Manually operated switch	General symbol.
07-07-02		Push-button switch, make contact and automatic return	
07-07-03		Pull-switch with make contact and automatic return	
07-07-04		Turn-switch and make contact without automatic return	

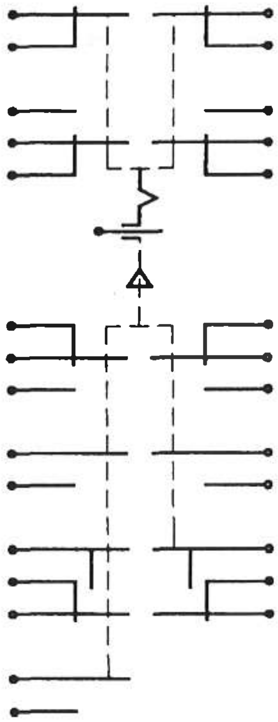
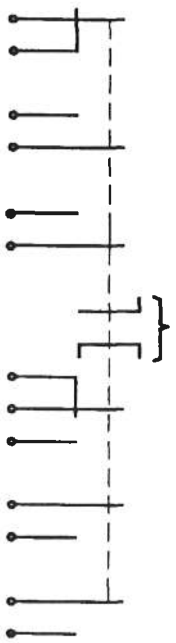
5.6.3.2 Position and limit switches

IEC No.	Symbol	Description	Remarks
07-08-01		Position switch, make contact	
07-08-02		Position switch, break contact	
07-08-03		Position switch mechanically operated in both directions with two separate circuits	
07-08-04		Position switch with positive opening operation of the break contact	

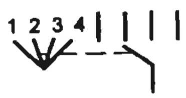
5.6.3.3 Temperature-sensitive switches

IEC No.	Symbol	Description	Remarks
07-09-01		Temperature-sensitive switch, make contact	θ may be replaced by the operating temperature conditions.
07-09-02		Temperature-sensitive switch, break contact	θ may be replaced by the operating temperature conditions.
07-09-03 07-09-03		Self-operating thermal switch (e.g. bi-metal), break contact	It is important to distinguish between a contact as shown and a contact of a thermal relay, which in detached representation may be shown as follows: 
07-09-04		Gas discharge tube with thermal element Starter for fluorescent lamp	

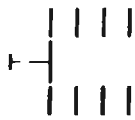
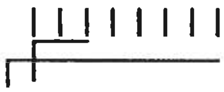
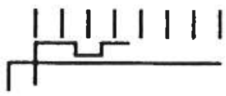
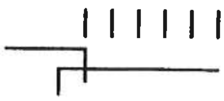
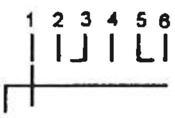
5.6.3.4 Examples of multipole and multiposition switches

IEC No.	Symbol	Description	Remarks
07-11-01		Three-position lever-operated switch, locking in the upper position and with spring return from the lower position to the middle one, shown with the terminals	
07-11-02		Button-operated switch in which one set of contacts is operated by pushing the button (non-locking) and another set by turning it (locking), shown with the terminals	The bracket indicates that there is only one actuator.

5.6.3.4 (continued)

IEC No.	Symbol	Description	Remarks
07-11-03		Button-operated switch in which the same set of contacts may be operated in two different ways: either by turning (with locking) or pushing (with spring return), shown with the terminals	
07-11-04		Multi position switch (6 positions shown)	
07-11-05		Multi position switch	To be used with a small number of positions (4 positions shown).
07-11-06		Example with position diagram  The operating device (for example, hand-wheel) can be turned only from positions 1 to 4 and back  The operating device can be turned in the clockwise direction only  The operating device can be turned in the clockwise direction, without limitation and may be turned in the counter-clockwise direction only between positions 3 and 1	It is sometimes convenient to indicate the purpose of each switch position by adding text to the position diagram. It is also possible to indicate limitations of movement of the operating device as in the examples.

5.6.3.4 (concluded)

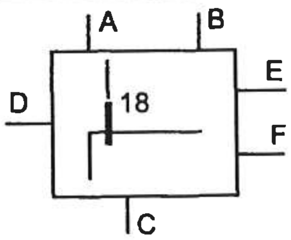
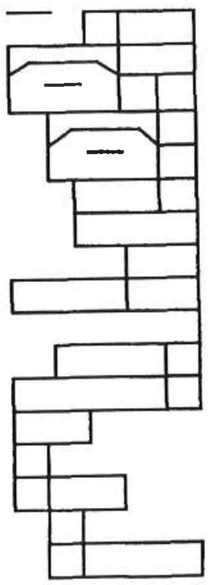
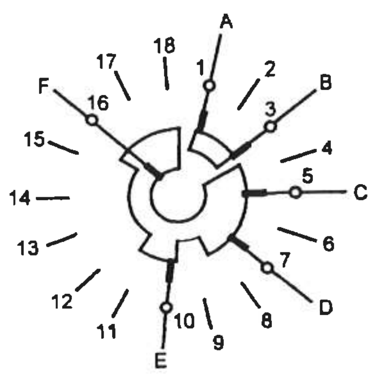
IEC No.	Symbol	Description	Remarks
07-11-07		Four-position switch, manually operated, having four independent circuits	
07-11-08		Single-pole, four-position switch in which position 2 cannot be connected	
07-11-09		Single-pole, six-position switch with a wiper that bridges only while passing from one position to the next	
07-11-10		Single-pole, multiposition switch with a wiper that bridges three consecutive terminals in each switch position	
07-11-11		Multiposition switch A wiper bridges three non-consecutive terminals in each position, but omits one intermediate terminal in each switch position	
07-11-12		Single-pole, multiposition switch for cumulative parallel switching	
07-11-13		One pole of a six-position, multipole switch The pole shown makes early than the other poles when the wiper moves from position 2 to 3, and breaks later than the other poles when the wiper moves from positions 5 to 6. When the wiper moves in the opposite direction the early make becomes a late break and vice versa	

5.6.3.5 Block symbols for complex switches

There are many ways in which complex switching functions can be achieved mechanically, for example, by rotary wafer switches, slide switches, drum controllers and cam-operated contact assemblies. There are also many ways in which the switching functions may be symbolized on circuit diagrams.

Studies have shown that there is no unique system of symbolization that is superior in every application. The system used should be chosen with due regard to the purpose of the diagram and the degree of complexity of the switching device it is desired to symbolize.

This section presents one possible method of symbolizing complex switches. To facilitate understanding, each example includes a constructional drawing of the device symbolized. The method shown here uses a general symbol for a complex switch, which has to be supplemented by a table of connections. Two examples are shown.

IEC No.	Symbol	Description	Remarks
07-12-01		Complex switch	General symbol.
07-12-02	 Table of connections	*Examples:* 18-position rotary wafer switch with six terminals, here designated A to F, constructed as shown below (switch shown in position 1)	
Position	Interconnections of terminals A B C D E F		
07-12-50 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18		07-12-49 	

5.6.3.5 (concluded)

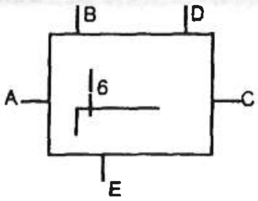
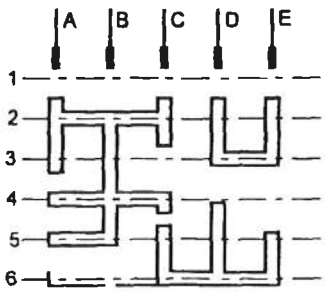
IEC No.	Symbol	Description	Remarks
07-12-03		Six-position rotary drum switch with five terminals, constructed as shown below: 	The symbols + - and 0 indicate the terminals that are connected together at any position (rest position or intermediate position) of the switch, i.e. terminals having the same indicating symbols, e.g. +, are inter-connected. Where additional symbols are required, the characters available on a typewriter should be used, e.g. ×, =. The letters shown are not part of the symbol.

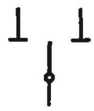
Table of connections

Position	Interconnections of terminals				
	A	B	C	D	E
1	+		+	0	0
2	+	+	+	0	0
3	+	+		0	0
		+			
4	+	+	+		
		+	+ -	-	
5	+	+	-	-	-
6			-	-	-

5.6.3.6 Switchgear and controlgear

IEC No.	Symbol	Description	Remarks
07-13-02		Contactor	Main make contact of a contactor (contact opened in the unoperated position).
07-13-03		Contactor with automatic tripping initiated by a built-in measuring relay or release	
07-13-04		Contactor Main break contact of a contactor (contact closed in the unoperated position)	
07-13-05		Circuit-breaker	

5.6.3.6 (concluded)

IEC No.	Symbol	Description	Remarks
07-13-06		Disconnector (isolator)	
07-13-07		Two-way disconnector (isolator) with off-position in the centre	
07-13-08		Switch-disconnector (on-load isolating switch)	
07-13-09		Switch-disconnector with automatic tripping initiated by a built-in measuring relay or release	

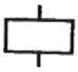
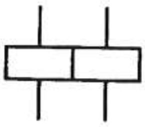
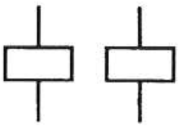
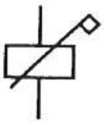
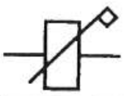
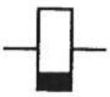
5.6.3.7 Block symbols for motor starters

IEC No.	Symbol	Description	Remarks
07-14-01		Motor starter	General symbol. Qualifying symbols may be shown inside the general symbol to indicate particular types of starters. See symbols 07-14-05, 07-14-07 and 07-14-08.
07-14-02		Starter operated in steps	The number of steps may be indicated.
07-14-03		Starter regulator	
07-14-04		Starter with automatic release	
07-14-05		Direct on line contactor starter for reversing motor	

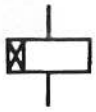
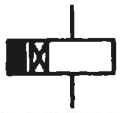
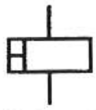
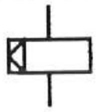
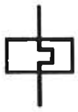
5.6.3.7 (concluded)

IEC No.	Symbol	Description	Remarks
07-14-06		Star-delta starter	
07-14-07		Auto-transformer starter	
07-14-08		Starter regulator with thyristors	

5.6.4 Electromechanical all-or-nothing relays

IEC No.	Symbol	Description	Remarks
07-15-01		Operating device	General symbol.
		Examples:	
07-15-03		Operating device with two separate windings, assembled representation	
07-15-05		Operating device with two separate windings, detached representation	
07-15-50		Operating device with flag indicator. Horizontal representation	
07-15-49		Vertical representation	
07-15-07		Relay coil of a slow-releasing relay. Horizontal representation	
07-15-48		Vertical representation	

5.6.4 (concluded)

IEC No.	Symbol	Description	Remarks
07-15-08		Relay coil of a slow-operating relay	
07-15-09		Relay coil of a slow-operating and slow-releasing relay	
07-15-10		Relay coil of a high speed relay (fast operating and fast releasing)	
07-15-14		Relay coil of a mechanically latched relay	
07-15-21		Operating device of a thermal relay	

5.6.5 Measuring relays and related devices

5.6.5.1 Block symbol and qualifying symbols

IEC No.	Symbol	Description	Remarks
07-16-01		Measuring relay or relative device The asterisk has to be replaced by one or more letters or qualifying symbols indicating the parameters of the device, in the following order: a) characteristic quantity and its mode of variation; b) direction of energy flow; c) setting range; d) resetting ratio; e) delayed action; and f) value of time delay.	Letter symbols for characteristic quantities should be in accordance with IEC 60027. Qualifying symbols will be found in 5 of IEC 60617-2. Symbols 07-16-02, 07-16-04 and 07-16-07 show how a letter and qualifying symbols may be combined. A figure giving the number of similar measuring elements may be included in the symbol, as shown in symbol 07-17-05. The symbol may be used as a functional symbol representing the whole of the device, or as a symbol representing only the actuating element of the device.

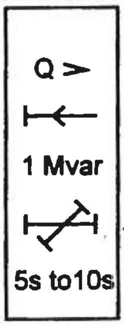
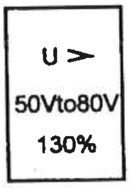
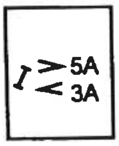
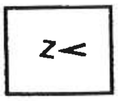
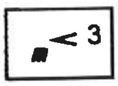
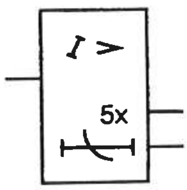
5.6.5.1 (concluded)

IEC No.	Symbol	Description	Remarks
07-16-02	U ⏊	Voltage failure-to-frame (frame potential in case of fault)	
07-16-03	U^{rsd}	Residual voltage	
07-16-04	$I\leftarrow$	Reverse current	
07-16-05	I_d	Differential current	
07-16-07	I ⏚	Earth fault current	
07-16-08	I N	Current in the neutral conductor	
07-16-11		Inverse time-lag characteristic	

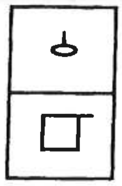
5.6.5.2 Examples of measuring relays

IEC No.	Symbol	Description	Remarks
07-17-01	$\boxed{U = 0}$	No voltage relay	
07-17-02	$\boxed{I\leftarrow}$	Reverse current relay	
07-17-03	$\boxed{P >}$	Underpower relay	
07-17-04	$\boxed{I >}$	Delayed over-current relay	
07-17-05	2 (I>) 5A to10A	Over-current relay with two current elements and a setting range of 5 A to 10 A	

5.6.5.2 (concluded)

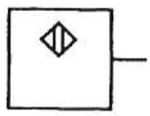
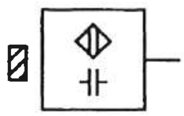
IEC No.	Symbol	Description	Remarks
07-17-06		Maximum reactive power relay: – energy flow towards the busbars – operating value 1 Mvar – time-lag adjustable from 5 s to 10 s	
07-17-07		Undervoltage relay: – setting range 50 V to 80 V – resetting ratio 130 %	
07-17-08		Current relay with maximum and minimum settings, shown with limits 3 A and 5 A	
07-17-09		Under-impedence relay	
07-17-10		Relay detecting short-circuits between windings	
07-17-12		Phase-failure detection relay in a three-phase system	
07-17-13		Locked-rotor detection relay operating by current measuring	
07-17-14		Over-current relay with two outputs, one active when the current is above five times the setting value, the other is active depending on the inverse time-lag characteristic setting of the device	

5.6.5.3 Other devices

IEC No.	Symbol	Description	Remarks
07-18-01		Buchholz protective device (gas relay)	
07-18-02		Auto-reclose device	

5.6.6 Proximity and touch-sensitive devices

5.6.6.1 Sensors and detectors

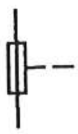
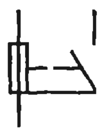
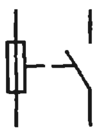
IEC No.	Symbol	Description	Remarks
07-19-01		Proximity sensor	
07-19-02		Proximity sensing device, block symbol	The method of operating may be indicated.
07-19-03		*Example:* Capacity proximity detector operating on the approach of solid material	
07-19-04		Touch sensor	

5.6.6.2 Switches

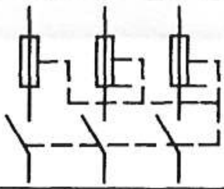
IEC No.	Symbol	Description	Remarks
07-20-01		Touch-sensitive switch, make contact	
07-20-02		Proximity switch, make contact	
07-20-03		Proximity switch, operated on the approach of a magnet, make contact	
07-20-04		Proximity switch, operated on the approach of iron, break contact	

5.6.7 Protective devices

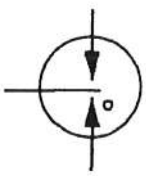
5.6.7.1 Fuses and fuse switches

IEC No.	Symbol	Description	Remarks
07-21-01		Fuse	General symbol.
07-21-02		Fuse with the side that remains live after blowing, indicated by a thick line	
07-21-03		Fuse with mechanical linkage (striker fuse)	
07-21-04		Fuse with alarm contact, three terminals	
07-21-05		Fuse with separate alarm circuit	

5.6.7.1 (concluded)

IEC No.	Symbol	Description	Remarks
07-21-06		Three-phase switch with automatic release by any one of the striker fuses	
07-21-07		Fuse switch	
07-21-08		Fuse disconnector (fuse isolator)	
07-21-09		Fuse switch disconnector (on-load isolating fuse switch)	

5.6.7.2 Gaps and arresters

IEC No.	Symbol	Description	Remarks
07-22-01		Gap	
07-22-02		Double spark-gap	
07-22-03		Surge arrester	
07-22-04		Protective gas discharge tube	
07-22-05		Symmetric protective gas discharge tube	

5.7 Measuring instruments, lamps and signalling devices

5.7.1 Indicating, recording, integrating instruments and general symbols

The asterisk within the symbols of this section shall be replaced with one of the following:

a) the letter symbol for the unit of the quantity measured, or a multiple or submultiple thereof (see symbols 08-02-01 and 08-02-07);

b) the letter symbol for the quantity measured (see symbols 08-02-05 and 08-02-06);

c) the chemical formula (see symbol 08-02-13);

d) graphical symbol (see symbol 08-02-08).

The symbol or formula used should be related to the information displayed by the instrument regardless of the means used to obtain the information.

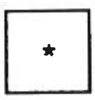
Letter symbols for units and for quantities shall be selected from IEC 60027-1.

Provided IEC 60027-1, or the letter symbols for chemical elements, do not apply, other letter symbols may be used, if they are explained on the diagram or in referenced documents.

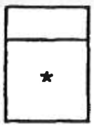
If the letter symbol for the unit of the quantity measured is used, it may be necessary to show the letter symbol for the quantity as supplementary information. It should be placed below the unit letter symbol (see symbol 08-02-02).

Supplementary information concerning the quantity measured, and any necessary qualifying symbol may be shown below the quantity letter symbol.

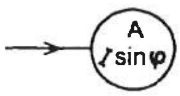
If for more than one quantity is indicated or recorded by an instrument, the appropriate symbol outlines shall be placed attached in line, horizontally or vertically (see symbols 08-03-02 and 08-04-14).

IEC No.	Symbol	Description	Remarks
08-01-01		Indicating instrument The asterisk shall be replaced in accordance with the rules given in 5.7.1	
08-01-50		Recording instrument The asterisk shall be replaced in accordance with the rules given in 5.7.1	

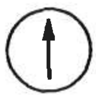
5.7.1 (concluded)

IEC No.	Symbol	Description	Remarks
08-01-02		Integrating instrument Energy meter The asterisk shall be replaced in accordance with the rules given in 5.7.1	The symbol may also be used for a remote instrument that repeats a reading transmitted from an integrating meter (e.g. see symbol 08-04-11). The outline may be combined with that for a recording instrument to represent a combined instrument (e.g. see symbol 08-04-14). Symbol elements, qualifing symbols and other symbols having general application may be used to specify the direction of energy flow (e.g. see symbols 08-04-04 to 08-04-07). The number of rectangles at the top of the symbol indicates the number of different summations by a multi-rate meter (e.g. see symbol 08-04-08).

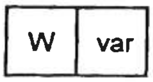
5.7.2 Examples of indicating instruments

IEC No.	Symbol	Description	Remarks
08-02-01		Voltmeter	
08-02-02		Reactive current ammeter	
08-02-03		Maximum demand indicator actuated by an integrating meter	

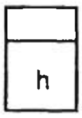
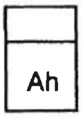
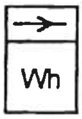
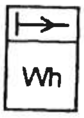
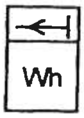
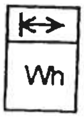
5.7.2 (concluded)

IEC No.	Symbol	Description	Remarks
08-02-04	var	Varmeter	
08-02-05	$\cos\varphi$	Power-factor meter	
08-02-06	φ	Phase meter	
08-02-07	Hz	Frequency meter	
08-02-08		Synchronoscope	
08-02-09	λ	Wavemeter	
08-02-10		Oscilloscope	
08-02-11	V Vd	Differential voltmeter	
08-02-12		Galvanometer	
08-02-13	NaCl	Salinity meter	
08-02-14	θ	Thermometer Pyrometer	
08-02-15	n	Tachometer	

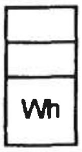
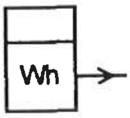
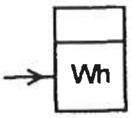
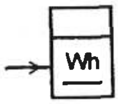
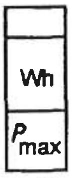
5.7.3 Examples of recording instruments

IEC No.	Symbol	Description	Remarks
08-03-01		Recording wattmeter	
08-03-02		Combined recording wattmeter and varmeter	
08-03-03		Oscillograph	

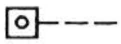
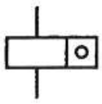
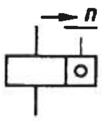
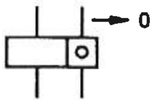
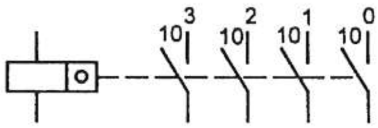
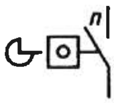
5.7.4 Examples of integrating instruments

IEC No.	Symbol	Description	Remarks
08-04-01		Hour meter	
08-04-02		Ampere-hour meter	
08-04-03		Watt-hour meter	
08-04-04		Watt-hour meter, measuring energy transmitted in one direction only	
08-04-05		Watt-hour meter, measuring the energy flow from the busbars	
08-04-06		Watt-hour meter, measuring the energy flow towards the busbars	
08-04-07		Watt-hour meter, counting in both energy flow directions (towards or from busbars)	

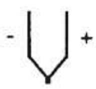
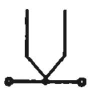
5.7.4 (concluded)

IEC No.	Symbol	Description	Remarks
08-04-08		Multi-rate watt-hour meter, two-rate shown	
08-04-09		Excess watt-hour meter	
08-04-10		Watt-hour meter with transmitter	
08-04-11		Remote meter (repeater), actuated by a watt-hour meter	
08-04-12		Remote meter (repeater) with printing device, actuated by a watt-hour meter	
08-04-13		Watt-hour meter with maximum demand indicator	
08-04-14		Watt-hour meter with maximum demand recorder	
08-04-15		Var-hour meter	

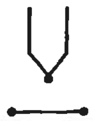
5.7.5 Counting devices

IEC No.	Symbol	Description	Remarks
08-05-01	Use symbol 02-14-02: 	Counting function of a number of events	Qualifying symbol.
08-05-02		Pulse meter (electrically operated counting device)	
08-05-03		Pulse meter manually pre-set to *n* (reset if *n* = 0)	
08-05-04		Pulse meter electrically reset to 0	
08-05-05		Pulse meter with multiple contacts	Respective contacts close once at every unit (10°), ten (10^1), hundred (10^2), thousand (10^3) events registered by the counter.
08-05-06		Counting device, cam driven and closing a contact at every *n* events	

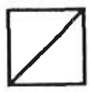
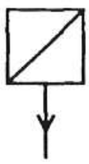
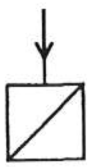
5.7.6 Thermocouples

IEC No.	Symbol	Description	Remarks
08-06-01		Thermocouple, shown with polarity symbols	
08-06-03		Thermocouple with non-insulated heating element	
08-06-04	Simplified form 		

5.7.6 (concluded)

IEC No.	Symbol	Description	Remarks
08-06-05		Thermocouple with insulated heating element	
08-06-06	Simplified form 		

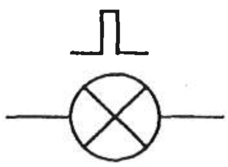
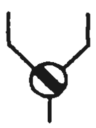
5.7.7 Telemetering devices

IEC No.	Symbol	Description	Remarks
08-07-01	Use symbol 02-17-06: 	Signal translator	General symbol.
08-07-02 Delete		Telemetering transmitter	
08-07-03 Delete		Telemetering receiver	

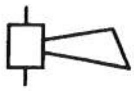
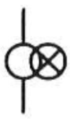
5.7.8 Electric clocks

IEC No.	Symbol	Description	Remarks
08-08-01		Clock Secondary clock	General symbol.
08-08-02		Master clock	
08-08-03		Clock with contact	

5.7.9 Lamps and signalling devices

IEC No.	Symbol	Description	Remarks
08-10-01		Lamp Signal lamp	General symbol. If it is desired to indicate the colour, a notation using the following codes is placed adjacent to the symbol: RD : red YE : yellow GN : green BU : blue WH : white If it is desired to indicate the type of lamp, a notation using the following code is placed adjacent to the symbol: Ne : neon Xe : xenon Na : sodium vapour Hg : mercury I : iodine IN : incandescent EL : electroluminescent ARC : arc FL : fluorescent IR : infra-red UV : ultraviolet LED : light-emitting diode
08-10-02		Signal lamp, flashing type	
08-10-03		Indicator, electromechanical Annunciator element	
08-10-04		Electromechanical position indicator with one de-energized (shown) and two operated positions	

5.7.9 (concluded)

IEC No.	Symbol	Description	Remarks
08-10-05		Horn	
08-10-06	Preferred form 	Bell	
08-10-08		Single-stroke bell	
08-10-09		Siren	
08-10-10	Preferred form 	Buzzer	
08-10-12		Whistle, electrically operated	Horizontal representation.
08-10-13		Indicator lamp energized by a built-in transformer	

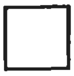
5.8 Architectural and topographical installation plans and diagrams

5.8.1 Generating stations and substations

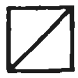
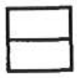
5.8.1.1 General symbols

A rectangular outline may be used instead of a square.

On small-scale maps it may be desirable to replace the hatched areas in the symbols by completely filled-in areas.

IEC No.	Symbol	Description	Remarks
11-01-01		Generating station (planned)	
11-01-02		Generating station (in service)	
11-01-03		Combined electric and heat generating station (planned)	
11-01-04		Combined electric and heat generating station (in service)	
11-01-05		Substation (planned)	
11-01-06		Substation (in service)	

5.8.1.2 Specific types of generating stations and substations

IEC No.	Symbol	Description	Remarks
11-02-01		Hydroelectric generating station (planned)	
11-02-02		Hydroelectric generating station (in service)	
11-02-03		Thermoelectric generating station (coal, lignite, oil, gas, etc.) (planned)	
11-02-04		Thermoelectric generating station (coal, lignite, oil, gas, etc.) (in service)	
11-02-07		Geothermic generating station (planned)	
11-02-08		Geothermic generating station (in service or unspecified)	
11-02-09		Solar generating station (planned)	
11-02-10		Solar generating station (in service)	
11-02-11		Wind generating station (planned)	
11-02-12		Wind generating station (in service)	

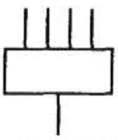
5.8.2 Installations in buildings

5.8.2.1 Identification of specific conductors for schematic diagrams

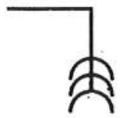
The symbols shown in this section may be replaced by letter symbols given in IEC 60445.

IEC No.	Symbol	Description	Remarks
11-11-01		Neutral conductor	
11-11-02		Protective conductor	
11-11-03		Combined protective and neutral conductor	
11-11-04		*Example:* Three-phase wiring with neutral conductor and protective conductor	

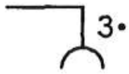
5.8.2.2 Wiring for layout diagrams

IEC No.	Symbol	Description	Remarks
11-12-01		Wiring going upwards	
11-12-02		Wiring going downwards	
11-12-03		Wire passing through vertically	
11-12-04		Box, general symbol	
11-12-05		Connection or junction box	
11-12-06		Consumer's terminal with wiring Service entrance equipment	
11-12-07		Distribution centre shown with five conduits	

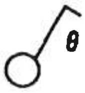
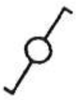
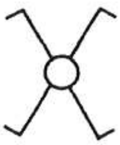
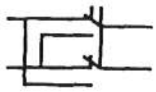
5.8.2.3 Socket outlets for layout diagrams

IEC No.	Symbol	Description	Remarks
11-13-01		Socket outlet (power) Receptacle outlet (power)	Symbol 03-03-01 is used.
11-13-03		Multiple socket outlet (power), three outlets shown	
11-13-04		Socket outlet (power) with protective contact	
11-13-05		Socket outlet (power) with shutter	
11-13-06		Socket outlet (power) with single pole switch	
11-13-07		Socket outlet (power) with interlocked switch	
11-13-08		Socket outlet (power) with isolating transformer, e.g. shaver outlet	
11-13-09		Socket outlet (telecommunications) NOTE Designations are used to distinguish different types of outlet in accordance with the following: TP : telephone M : microphone ◀ : loudspeaker FM : frequency modula-tion TV : television TX : telex DP : data processing	General symbol.

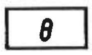
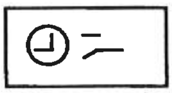
5.8.2.3 (concluded)

IEC No.	Symbol	Description	Remarks
00-13-01		Socket outlet Three-phase	Not in IEC 60617.
00-13-02		Socket outlet Three-phase switched	Not in IEC 60617.
00-13-03		Dedicated socket outlet	Non-standard. Not in IEC 60617.

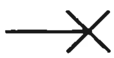
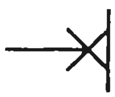
5.8.2.4 Switches for layout diagrams

IEC No.	Symbol	Description	Remarks
11-14-01		Switch, general symbol	
11-14-02		Switch with pilot light	
11-14-03		Period limiting switch, single-pole	
11-14-04		Switch, two-pole	
11-14-05		Multiposition switch, e.g. for different degrees of lighting. Single-pole	
11-14-06		Two-way switch. Single-pole	For schematic (see symbol 07-02-05).
11-14-07		Intermediate switch	Equivalent circuit diagram. 
11-14-08		Dimmer	

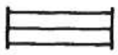
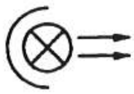
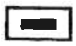
5.8.2.4 (concluded)

IEC No.	Symbol	Description	Remarks
11-14-09		Pull-cord switch, single-pole	
11-14-10		Push-button	
11-14-11		Push-button with indicator lamp	
11-14-12		Push-button with restricted access (glass cover, etc.)	
11-14-13		Period limiting equipment	
11-14-14		Time switch	
11-14-15		Key-operated switch Watchman's system device	

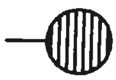
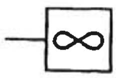
5.8.2.5 Lighting outlets and fittings for layout diagrams

IEC No.	Symbol	Description	Remarks
11-15-01		Lighting outlet position. The symbol is shown with wiring	
11-15-02		Lighting outlet on wall. The symbol is shown with wiring from the left	
11-15-03		Lamp general symbol The symbol may be qualified as shown in IEC 60617-8	Symbol 08-10-01 is used.

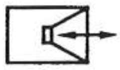
5.8.2.5 (concluded)

IEC No.	Symbol	Description	Remarks
11-15-04		Luminaire, general symbol Fluorescent lamp	
11-15-05		*Examples:* Luminaire with three fluorescent lamps	
11-15-06		Luminaire with five fluorescent lamps	
11-15-07		Projector, general symbol	
11-15-08		Spotlight	
11-15-09		Floodlight	
11-15-10		Auxiliary apparatus for discharge lamp The symbol shall be used only when the auxiliary apparatus is not incorporated in the luminaire	
11-15-11		Emergency lighting luminaire on special circuit	
11-15-12		Self-contained emergency lighting luminaire	

5.8.2.6 Miscellaneous symbols for layout diagrams

IEC No.	Symbol	Description	Remarks
11-16-01		Water heater, shown with wiring	
11-16-02		Fan, shown with wiring	

5.8.2.6 (concluded)

IEC No.	Symbol	Description	Remarks
11-16-03		Time clock	For schematic diagram, see 08-08-01.
11-16-04		Electric lock	
11-16-05		Intercommunication instrument	
00-16-01		Disconnector (isolator)	Used with water heaters, fans, coolers, etc. Not in IEC 60617.

5.8.3 Reticulation systems

The symbols shown in this section are not included in IEC 60617and have been selected from symbols used by certain of the larger supply authorities in the Republic of South Africa.

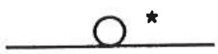
NOTE Certain items are designated as planned items to cater for the drawing and installation instruction systems of certain supply authorities.

IEC No.	Symbol	Description	Remarks
00-17-01 00-17-02	———— — — — — — —	Underground cable Planned underground cable	
00-17-03 00-17-04	Form 1  Form 2	Cable joint	Form 1 is the preferred symbol for a cable joint. Form 2 may be used where there is a space constraint on the plan.
00-17-05	—x——x—	Underground services The asterisk * shall be replaced by a qualifying letter designation Standard qualifying letters are: T : Telkom services W : water pipes S : sewerage pipes SW : storm water pipes	General symbol. Other letters may be used to suit a specific application, however, a suitable legend shall appear on the plan.

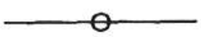
5.8.3 (continued)

IEC No.	Symbol	Description	Remarks
00-17-06		Cable ducts	If required, a user may label the symbol to indicate the number and size of ducts.
00-17-07		Planned cable ducts	
00-17-08		Overhead mains	The position of the symbol on the plan does not necessarily indicate the "in-situ" pole position.
00-17-09		Planned overhead mains	The gap in the line may be used to indicate pole separation distances.
00-17-10		Pole	
00-17-11		Planned pole	
00-17-12		Earth spike	
00-17-13		Pole-mounted transformer	Further intelligence may be added by adaptation of the basic symbol, e.g. a pole on each side of the transformer would indicate an "H" pole mounting.
00-17-14		Planned pole-mounted transformer	A label may be added to indicate the transformer rating.
00-17-15		Aerial stay	
00-17-16		Planned aerial stay	
00-17-17		Strut	
00-17-18		Planned strut	
00-17-19		Stay	
00-17-20		Planned stay	

5.8.3 (continued)

IEC No.	Symbol	Description	Remarks
00-17-21		Miniature substation	The transformer rating may be inserted in the centre block.
00-17-22		Planned miniature substation	
00-17-23		Substation	General symbol.
00-17-24		Planned substation The asterisk * shall be replaced by a qualifying letter designation. Standard qualifying letters are: T : transformer substation D : distribution substation MVC : medium-voltage consumer MSC : multiple service connection	General symbol. Other letters may be used to suit a specific application, however, a suitable legend shall appear on the plan.
00-17-25		Service pillar	General symbol.
00-17-26		Planned service pillar The asterisk * shall be replaced by a qualifying letter designation. Standard qualifying letters are: D : distribution pillar M : multiple metering unit I : multiple metering unit with individual isolation	General symbol. Other letters may be used to suit a specific application, however, a suitable legend shall appear on the plan.
00-17-27		Consumer's distribution unit	
00-17-28		Planned consumer's distribution unit	

5.8.3 (concluded)

IEC No.	Symbol	Description	Remarks
00-17-29		Shackle pole	
00-17-30		Planned shackle pole	
00-17-31		Pole with double outreach streetlights	
00-17-32		Planned pole with double out-reach streetlights	
00-17-33		Pole with single outreach streetlight	
00-17-34		Planned pole with single out-reach streetlight	
00-17-35		Pole with floodlight	
00-17-36		Planned pole with floodlight	
00-17-37		High mast floodlights	
00-17-38		Planned high mast floodlights	
00-17-39		Post-top luminaire	
00-17-40		Planned post-top luminaire	
00-17-41	E/F  IND	Earth fault indicator	General symbol.
00-17-42	* 	Pole-mounted line break equipment The asterisk *shall be replaced by a qualifying letter designa-tion. Standard qualifying letters are: A/R : auto-recloser SEC : sectionalizer L/L : line link F/S : fused switch	General symbol. Other letters may be used to suit a specific application, however, a suitable legend shall appear on the plan.

Bibliography

IEC 60617:(all parts), *Graphical symbols for diagrams.*

IEC 61346-1, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules.*

General index

The letter codes for the type of item in the third column of the general index conform to Table E.1 of IEC 61346-1. However, 2.5 of that standard permits the use of alternative codes, depending on the item's use. The codes shown in the index are those most commonly used.

Description	Symbol No.	Letter code
C (continued)		
Cables		
ducts (see Reticulation systems)		
general symbol	03-01-01	W
joint (see Reticulation systems)		
underground (see Reticulation systems)		
Capacitor		
adjustable	04-02-07	C
feed-through	04-02-03	C
general symbol	04-02-01	C
lead-through	04-02-03	C
polarized	04-02-05	C
variable	04-02-07	C
with pre-set adjustment	04-02-09	C
Cell		
photovoltaic	05-06-03	B,G
primary	06-15-01	G
Change-over contact		
break before make	07-02-04	
make before break (bridging)	07-02-06	
Changer		
general symbol	02-17-06	U
Chassis (connection)	02-15-04	
Choke	04-03-01	L
Circuit-breaker	07-13-05	Q
Circuit (general symbol)	03-01-01	W
Clock; Electric		
general symbol	08-08-01	P
master	08-08-02	P
secondary	08-08-01	P
with switch	08-08-03	P
Coaxial plug and socket	03-03-15	X
Coaxial pair		
connected to terminals	03-01-12	
general symbol	03-01-11	W
with screen	03-01-13	
Coil	04-03-01	L
Collector for semiconductor devices	05-01-18	
Complex switch		
eighteen-position rotary wafer switch with six terminals	07-12-02	S
six-position rotary drum switch with five terminals	07-12-03	S
Conductor		
flexible	03-01-06	W
general symbol	03-01-01	W
group of	03-01-01	W
in cable	03-01-09	W
screened	03-01-07	W
twisted	03-01-08	W
Conductor; Identification of (For architectural diagrams)		
combined protective and neutral	11-11-03	
neutral	11-11-01	
protective	11-11-02	
Connecting devices		
coaxial plug and socket	03-03-15	X
connecting link		
closed	03-03-17	X
open	03-03-19	X
multipole plug and socket		
multi-line representation	03-03-07	X
single-line representation	03-03-08	X
plug (male)	03-03-03	X
plug and socket	03-03-05	X
plug and socket type connector		
male-male	03-03-20	X

Description	Symbol No.	Letter code
C (concluded)		
Controls; Mechanical		
automatic return	02-12-07	
brake	02-12-20	
clutch	02-12-16	
delayed action	02-12-05	
detent	02-12-08	
disengage	02-12-09	
engaged	02-12-10	
device		
blocking	02-12-14	
blocking engaged	02-12-15	
for maintaining a given position	02-12-08	
latching disengaged	02-12-12	
latching engaged	02-12-13	
gearing	02-12-23	
hydraulic connection (link)	02-12-01	
mechanical connection (link)	02-12-01	
mechanical coupling	02-12-16	
disengaged	02-12-17	
engaged	02-12-18	
mechanical interlock	02-12-11	
non-automatic return	02-12-08	
pneumatic connection (link)	02-12-01	
Converters		
d.c. to d.c. rotary, with common field winding	06-05-05	G.U
d.c.to d.c. rotary, with common permanent magnetic field	06-05-04	G.U
dynamotor	06-05-04	G.U
general symbol	02-17-06	U.B
rotary transformer d.c./d.c.	06-05-04	G.U
synchronous, three-phase, shunt excited	06-07-05	G.U
Converter; Power		
direct current	06-14-02	U
general symbol	06-14-01	U
inverter	06-14-05	U
rectifier	06-14-03	U
rectifier in full wave (bridge) connection	06-14-04	
rectifier/inverter	06-14-06	U
Counting device, cam driven	08-05-06	P
Counting function (qualifying symbol)	08-05-01	
Current and voltage; Types of (qualifying symbols)		
alternating	02-02-04	
medium frequencies	02-02-10	
relatively high frequencies	02-02-11	
relatively low frequencies	02-02-09	
direct	02-02-03	
form 2	02-02-16	
mid-wire	02-02-14	
negative polarity	02-02-15	
neutral	02-02-13	
positive polarity		
D		
Delay	02-08-05	
Dependence		
magnetic field effect	02-08-04	
Detent	02-12-08	
disengaged	02-12-09	
engaged	02-12-10	
Diac	05-03-09	V
Differential voltmeter	08-02-11	P
Dimmer	11-14-08	Q.S

Description	Symbol No.	Letter code
D (concluded)		
Diodei Semiconductor		
Esaki	05-03-06	V
Varactor	05-03-04	V
backward	05-03-08	B
bidirectional	05-03-09	V
breakdown, bidirectional	05-03-07	V
breakdown, unidirectional	05-03-06	V
general symbol	05-03-01	V
light-emitting (general symbol)	05-03-02	V.H
photo-	05-06-02	B.V
tunnel	05-03-05	V
unitunnel	05-03-08	V
variable capacitance	05-03-04	V
voltage regulator	05-03-06	V
where use is made of its temperature dependence	05-03-03	V
Direction		
of flow (see Flow)		
of force (see Force)		
of motion (see Motion)		
of rotation (see Rotation)		
Disconnector	07-13-06	Q
two-way with centre-off position	07-13-07	Q
(isolator) used with water heater, fans, coolers, etc.	00-16-01	
Distribution centre (For architectural diagrams)	11-12-07	A
Double spark gap	07-22-02	F
E		
Earth and frame connections		
chassis	02-15-04	
frame	02-15-04	
general symbol	02-15-01	
noiseless	02-15-02	
Earth fault indicator (see Reticulation systems)		
Earth spike (see Reticulation systems)		
Effect		
electromagnetic	02-08-02	
magnetic field	02-08-04	
thermal	02-08-01	
Electric lock	11-16-04	Y
Electromagnetic		
effect	02-08-02	
radiation, non-ionizing	02-09-01	
Emergency lighting luminaire		
on special circuit	11-15-11	E
self-contained	11-15-12	E
Emergency switch	02-13-08	S.Q
Enclosure (symbol element)		
form 1	02-01-04	
form 2	02-01-05	
Envelope (symbol element)		
form 1	02-01-04	
form 2	02-01-05	
Equipment (symbol element)	02-01-01	
Esaki diode	05-03-06	
F		
Fan	11-16-02	E
Fault	02-17-01	

Description	Symbol No.	Letter code
F (concluded)		
Feed-through capacitor	04-02-03	C
Field effect transistor		
with N-type channel	05-05-09	V
with P-type channel	05-05-10	V
Flashover		
Flow; Direction of		
alternate transmission and reception	02-05-03	
bidirectional energy flow	02-05-08	
energy flow, from the busbars	02-05-06	
energy flow, one way	02-05-01	
energy flow towards the busbars	02-05-07	
propagation, both ways, not simultaneously	02-05-03	
propagation, both ways, simultaneously	02-05-02	
propagation, one way	02-05-01	
reception	02-05-05	
signal flow, one way	02-05-01	
simultaneous transmission and reception	02-05-02	
transmission	02-05-04	
Force; Direction of		
bidirectional	02-04-02	
unidirectional	02-04-01	
Four-position switch, manually operated with four independent circuits	07-11-07	S
Frame (connection)	02-15-04	
Frequency meter	08-02-07	P
Functional unit (symbol element)	02-01-01	
Fuse disconnector	07-21-08	Q.F
Fuse isolator	07-21-08	Q.F
Fuse switch disconnector	07-21-09	Q.F
Fuse		
general symbol	07-21-01	F
striker	07-21-03	F
with alarm contact	07-21-04	F
with mechanical linkage	07-21-03	F
with separate alarm circuit	07-21-05	F
Fuse disconnector	07-21-08	Q.F
Fuse switch	07-21-07	Q.F
disconnector	07-21-09	Q.F
on-load isolating	07-21-09	Q.F
three-phase with automatic release	07-21-06	Q.F
G		
Galvanometer	08-02-12	P
Gap	07-22-01	F
double spark	07-22-02	F
Gas relay	07-18-01	F.B
Gearing	02-12-23	
Generating stations (general symbols)		
combined electric and heat		
in service	11-01-04	
planned	11-01-03	
station		
in service	11-01-02	
planned	11-01-01	
substation		
in service	11-01-06	
planned	11-01-05	

Description	Symbol No.	Letter code
G (concluded)		
Generating stations; Specific types		
hydroelectric in service	11-02-02	
planned	11-02-01	
solar		
in service	11-02-10	
planned	11-02-09	
thermoelectric		
in service	11-02-04	
planned	11-02-03	
wind		
in service	11-02-12	
planned	11-02-11	
Generator		
d.c. compound excited (short shunt)	06-05-03	G
hand	06-04-04	G
magneto caller	06-04-04	G
Ground and frame connections		
chassis	02-15-04	
frame	02-15-04	
general symbol	02-15-01	
noiseless	02-15-02	
Group of conductors	03-01-01	
H		
Hand generator	06-04-04	G
Heating element	04-01-12	R.E
High mast floodlight (see Reticulation systems)		
Horn	08-10-05	H
Hour meter	08-04-01	P
Hydroelectric generating station	11-02-01	
I		
Identifier		
of analogue signals	02-17-08	
of digital signals	02-17-09	
IGFET transistor		
depletion type with two gates, N-type channel	05-05-17	V
depletion type, single gate, N-type channel	05-05-15	V
enhancement type, single gate, P-type channel	05-05-11	V
Indicating instrument		
differential voltmeter	08-02-11	P
frequency meter	08-02-07	P
galvanometer	08-02-12	P
general symbol	08-01-01	P
maximum demand indicator	08-02-03	P
oscilloscope	08-02-10	P
phase meter	08-02-06	P
power-factor meter	08-02-05	P
pyrometer	08-02-14	P
reactive current ammeter	08-02-02	P
salinity meter	08-02-13	P
synchronoscope	08-02-08	U.C
tachometer	08-02-15	P
thermometer	08-02-14	P
varmeter	08-02-04	P
voltmeter	08-02-01	P
wavemeter	08-02-09	P
Indicator; Test point	02-17-05	
Indicator (Instrument)		
electromechanical	08-10-03	H
electromechanical position	08-10-04	H

Description	Symbol No.	letter code
I (concluded)		
Induction motor		
single-phase, squirrel cage	06-08-02	M
three-phase, star-connected, with automatic starter in the rotor	06-08-04	M
three-phase, with wound rotor	06-08-03	M
three-phase, squirrel cage	06-08-01	M
Induction regulator, three-phase		
form 1	06-12-01	T
form 2	06-12-02	T
Inductor		
choke	04-03-01	L
continuously variable	04-03-05	L
variometer	04-03-08	L
with fixed tappings	04-03-06	L
with gap in magnetic core	04-03-04	L
with magnetic core	04-03-03	L
with moving contact, variable in steps	04-03-07	L
Interview variability	02-03-03	S
Inherent, non-linear variability	02-03-04	
Instrument, intercommunication	11-16-05	A.B
Instruments; Integrating (see Integrating instruments)		
Instruments; Measuring (general symbols)		
energy meter	08-01-03	P
indicating	08-01-01	P
integrating	08-01-03	P
recording	08-01-02	P
Instruments; Recording (see Recording instrument)		
Instruments; Indicating (see Indicating instrument)		
Integrating instruments		
ampere-hour meter	08-04-02	P
excess watt-hour meter	08-04-09	P
general symbol	08-01-03	P
hour meter	08-04-01	P
import-export watt-hour meter	08-04-07	P
multi-rate watt-hour meter	08-04-08	P
remote meter (repeater) with printing device, actuated by a watt-hour meter	08-04-12	P
remote meter (repeater), actuated by a watt-hour meter	08-04-11	A
var-hour meter	08-04-15	P
watt-hour meter	08-04-03	P
watt-hour meter, measuring energy transmitted in one direction only	08-04-04	P
watt-hour meter, measuring the energy flow towards the busbars	08-04-06	P
watt-hour meter, measuring the energy flow from the busbars	08-04-05	P
watt-hour meter with maximum demand indicator	08-04-13	P
watt-hour meter with maximum demand recorder	08-04-14	P
watt-hour meter with transmitter	08-04-10	P
Intercommunication instrument	11-16-05	A.B
Intermediate switch	11-14-07	Q.S
Inverter	06-14-05	U
Isolator, with centre-off position	07-13-07	Q
J		
Junction box	03-04-05	X
Junction		
of conductors	03-02-05	
of conductors, double	03-02-06	
K		
Key-operated switch	11-14-15	Q.S

Description	Symbol No.	Letter code
N (concluded)		
NPN transistor		
avalanche	05-05-03	V
with collector connected to the envelope	05-05-02	V
with transverse biased base	05-05-06	V
O		
On-load isolating fuse switch	07-21-09	Q.F
On-load isolating switch	07-13-08	Q
Operating device of a relay		
general symbol	07-15-01	
with two separate windings		
assembled representation	07-15-03	
detached representation	07-15-05	
Operation; Methods of		
by cam	02-13-16	
by cam and roller	02-13-19	
by crank	02-13-14	
by electric clock	02-13-27	
by electric motor	02-13-26	
by electromagnetic actuator	02-13-23	
by electromagnetic over-current protection	02-13-24	
by emergency push-button switch	02-13-08	
by hand wheel	02-13-09	
by key	02-13-13	
by lever	02-13-11	
by pedal	02-13-10	
by proximity effect	02-13-06	
by pulling	02-13-03	
by pushing	02-13-05	
by removable handle	02-13-12	
by roller	02-13-15	
by stored mechanical energy	02-13-20	
by thermal actuator	02-13-25	
by touching	02-13-07	
by turning	02-13-04	
hydraulic control, double acting	02-13-22	
hydraulic control, single acting	02-13-21	
manual, general case	02-13-01	
manual, with restricted access	02-13-02	
pneumatic control, double acting	02-13-22	
pneumatic control, single acting	02-13-21	
Operational dependence on a characteristic quantity becoming zero	02-06-04	
differing from zero by an amount which is very small compared with the normal value	02-06-05	
either higher than a given high setting or lower than a given low setting	02-06-03	
higher than the setting value	02-06-01	
lower than the setting value	02-06-02	
Oscillograph	08-03-03	P
Oscilloscope	08-02-10	
Outlet		
on wall	11-15-02	X
position, lighting	11-15-01	X
receptacle (power) (general symbol)	11-13-01	X
receptacle (telecommunication) (general symbol)	11-13-09	X
socket (power) (general symbol)	11-13-01	X
socket (telecommunication) (general symbol)	11-13-09	X
Outlines and enclosures (symbol elements)		
enclosure	02-01-04	
envelope	02-01-04	
equipment	02-01-01	
functional unit	02-01-01	
item	02-01-01	
tank	02-01-04	

Description	Symbol No.	Letter Code
O (concluded)		
Overcurrent		
relay delayed	07-17-04	K
relay with two current elements	07-17-05	K
relay with two outputs	07-17-14	K
Overhead mains (see Reticulation systems)		
P		
Period limiting equipment	11-14-13	Q.S
Permanent magnet	02-17-03	
Phase meter	08-02-06	P
Photoconductive device		
with asymmetrical conductivity	05-06-01	B.V
with symmetrical conductivity	05-06-02	B.R
Photodiode	05-06-02	B.V
Phototransistor	05-06-04	B.V
Photovoltaic cell	05-06-03	B.G
Plug (male)	03-03-03	X
Plug and socket	03-03-05	X
coaxial	03-03-15	X
multipole	03-03-07	X
Plug and socket type connector, male-male	03-03-20	X
PNIN transistor	05-05-08	V
PNIP transistor	05-05-07	V
PNP transistor	05-05-01	V
Polarity		
negative	02-02-14	
positive	02-02-13	
Polarized capacitor	04-02-05	C
temperature dependent	04-02-15	C
voltage dependent	04-02-16	C
Pole	00-17-10	
Pole-mounted equipment (see Reticulation systems)		
Pole-mounted transformer (see Reticulation systems)		
Position switch		
break contact	07-08-02	S.Q
make contact	07-08-01	S.Q
mechanically operated in both directions with two separate circuits	07-08-03	S.Q
Positive polarity	02-02-13	
Potentiometer		
pre-set	04-01-08	R
with sliding contact	04-01-07	R
Power-factor meter	08-02-05	P
Pre-set adjustment	02-03-05	
Primary cell	06-15-01	G
Primary cells; Battery of	06-15-01	G
Propagation		
both ways, not simultaneously	02-05-03	
both ways, simultaneously	02-05-02	
one way	02-05-01	
Protective gas discharge tube	07-22-04	F.V
Protective gas discharge tube, symmetric	07-22-05	F.V
Proximity detector, capacitive	07-19-03	B
Proximity sensing device (block symbol)	07-19-02	B
Proximity sensor	07-19-01	B
Proximity switch	07-20-02	S
operated on the approach of a magnet	07-20-03	S
operated on the approach of iron	07-20-04	S
Pull-switch	07-07-03	S
Pulse meter	08-05-02	P
electrically reset to zero	08-05-04	P
manually pre-set to *n*	08-05-03	P
with multiple contacts	08-05-05	P

Description	Symbol No.	Letter code
P (concluded)		
Push-button emergency switch	02-13-08	
Push-button switch	07-07-02	
with indicator lamp	11-14-11	Q.S
with restricted access	11-14-12	Q.S
Pyrometer	08-02-14	P
R		
Radiation		
coherent, non-ionizing	02-09-02	
electromagnetic, non-ionizing	02-09-01	
Reactive current ammeter	08-02-02	P
Receiver; telemetering	08-07-03	U
Receptacle outlet (power)	11-13-01	X
Receptacle outlet (telecommunications)	11-13-09	X
Recording instrument		
combined recording wattmeter and varmeter	08-03-02	P
general symbol	08-01-02	P
oscillograph	08-03-03	P
recording wattmeter	08-03-01	P
Recording wattmeter	08-03-01	P
Recording wattmeter and varmeter, combined	08-03-02	P
Rectifier		
inverter	06-14-06	U
general symbol	06-14-03	U
in full wave (bridge) connection	06-14-04	U
Regulator, three-phase induction		
form 1	06-12-01	T
form 2	06-12-02	T
Relay coil of a		
high speed relay	07-15-10	
mechanically latched relay	07-15-14	
slow-operating and slow-releasing relay	07-15-09	
slow-operating relay	07-15-08	
slow-releasing relay	07-15-07	
thermal relay	07-15-21	
Relays and related devices; Measuring (block symbol)	07-16-01	K
qualifying symbols		
current in the neutral conductor	07-16-08	
differential current	07-16-05	
earth fault current	07-16-07	
inverse time-lag characteristic	07-16-11	
residual voltage	07-16-03	
reverse current	07-16-04	
voltage failure to frame	07-16-02	
Relays; Measuring; Examples of		
current	07-17-08	K
delayed over-current	07-17-04	K
detecting inter-turn short-circuits	07-17-10	K
locked-rotor detection	07-17-13	K
maximum reactive power	07-17-06	K
no voltage	07-17-01	K
over-current relay with two outputs	07-17-14	K
over-current with two current elements	07-17-05	K
phase-failure detection	07-17-12	K
reverse current	07-17-02	K
under-impedance	07-17-09	K
underpower	07-17-03	K
undervoltage	07-17-07	K

Description	Symbol No.	Letter code
R (continued)		
Remote meter (repeater)	08-04-11	P
with printing device	08-04-12	P
Repulsion motor, single-phase	06-06-02	M
Resistor		
adjustable	04-01-03	R
carbon-pile	04-01-11	R
general symbol	04-01-01	R
light dependent	05-06-01	B.R
variable	04-01-03	R
voltage dependent	04-01-04	R
with fixed tappings (taps)	04-01-09	R
with separate current and voltage terminals	04-01-10	R
with sliding contact	04-01-05	R
with sliding contact and off-position	04-01-06	R
Reticulation systems, symbols for plans		
aerial stay	00-17-15	
aerial stay, planned	00-17-16	
cable ducts	00-17-06	
cable ducts, planned	00-17-07	
cable joint		
form 1	00-17-03	
form 2	00-17-04	
consumer's distribution unit	00-17-27	
consumer's distribution unit, planned	00-17-28	
earth fault indicator	00-17-41	
earth spike	00-17-12	
high mast floodlight	00-17-37	
high mast floodlight, planned	00-17-38	
miniature substation	00-17-21	
miniature substation, planned	00-17-22	
overhead mains	00-17-08	
overhead mains, planned	00-17-09	
pole	00-17-10	
pole, planned	00-17-11	
pole, shackle	00-17-29	
pole shackle, planned	00-17-30	
pole-mounted line-break equipment (general symbol), with qualifying letters for type	00-17-42	
pole-mounted transformer	00-17-13	
pole-mounted transformer, planned	00-17-14	
pole with floodlight	00-17-35	
pole with floodlight, planned	00-17-36	
pole with double outreach streetlight	00-17-31	
pole with double outreach streetlight, planned	00-17-32	
pole with single outreach streetlight	00-17-33	
pole with single outreach streetlight, planned	00-17-34	
post top	00-17-39	
post top, planned	00-17-40	
service pillar	00-17-25	
service pillar, planned	00-17-26	
stay	00-17-19	
stay, planned	00-17-20	
strut	00-17-17	
strut, planned	00-17-18	
substation (general symbol), with qualifying letters for type	00-17-23	
substation, planned (general symbol), with qualifying letters for type	00-17-24	
underground cable	00-17–01	
underground cable, planned	00-17-02	
underground services (general symbol), with qualifying letters for type of service	00-17-05	

Description	Symbol No.	Letter code
R (concluded)		
Reverse blocking		
diode thyristor	05-04-01	V
thyristor, tetrode type	05-04-10	V
triode thyristor, N-gate	05-04-05	V
triode thyristor, P-gate	05-04-06	V
Reverse conducting		
diode thyristor	05-04-02	V
triode thyristor, gate not specified	05-04-12	V
triode thyristor, N-gate	05-04-13	V
triode thyristor, P-gate	05-04-14	V
Rotation; Direction of		
bidirectional	02-04-04	
limited in both directions	02-04-05	
unidirectional	02-04-03	
S		
Salinity meter	08-02-13	P
Screen	02-01-07	
Secondary clock	08-08-01	B
Semiconductor devices (qualifying symbols)		
backward effect	05-02-05	
breakdown effect		
bidirectional	05-02-04	
unidirectional	05-02-03	
Schottky effect	05-02-01	
tunnel effect	05-02-02	
unitunnel effect	05-02-05	
Semiconductor diode	05-03-01	
Esaki	05-03-06	V
bidirectional	05-03-09	V
breakdown, bidirectional	05-03-07	V
breakdown, unidirectional	05-03-06	V
general symbol	05-03-01	V
light-emitting (general symbol)	05-03-02	V.H
tunnel	05-03-05	V
unitunnel	05-03-08	V
Varactor	05-03-04	V.C
variable capacitance	05-03-04	V.C
voltage regulator	05-03-06	V
where use is made of its temperature dependence	05-03-03	V.B
Semiconductors (symbol elements)		
channel for transistor IGFET		
N-type on P-type substrate	05-01-11	
P-type on N-type substrate	05-01-12	
collector		
on a region of dissimilar conductivity type	05-01-18	
several collectors on a region of dissimilar conductivity type	05-01-19	
conduction channel		
for depletion type devices	05-01-05	
for enhancement devices	05-01-06	
emitter		
N on P-region	05-01-16	
P on N-region	05-01-14	
several N on P-region	05-01-17	
several P on N-region	05-01-15	
gate, insulated	05-01-13	
junction		
N-region that influences a P-layer	05-01-10	
P-region that influences an N-layer	05-01-09	
rectifying	05-01-07	

Description	Symbol No.	Letter code
S (continued)		
Semiconductors (Symbol elements) (continued)		
region		
with one ohmic connection	05-01-01	
with several ohmic connections		
form 1	05-01-02	
form 2	05-01-03	
form 3	05-01-04	
region, intrinsic, separating		
a collector and a region of dissimilar conductivity type	05-01-23	
a collector and a region of similar conductivity type	05-01-24	
regions of dissimilar conductivity	05-01-21	
regions of similar conductivity type	05-01-22	
transitions between regions of dissimilar conductivity types	05-01-20	
Sensor		
proximity	07-19-01	B
touch	07-19-04	B
Shackle pole (see Reticulation systems)		
Shield	02-01-07	R
Shunt	04-01-10	
Signal lamp		
flashing type	08-10-02	H
general symbol	08-10-01	H
Signal waveforms		
negative-going pulse	02-10-02	
negative-going step function	02-10-05	
positive-going pulse	02-10-01	
positive-going step function	02-10-04	
pulse of alternating current	02-10-03	
sawtooth	02-10-06	
Siren	08-10-09	H
Socket (female)	03-03-01	X
dedicated	00-13-03	
general symbol	11-13-01	X
multiple	11-13-03	X
receptacle outlet (general symbol)	11-13-01	X
three-phase	00-13-01	
three-phase, switched	00-13-02	
with interlocked switch	11-13-07	X
with isolating transformer	11-13-08	X
with protective contact	11-13-04	X
with shutter	11-13-05	X
with single-pole switch	11-13-06	X
Socket outlet (telecommunications)	11-13-09	X
Solar generating station, in service	11-02-10	
Solar generating station, planned	11-02-09	
Spark gap, double	07-22-02	F
Starter; Motor (block symbols)		
auto-transformer	07-14-07	A.Q
direct on line contactor, for reversing motor	07-14-05	A.Q
full voltage contactor, for reversing motor	07-14-05	A.Q
general symbol	07-14-01	A.Q
operated in steps	07-14-02	A.Q
regulator	07-14-03	A.Q
regulator with thyristors	07-14-08	A.Q
star-delta	07-14-06	A.Q
with automatic release	07-14-04	A.Q
Stay (see Reticulation systems)		
Stepping action	02-03-07	
Stepping motor (general symbol)	06-04-03	M
Strut (see Reticulation systems)		
Substation; Generating stations		
general symbol	11-01-05	
Substation (specific) with qualifying letters for type (see Reticulation systems)		
Substation, miniature (see Reticulation systems)		

Description	Symbol No.	Letter code
S (continued)		
Switch (for architectural diagrams)		
dimmer	11-14-08	Q.S
general symbol	11-14-01	Q.S
intermediate	11-14-07	Q.S
key-operated	11-14-15	Q.S
multiposition	11-14-05	
period limiting, single-pole	11-14-03	Q.S
pull cord, single-pole	11-14-09	Q.S
push-button	11-14-10	Q.S
period limiting	11-14-13	Q.S
time	11-14-14	Q.S
with indicator lamp	11-14-11	Q.S
with restricted access	11-14-12	Q.S
time	11-14-14	Q.S
two-pole	11-14-04	Q.S
two-way, single-pole	11-14-06	Q.S
watchman's system device	11-14-15	Q.S
with pilot light	11-14-02	Q.S
Switch (Proximity and touch sensitive)		
proximity, make contact	07-20-02	S
operated on the approach of a magnet, make contact	07-20-03	S
operated on the approach of iron, break contact	07-20-04	S
touch-sensitive, make contact	07-20-01	S
Switch; Complex		
eighteen-position rotary wafer switch with six terminals	07-12-02	S
six-position rotary drum with five terminals	07-12-03	S
Switch; Diverse		
limit		
break contact	07-08-02	S.Q
make contact	07-08-01	S.Q
mechanically operated in both directions with two separate circuits	07-08-03	S.Q
position		
break contact	07-08-02	S.Q
make contact	07-08-01	S.Q
temperature-sensitive		
break contact	07-09-02	S.Q
make contact	07-09-01	S.Q
thermal, self-operating, break contact	07-09-03	S.Q
Switch; Multipole and multiposition		
button-operated, one set of contacts operated by pushing and another by turning	07-11-02	S
button-operated, the same set of contacts operated in two different ways	07-11-03	S
single-pole		
four-position, manually operated with four independent circuits	07-11-07	S
multiposition, bridging	07-11-10	S
multiposition for cumulative parallel switching	07-11-12	S
six-position, bridging	07-11-09	S
three-position lever-operated and non-identical return conditions	07-11-01	S
Switch; Single-pole		
emergency push-button	02-13-08	S.Q
manually operated, general symbol	07-07-01	S.Q

Description	Symbol No.	Letter code
S (concluded)		
pull-switch	07-07-03	S
push-button	07-07-02	S
turn-switch	07-07-04	S.Q
Switch-disconnector	07-13-08	Q
with automatic release	07-13-09	Q
Switchgear and controlgear		
circuit-breaker	07-13-05	Q
contactor (contact closed in the unoperated position)	07-13-04	K.Q
contactor (contact open in the unoperated position)	07-13-02	K.Q
contactor with automatic release	07-13-03	K.Q
disconnector	07-13-06	Q
two-way with centre-off position	07-13-07	Q
isolator	07-13-06	Q
with centre-off position	07-13-07	Q
on-load isolating switch	07-13-08	Q
switch-disconnector	07-13-08	Q
with automatic release	07-13-09	Q
Synchronoscope	08-02-08	P
Synchronous machines		
converter, three-phase, shunt excited	06-07-05	G
generator, three-phase, both leads of each phase winding brought out	06-07-04	G
generator, three-phase, permanent magnet	06-07-01	G
generator, three-phase, star-connected with neutral brought out	06-07-03	M
T		
Tachometer	08-02-15	P
Tank (symbol element)	02-01-04	
Telemetering devices		
signal translator (general symbol)	08-07-01	U
receiver	08-07-03	U.B
transmitter	08-07-02	U.B
Temperature-sensitive switch		
break contact	07-09-02	S
make contact	07-09-01	S
Terminal	03-02-02	X
Terminal strip	03-02-03	X
Test point indicator	02-17-05	
Thermal		
actuating device, relay	07-15-21	
effect	02-08-01	
Thermal switch, self-operating, break contact	07-09-03	S.Q
Thermocouple		
shown with polarity symbols	08-06-01	B
with insulated heating element	08-06-05	B
simplified form	08-06-06	B
with non-insulated heating element	08-06-03	B
simplified form	08-06-04	B
Thermoelectric generating station	11-02-03	
Thermometer	08-02-14	P
Three-position lever-operated multiposition switch	07-11-01	S
Thyristor		
diode, bidirectional	05-04-03	V
diode, reverse blocking	05-04-01	V
diode, reverse conducting	05-04-02	V
tetrode type, reverse blocking	05-04-10	V
triode, bidirectional	05-04-11	V

Description	Symbol No.	Letter code
T (continued)		
triode, reverse blocking, N-gate	05-04-05	V
triode, reverse blocking, P-gate	05-04-06	V
triode, reverse conducting, gate not specified	05-04-12	V
triode, reverse conducting, N-gate	05-04-13	V
triode, reverse conducting, P-gate	05-04-14	V
triode, turn-off, gate not specified	05-04-07	V
triode, turn-off, N-gate	05-04-08	V
triode, turn-off, P-gate	05-04-09	V
triode, type unspecified	05-04-04	V
Time clock	11-16-03	P
Time switch	11-14-14	Q.S
Touch-sensitive switch, make contact	07-20-01	S
Touch sensor	07-19-04	B
Transformer		
single-phase with two windings and screen		
form 1	06-10-01	T
form 2	06-10-02	T
three-phase bank of single-phase, connection star-delta		
form 1	06-10-11	T
form 2	06-10-12	T
three-phase, connection star-zigzag		
form 1	06-10-15	
form 2	06-10-16	
three-phase with four tappings		
form 1	06-10-09	T
form 2	06-10-10	T
three-phase with on-load tap charger, connection star-delta		
form 1	06-10-13	T
form 2	06-10-14	T
three-phase, connection star-delta		
form 1	06-10-07	T
form 2	06-10-08	T
three-phase, three winding, connection star-star-delta		
form 1	06-10-17	T
form 2	06-10-18	T
with centre tapping on one winding		
form 1	06-10-03	T
form 2	06-10-04	T
with variable coupling		
form 1	06-10-05	T
form 2	06-10-06	T
Transformer; Measuring		
current, with one secondary winding with one tapping		
form 1	06-13-06	T
form 2	06-13-07	T
current, with two cores and two secondary windings		
form 1	06-13-02	T
form 2	06-13-03	T
current, with two secondary windings on one core		
form 1	06-13-04	T
form 2	06-13-05	T
voltage	06-13-01	T
Transformers (general symbols)		
auto-transformer		
form 1	06-09-06	T
form 2	06-09-07	T

Description	Symbol No.	Letter code
T (concluded)		
Transformers (general symbols) (continued)		
choke		
form 1	06-09-08	
form 2	06-09-09	
current		
form 1	06-09-10	T
form 2	06-09-11	T
pulse		
form 1	06-09-10	T
form 2	06-09-11	T
reactor		
form 1	06-09-08	L
form 2	06-09-09	L
with three windings		
form 1	06-09-04	T
form 2	06-09-05	T
with two windings		
form 1	06-09-01	T
form 2	06-09-02	T
with two windings, shown with instantaneous voltage polarity indicators	06-09-03	
Transistor		
IGFET depleted one gate, N-type, without substrate connection	05-05-15	V
IGFET depleted one gate, P-type, without substrate connection	05-05-16	V
IGFET depleted two gates, N-type, with substrate connection brought out	05-05-17	V
IGFET enhanced one gate, N-type, channel with substrate internally connected	05-05-14	V
IGFET enhanced one gate, P-type, with substrate connection brought out	05-05-13	V
IGFET enhanced one gate, N-type without substrate connection	05-05-12	V
IGFET enhanced one gate, P-type without substrate connection	05-05-11	V
NPN avalanche	05-05-03	V
NPN with collector connected to the envelope	05-05-02	V
NPN with transverse biased base	05-05-06	V
PNIN with ohmic connection to the intrinsic region	05-05-08	V
PNIP with ohmic connection to the intrinsic region	05-05-07	V
PNP	05-05-01	V
junction field effect with N-type channel	05-05-09	V
junction field effect with P-type channel	05-05-10	V
photo-	05-06-04	B.V
unijunction with N-type base	05-05-05	V
unijunction with P-type base	05-05-04	V
Translator, signal (general symbol)	08-07-01	U
Transmitter (Instrument)		
telemetering	08-07-02	U.B
Transmitter, telemetering	08-07-02	U.B
Triac	05-04-11	V
Tube		
protective gas discharge	07-22-04	F
protective gas discharge, symmetric	07-22-05	F
Tunnel diode	05-03-05	V
Turn-off		
triode thyristor, gate not specified	05-04-07	V
triode thyristor, N-gate	05-04-08	V
triode thyristor, P-gate	05-04-09	V
Turn-switch	07-07-04	S.Q
Two-way contact with centre-off position	07-02-05	
Two-way switch, single-pole	11-14-06	Q.S
U		
Unijunction transistor with N-type base	05-05-05	V
Unijunction transistor with P-type base	05-05-04	V
Unitunnel diode	05-03-08	V

Description	Symbol No.	Letter code
V		
Var-hour meter	08-04-15	P
Varactor	05-03-04	V.C
Variability		
continuous	02-03-09	
in steps	02-03-07	
inherent	02-03-03	
inherent, non-linear	02-03-04	
non-inherent	02-03-01	
non-inherent, non-linear	02-03-02	
pre-set adjustment	02-03-05	
stepping action	02-03-07	
Variable capacitance diode	05-03-04	V.C
Variable capacitor	04-02-07	C
Variable resistor	04-01-03	R
Variometer	04-03-08	L
Varistor	04-01-04	R
Varmeter	08-02-04	P
Voltage dependent resistor	04-01-04	R
Voltage regulator diode	05-03-06	V
Voltmeter	08-02-01	P
differential	08-02-11	P
W		
Watchman's system device	11-14-15	Q.S
Water heater	11-16-01	E
Watt-hour meter	08-04-03	P
Wattmeter and varmeter combined, recording	08-03-02	P
Wattmeter, recording	08-03-01	P
Waveform of signals (see Signal waveforms)		
Wavemeter	08-02-09	P
Whistle, electrically operated	08-10-12	H
Wind generating station	11-02-11	
Winding	04-03-01	L
Winding; Internally connected		
six-phase, double delta	06-02-10	
six-phase, fork with neutral brought out	06-02-13	
six-phase, polygon	06-02-11	
six-phase, star	06-02-12	
three-phase, delta	06-02-05	
three-phase, interconnected star	06-02-09	
three-phase, open delta	06-02-06	
three-phase, star	06-02-07	
three-phase, star, with neutral brought out	06-02-08	
three-phase, zigzag	06-02-09	
Winding; Separate		
m-phase, phases not interconnected	06-01-05	
one winding	06-01-01	
six separate	06-01-03	
three-phase , phases not interconnected	06-01-04	
three separate	06-01-02	
two-phase, four-wire	06-01-06	
Winding for machines		
commutating	06-03-01	
compensating	06-03-01	
separate	06-03-03	

Description	Symbol No.	Letter code
W (concluded)		
Winding for machines (continued)		
series	06-03-02	
shunt	06-03-03	
Wiring (for architectural)		
box (general symbol)	11-12-04	X
connection box	11-12-05	X
consumer's terminal with wiring	11-12-06	X.A
distribution centre	11-12-07	A
going downwards	11-12-02	
going upwards	11-12-01	
junction box	11-12-05	X
passing through vertically	11-12-03	
service entrance equipment	11-12-06	X.A

TRANSNET PIPELINES			
Document Name	Document Number	Revision Number	Page
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DRAWING OFFICE STANDARD (PL103)

DOCUMENT APPROVAL PROCESS

NAME		**POSITION/MEETING NO.**	**SIGNATURE**	**DATE**
Originator:	Zandile Moloi	Drawing Office Manager		20/06/2016
Approver:	Petros Khumalo	Technical Support Manager		30-06-2016
Original date: 15 June 2016				
Effective date: 06 July 2016				

TABLE OF CONTENT

1. INTRODUCTION

The objective of this General Drawing Standards Document is to establish a set of approved drawing standards and codes of practise that shall be required to be adhered to by both Contractor and Client in the preparation of Engineering Documentation for and on behalf of Transnet Pipelines, a Division of Transnet Ltd. By ensuring comprehensive, consistent and uniform means of presentation of information, these Standards and Codes of Practise are intended to facilitate rapid comprehension by the users of the information, and thus assist in the maintenance and fault finding of installed technology.

2. SCOPE

2.1. GENERAL

This document defines as a minimum, the general responsibilities for the provision of all Engineering Documentation, whether it be by the Client or Contractor, for and on behalf of Transnet Pipelines. In this regard, providers of Engineering Documentation are required to familiarise themselves with all applicable Standards and Codes of Practise listed herein, and to ensure compliance in the execution of any work in terms of this document. Failure to comply may render the provider liable for corrections at his own cost.

These Standards and Codes of Practise should be read in conjunction with all other Specifications and drawings as issued for a particular contract. Where discrepancies occur, these must be brought to the attention of Transnet Pipelines in writing before commencement of work. In the event of any conflict between the contents of any documents forming part of a contract (as listed in the Schedule of Contract Documents) and this document, the former shall prevail.

2.2. APPLICATION TO WORK ACTIVITIES

The Standards and Codes of Practise contained herein are suitable for use whenever Engineering Documentation is required to be produced and includes amongst others the following:

- Design Sketches
- Technical Papers and literature
- Equipment Identification and Tagging
- Construction Drawings
- Specifications, both Functional and Technical
- Installation, operating and maintenance instructions, drawings and records

3. REFERENCE DOCUMENTATION

The following standard specifications are to be used for reference purposes. It is expected of Tenderers that they be familiar with the applicable clauses and that these will be adhered to in the execution of any work in terms of this specification.

A. Standards and Recommended Practices for Instrumentation and Control, 11th Edition, Instrument Society of America.

ANSI/ISA-S5.1-2009	Instrument Symbols and Identification
ANSI/ISA - S 5.2-1992	Binary Logic Diagrams for Process Operations
ANSI/ISA-S5.3-1983	Graphic Symbols for Distributed Control, Shared Display Instrumentation, Logic and Computer Systems
ANSI/ISA - S 5.5-1985	Graphic Symbols for Process Displays

B. Graphical Symbols for Electrical Diagrams NRS 002-2000 second edition.

C. International Electrotechnical Commission Standards for Electrical Drawings

IEC Publication 27	Letter Symbols to be used in Electrical Technology
IEC Publication 50	International Electrotechnical Vocabulary
IEC Publication 617	Graphical Symbols for Diagrams

D. American Society of Mechanical Engineers (ASME)

ASME Y32.11 - 1961	Graphical Symbols for Process Flow Diagrams
ASME Y32.2.3 - 1994	Graphical Symbols for Pipe Fittings, Valves & Piping.

E.	TPL-TECH-I-POL-001	Measurement Policy
F.	TPL-TECH-I-POL-002	Control Policy
G.	TPL-TECH-I-POL-003	Instrumentation Policy
H.	SANS-10111-1-2011	Engineering Standards

4. ABBREVIATION

For the purpose of understanding these Standards, the following abbreviations apply.

ANSI	:	American National Standards Institute
C & I	:	Control and Instrumentation
IEC	:	International Electrotechnical Commission
ISA	:	Instrument Society of America
SABS	:	South African Bureau of Standards
ASA	:	American Standards Association

5. EQUIPMENT & INSTRUMENT SYMBOLOGY STANDARD

This specification details general drawing standards to be adhered to in the production of Engineering Documentation for and on behalf of Transnet Pipelines.

5.1. UNITS AND LANGUAGE

5.1.1. All drawings shall conform to SI (System International) units.

5.2.1. All notes, comments and text shall be in the English language.

5.2. SIZES

5.2.1 . All drawings shall be supplied on standard sized media as listed in Table 1 below:

Table 1. Sizes of Drawing Sheets (SABS 0111-1990 Table 1).

DESIGNATION	TRIMMED SIZE (mm)	WIDTH OF BORDER (mm)
A0	841 X 1189	20
A1	594 X 841	20
A2	420 X 594	15
A3	297 X 420	15
A4	210 X 297	15

5.2.2 . Media exceeding A0 length may be used only where absolutely necessary e.g. Long sections / pipe profiles etc, but with prior approval from Transnet Pipelines.

5.2.3. Where possible, the following drawing sizes shall be adhered to in the production of Engineering Documentation. Where undecided, the smallest of the recommended sizes that is consistent with clarity should be used where ever possible. Deviations from the under mentioned drawing sizes shall require prior approval from Transnet Pipelines.

DOCUMENTATION TYPE	DRAWING SIZE
Process Drawings	
Piping & Instrumentation Diagrams	A1
Process Flow Diagrams	A1
Heating Ventilation & Air Conditioning (HVAC)	A1
Hazardous Area Classification Diagrams	A1
Metering & Instrumentation	
Instrument Schedules/ Data Sheets	A4
Instrument Hookup Diagrams	A4
Instrument Location Diagrams	A1
Loop Drawings	A4
Panel GA / Layout Diagrams – Internal & External	A1
Panel Wiring Diagrams	A1/A4
Cable Schedules	A1/A4
Cable Block/ Routing/ Interconnection Diagrams	A1

Safety Integrity Levels (SILs) Report	A4
HAZOP Report	A4
Software Documentation	
Engineering Design / Functional Design Spec (EDS/FDS)	A4
Plant Input/ Output (I/O) Schedules	A4
Metering Configuration Documentation	A4
Metering Detailed Design Spec (DDS)	A4
Site Acceptance Test (SAT)	A4
Electrical Documentation	
Electrical Load & Fault Calculations	A4
Single Line Diagrams	A1/A4
Panel GA / Layout Diagrams – Internal & External	A1
Electrical Schematic & Wiring Diagrams	A1
Cable Schedules	A1/A4
Cable Block/ Routing/ Interconnection Diagrams	A1
Protection settings schedule and curves	A4
Cable schedule to include – de-rating factor Philosophy / calculations, cable lengths, voltdrop calculations	A2
Earthing Single line diagrams	A1
Electrical equipment data sheets	A4
Hazardous area equipment certification	A4
Site and manifold Hazardous area classification drawings	A1
High Voltage yards structural equipment design and foundation drawings	A3
Mechanical Documentation	
General Arrangement Diagrams	As required
3D CAD views of Piping, Structural Steel & Mechanical	As required
3D model Isometric views	As required
Underground Drawings	As required
Civil/Site Layout Drawings	
Site Layout Diagrams	A0/A1
Cable, Racking & Trenching Layout Diagrams	A0/A1
Survey Drawings	A0/A1
Earthing Reticulation Diagrams	A0/A1
Location Drawings (Plot Plans)/ 3D CAD views	A0/A1
Structural Arrangement Drawings	A0/A1
Structural Fire Protection Drawings	A0/A1
Structural Steel Detail Drawings	A0/A1
Foundation Drawings	A0/A1
Pipe/ Ducting Support Drawings	A0/A1
Weight/ Structural Analysis Design Reports	A4/A3

5.3. TEXT SIZES & CORRESPONDING LINE THICKNESSES

5.3.1. One of the following sets of standard text sizes and corresponding line thickness' shall be used:

__Table 2.__ Text Size & Line Thickness (SABS 0111 1990 Table 2).

SET 1	
Text Size	Line Thickness
1.8 mm	0.18 mm
2.5 mm	0.25 mm
3.5 mm	0.35 mm
5 mm	0.5 mm
7 mm	0.7 mm
10 mm	1.0 mm

SET 2	
Text Size	Line Thickness
2.0 mm	0.2 mm
3.0 mm	0.3 mm
5.0 mm	0.5 mm
7.0 mm	0.7 mm
10.0 mm	1.0 mm
14.0 mm	1.4 mm

5.4. LINE TYPES

5.4.1. MECHANICAL DIAGRAMS

5.4.1.1. The following line types shall be adhered to in the production of Mechanical manufacturing drawings:

Table 3. Types of Lines (SABS 0111 1990 Table 3)

LINE	DESCRIPTION APPLICATION
A	Visible outlines/edges
B	Dimension, projection and leader lines cross hatching, short centre lines, imaginary lines of intersection, outlines of revolved sections
C	Break lines
D	Hidden features
E	Centre lines and lines of symetry, pitch circles, paths of motion, repeated details
F	Cutting planes
G	Limit of maximum or final maching
H	Existing or adjacent parts, alternative and extreme positions of movable parts, developed views and bend lines, feature located in front of a cutting plane, portions to be removed

5.4.2. PROCESS DIAGRAMS

5.4.2.1. Line Types to be adhered to in the production of Process Diagrams (e.g. Piping & Instrumentation Diagrams, Flow Diagrams) are defined in Transnet Pipelines Specification PL 102 Equipment, Instrument and Electrical Symbology Standards Document, Table 3.

5.5. SCALES

5.5.1. All engineering drawings shall be produced to one of the standard scales defined below, or should the need arise, a multiple of ten thereof:

10:1	1:2	1:50	1:1000
5:1	1:5	1:100	1:2000
2:1	1:10	1:200	1:2500
1:1	1:20	1:250	1:5000

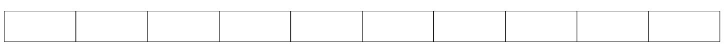
5.2.2. Conceptual drawings not drawn to scale shall be marked as "NTS" in the box provided in the title block. Plot scales shall be noted elsewhere on the drawing in these cases.

5.5.3. Where details (either enlarged or reduced), are drawn on the same sheet as the subject, the scale shall be indicated on the drawing, directly under the title of the detail.

5.5.4. Metric Reference Scale

All original drawings shall be marked with a metric reference scale at the bottom of the drawing, placed symmetrically about a centring mark near the frame of the border. The scale shall be 100 mm in length, with a maximum width of 5 mm and marked off in units of 10 mm.

<u>Metric Reference Scale.</u> (SABS 0111 Drg 10759/E)



5.6. TOLERANCES

5.6.1. Tolerances shall be indicated on all manufacturing drawings, whether as a general note, or on specific dimensions.

5.7. DIMENSIONS/NOTES

5.7.1. All manufacturing drawings shall be comprehensively dimensioned and annotated, to ensure that manufacturing methods, sizes and materials etc are clear to the manufacturer.

5.8. TITLE BLOCK

5.8.1. All drawings are to bear the Transnet Pipelines title block (ANNEXURE A), with the space allocated for the drawing number left blank.

5.8.2. A space of either 25 mm high may be added to the top or 40 mm high may be added to the left hand side of the Transnet Pipelines title block, in which space the Contractor's details and title block may be added.

5.8.3. A further space of not more than 8 mm high may be added in the same area for the Contractor's drawing number.

5.8.4. The Contractor shall indicate the persons responsible for producing the drawing, the title, scale, project name, date, revision etc. in the spaces provided for in the Transnet Pipelines title block. (ANNEXURE A hereof)

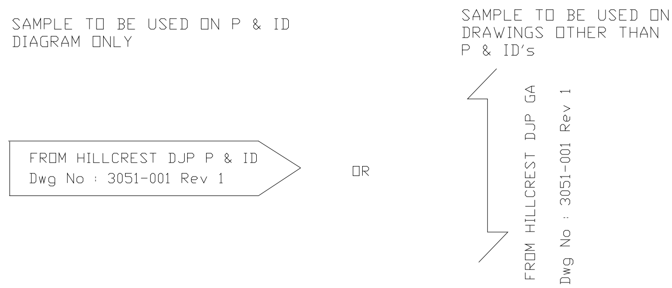
5.8.5. On application, Transnet Pipelines will supply, free of charge, one “soft copy AutoCAD version” of their title block.

5.9. REFERENCE DRAWINGS

5.9.1. Where applicable, all reference drawings shall be noted in an appropriate place, on all drawings.

5.9.2. Smaller series drawing (A4 and A3) may bear reference drawing numbers as a note, in an appropriate position, on the drawing.

5.9.3. Where a drawing is of sufficient complexity and size that warrants being split over several pages, continuation lines shall be conveyed by means of either of the under mentioned symbols. Note that the direction of the arrow shall indicate the direction of information flow.



5.10. CONTRACTOR’S AMENDMENT BLOCKS

5.10.1. All amendments made to existing drawings shall be indicated by the placement of the following information within a Revision Block included as part of the Drawing Border:

-	Drawing Revision Number	Marked as the next consecutive alpha character.
-	Revision Date	Date on which the amendment was made.
-	Name	Name of Draughtsman responsible
-	Description	Description of the amendment made.

5.10.2. Revision Numbers ascribed to Engineering Design Drawings (prior to completion of a project and production of AS BUILTS) shall be placed in the Contractor’s Amendment Block and shall be numbered numerically commencing with the numerals 001. AS BUILT Drawings shall be indicated by the last revision number contained in the Contractor’s Amendment Block.

5.10.3. In order to indicate the most recent amendments made to a drawing, all amendments relating to the most recent revision number shall be highlighted by means of a "cloud" symbol placed around the modification with the Revision Number inserted within. Only the most recent amendments shall be highlighted on a drawing in this manner.

5.11. LAYOUT

5.11.1. All drawings shall be laid out in a logical and legible manner and shall comply fully with all provisions as detailed in the Drawing Standards Document PL 100. Where Typical Drawing Layouts have been included in the Drawing Standards Document, Contractors shall be required to ensure compliance to such standards. Where Typical Drawing Layouts have not been defined, all proposed layouts shall be required to be approved by the nominated Transnet Pipelines representative prior to commencement of draughting work.

5.11.2. All orthographic projections are to be in the first angle.

5.11.3. Typical Drawing Layout Standards have been defined for the following documentation types and are required to be complied within the compilation of Engineering Documentation:

(PL 100 APPENDIX B Documentation Layout Standards/Typicals)

Process Drawings
Piping & Instrumentation Diagrams (P&IDs)
Process Flow Diagrams (PFDs)
Heating Ventilation & Air Conditioning (HVAC)
Hazardous Area Classification Diagrams
Hazop Studies

Metering & Instrumentation
Instrument Schedules
Instrument Data Sheets
Instrument Hook-up Diagrams
Loop Reports/ Drawings
Panel Layout and General Arrangements
Panel Wiring Diagrams
Cable Schedules (Refer to Electrical Typicals)
Cable Block Diagrams (Refer to Electrical Typicals)
Cable Interface Wiring Diagrams

Electrical Documentation
Single Line Diagrams
Electrical Schematic & Wiring Diagrams
Panel Layout and General Arrangements
Cable Schedules
Cable Block Diagrams
Cable Interface Wiring Diagrams
Connection/ Hook-up Diagrams

Mechanical Documentation
General Arrangement/ 3D CAD views of Piping, Structural Steel & Mechanical, Installations.
Layout Drawings/ 3D model Isometric views
Underground Drawings

Civil/Site Layout & Survey Documentation
Trenching and Services Layout Diagrams
Earthing Reticulation Diagrams
Cable Routing Reticulation Diagrams
Structural Arrangement Drawings
Structural Fire Protection Drawings
Structural Steel Detail Drawings
Foundation Drawings
Pipe/ Ducting Support Drawings

5.12. SYMBOLOGY

5.12.1. PROCESS DIAGRAMS, METERING AND INSTRUMENT DRAWINGS

All Process Diagram and Metering & Instrument Diagram symbols shall comply with those stipulated in the Equipment, Instrument and Electrical Symbology Standards Document PL 102 Tables 1 to 10. Symbols defined in this Standard cover production of the following Document types:

Process Drawings
Piping & Instrumentation Diagrams
Process Flow Diagrams

Metering & Instrumentation
Instrument Schedules
Instrument Data Sheets
Instrument Hookup Diagrams
Instrument Location Diagrams
Loop Drawings
Panel GA / Layout Diagrams – Internal & External
Panel Wiring Diagrams
Cable Schedules
Cable Block Diagrams
Cable Interconnection Diagrams
Cable Routing Diagrams

Software Documentation
Engineering Design / Functional Design Specs
Plant I/O Schedules
Flow Charts
Software Listing

Graphical instrument/equipment symbols have been based on compliance with ISA Standards 11th Edition Vol 1. Standards and Recommended Practices for Instrumentation and Control, and American Society of Mechanical Engineers Standards ASA 732.11 / 232.2.3.:

5.12.2. MANUFACTURING / MACHINING DRAWINGS

5.12.2.1. MACHINING SYMBOLS / ROUGHNESS VALUES

5.12.2.1.1. Machining and surface finish symbols and roughness values shall comply with the Code of Practice for Engineering Drawing SABS 0111/1990 as amended.

5.12.2.2. WELDING SYMBOLS

5.12.2.2.1. All welding symbols used shall comply with the Code of Practice for Welding, SABS 044 parts I and II, as amended.

5.12.3. ELECTRICAL DRAWINGS

5.12.3.1. All cable and wire sizes, values of resistance, breaking capacity of switches and ratings of equipment shall be clearly specified on a drawing.

5.12.3.2. ELECTRICAL SYMBOLS

All Electrical Diagram symbols shall comply with those stipulated in the Equipment, Instrument and Electrical Symbology Standards Document PL 102 Section 5. Symbols defined in this Standard covers production of the following Document types:

Electrical Documentation
Single Line Diagrams
Panel GA / Layout Diagrams – Internal & External
Electrical Schematic & Wiring Diagrams
Cable Schedules
Cable Block Diagrams
Cable Interconnection Diagrams
Cable Routing Diagrams

5.12.3.3. Graphical Symbols for Electrical Diagrams NRS 002-2000 second edition

5.12.4. OTHER DRAWINGS

5.12.4.1. All other drawings using symbols, must state the standard used, or else have a key as to the meaning of such symbols.

5.13. DRAWING LAYER CONTROL

5.13.1. The following Layer structures shall be utilised by the Contractor in the provision of all Engineering Design Drawings. All Layer Descriptors shall comprise of alphanumeric characters and shall be descriptive in nature.

5.13.2. PROCESS DIAGRAMS

All Process Diagrams shall comply with the following Layer structure:

0	General
ALCOHOL	Alcohol Manifold Piping
AUX	Auxiliary Manifold Piping
BORDER	Border
CDRAIN	Closed Drain System
CDRAINHID	Closed Drain System - below ground
DEFPOINTS	
DIESEL	Diesel Manifold Piping
EFFLUENT	Effluent System
FIRE	Fire System
FUTURE	Future Equipment, Piping
INSTR-ATTR	Instrument Attributes
INSTR-LINE	Instrument Piping
MAIN	Main Manifold Piping
NEW	
ODRAIN	Open Drain System
ODRAINHID	Open Drain System - below ground
PETROL	Petrol Manifold Piping
PIPE-ATTR	Pipe Attributes
TEXT	
TITLE	Title Block
ULP	Unleaded Manifold Piping

Layers defined in this Standard cover production of the following Document types:

Process Drawings
Piping & Instrumentation Diagrams
Process Flow Diagrams
Hazardous Area Classification Diagrams

5.13.3. METERING & INSTRUMENTATION DIAGRAMS

All Metering & Instrumentation Diagrams shall comply with the following Layer structure:

0	General
BORDER	Border
DEFPOINTS	
DIM	Dimensions
FUTURE	Future Installations

INSTR-ATTR	Instrument Attributes
INSTR-LINE	Instrument Piping
NEW	
PROCESS	Process Connections
PNEU	Pneumatics
TEXT	
TITLE	Title Block

Layers defined in this Standard cover production of the following Document types:

Metering & Instrumentation
Instrument Schedules
Instrument Data Sheets
Instrument Hookup Diagrams
Instrument Location Diagrams
Loop Drawings
Panel GA / Layout Diagrams – Internal & External
Panel Wiring Diagrams
Cable Schedules
Cable Block Diagrams
Cable Interconnection Diagrams
Cable Routing Diagrams

5.13.4. ELECTRICAL SWITCHGEAR DIAGRAMS

All Electrical Diagrams shall comply with the following Layer structure:

0	General
BORDER	Border
C1	Control Circuitry 1
C2	Control Circuitry 2
C3	Control Circuitry 3
C4	Control Circuitry 4
DEFPOINTS	
ELEC-ATTR	Electrical Attributes
FUTURE	Future Installations
MAIN	
NEW	
T1	Power Circuitry 1
T2	Power Circuitry 2
T3	Power Circuitry 3
T4	Power Circuitry 4
TEXT	
TITLE	Title Block

Layers defined in this Standard cover production of the following Document types:

Electrical Documentation
Single Line Diagrams

Panel GA / Layout Diagrams – Internal & External
Electrical Schematic & Wiring Diagrams
Cable Schedules
Cable Block Diagrams
Cable Interconnection Diagrams
Cable Routing Diagrams

5.13.5. Mechanical Diagrams, Manifold Piping and General Arrangements

All Mechanical Diagrams shall comply with the following Layer structure:

0	General
BORDER	Border
CDRAIN	Closed Drain System
CDRAINHID	Closed Drain System - below ground
DEFPOINTS	
DIMENSION	Dimensions
FUTURE	Future Equipment, Piping
HIDDEN	Hidden - underground
MAIN	
NEW	
ODRAIN	Open Drain System
ODRAINHID	Open Drain System - below ground
PLINTH	Plinth Details
PIPE-ATTR	Pipe Attributes
TEXT	
TITLE	Title Block

Layers defined in this Standard cover production of the following Document types:

Mechanical Documentation
General Arrangement/ 3D CAD views of Piping, Structural Steel & Mechanical, Installations.
Layout Drawings/ 3D model Isometric views
Underground Drawings

5.13.6. CIVIL / SITE LAYOUT DIAGRAMS

All Civil/Site Layout Diagrams shall comply with the following Layer structure:

0	General
AUX	Auxiliary Manifold Piping
BORDER	Border
BUND	Bund
BUNDW	Bund Wall
CABLE	Cable Reticulation
CDRAIN	Closed Drain System
CDRAINHID	Closed Drain System - below ground
DEFPOINTS	

DRAIN	Drainage
EARTH	Earthing System
EFFLUENT	Effluent System
FENCE	Fencing
FIRE	Fire System
FUTURE	Future Equipment, Piping
INSTR-ATTR	Instrument Attributes
INSTR-LINE	Instrument Piping
MAIN	Main Manifold Piping
NEW	
ODRAIN	Open Drain System
ODRAINHID	Open Drain System - below ground
PIPE-ATTR	Pipe Attributes
RACK	Racking Reticulation
TEXT	
TITLE	Title Block
TRENCH	Trenching Reticulation
ZONE0	Hazardous Area Classification Zone 0
ZONE1	Hazardous Area Classification Zone 1
ZONE2	Hazardous Area Classification Zone 2

Layers defined in this Standard cover production of the following Document types:

Civil/Site Layout Drawings

Trenching and Services Layout Diagrams
Earthing Reticulation Diagrams
Cable Routing Reticulation Diagrams
Structural Arrangement Drawings
Structural Fire Protection Drawings
Structural Steel Detail Drawings
Foundation Drawings
Pipe/ Ducting Support Drawings

5.14. SCOPE OF SUPPLY

5.14.1. PRESENTATION

5.14.1.1. All documentation shall be professionally reproduced and bound to the satisfaction of the nominated Transnet Pipelines representative. At least one set of documentation shall be marked as a "MASTER" set, and shall be presented in electronic medium suitable for reproduction. All binders and binding methods used, shall be approved by Transnet Pipelines prior to the documentation being bound.

5.14.2. SUPPLY REQUIREMENTS

Unless stipulated elsewhere in a Contract Document, the Contractor shall be required to provide the following Documentation:

5.14.2.1. ENGINEERING DESIGN DOCUMENTATION (PRIOR TO CONSTRUCTION)

The Contractor shall be required to prepare and submit to the Engineer three prints of each working drawing/design specification for approval. One print/copy of each drawing/specification shall be returned to the Contractor once approved. Notwithstanding any approval of design or working drawings by Transnet Pipelines or a nominated representative, the responsibility for the correct functioning of the system shall rest entirely with the Contractor.

As a minimum, the following documentation is required to be approved by Transnet Pipelines prior to commencement of construction activities:

Process Drawings
Piping & Instrumentation Diagrams
Process Flow Diagrams
Hazardous Area Classification Diagrams

Metering & Instrumentation
Instrument Schedules
Instrument Data Sheets (if different from Transnet Pipelines standard Data Sheets)
Instrument Hookup Diagrams (if different from Transnet Pipelines standard Hookups)
Loop Drawings (if different from Transnet Pipelines standard Loop Drawings)
Panel GA / Layout Diagrams – Internal & External
Panel 220V/24V Power Distribution and Barrier Layout schedules
Control System Architecture Diagrams
Communication Architecture & Interconnection Diagrams
Instrument Junction Box Layout Diagrams
Cable Block Diagrams

Software Documentation
Engineering Design Specification (Software Functional Design Specification)
Plant I/O Schedules
Flow Charts

Electrical Documentation
Electrical Load & Fault Calculations
Single Line Diagrams
Panel GA / Layout Diagrams – Internal & External
Electrical Schematic & Wiring Diagrams
Cable Block Diagrams

Mechanical Documentation
General Arrangement/ 3D CAD views of Piping, Structural Steel & Mechanical.
Layout Drawings/ 3D model Isometric views
Underground Drawings

Civil/Site Layout & Survey Documentation
Site Layout Diagrams
Cable, Racking & Trenching Layout Diagrams
Earthing Reticulation Diagrams
Structural Arrangement Drawings
Foundation Drawings

5.14.2.2. FINAL CONTRACT DOCUMENTATION

Unless stipulated elsewhere in a Contract Document, the Contractor shall provide as a Minimum the following Final Contract Documentation:

5.14.2.2.1. MAINTENANCE AND OPERATING LITERATURE

Maintenance and Operating Literature is deemed to form an integral part of all equipment supplied and shall require to be supplied along with all equipment installed on Transnet Pipelines sites. Supply shall include comprehensive data on servicing, faultfinding, repairs, procedures and full particulars with diagrams of how the equipment functions. All technical literature, calculations and drawings, which will enable Engineering Staff to be fully informed on electrical, control and mechanical aspects, shall be included.

5.14.2.2.2. AS BUILT DOCUMENTATION

Process Drawings
Piping & Instrumentation Diagrams (P&IDs)
Process Flow Diagrams (PFDs)
Heating Ventilation & Air Conditioning (HVAC)
Hazardous Area Classification Diagrams
Hazop Studies

Metering & Instrumentation
Instrument Schedules/ Data Sheets
Instrument Hook-up/ Location Diagrams
Loop Drawings
Panel GA / Layout Diagrams – Internal & External
Panel Wiring Diagrams
Panel 220V/24V Power Distribution and Barrier Layout schedules
Control System Architecture Diagrams

Communication Architecture & Interconnection Diagrams
Instrument Junction Box Layout Diagrams
Cable Schedules
Cable Block/ Interconnection/ Routing Diagrams
Safety Integrity Levels (SILs) Report

Software Documentation
Engineering Design Specification (Software Functional Design Specification)
Plant I/O Schedules
Flow Charts
Detail Software Listings

Electrical Documentation
Electrical Load & Fault Calculations
Single Line Diagrams
Panel GA / Layout Diagrams – Internal & External
Electrical Schematic & Wiring Diagrams
Cable Schedules
Cable Block/ Interconnection/ Routing Diagrams
Protection settings schedule and curves.
Cable schedule to include – de-rating factor philosophy / calculations, cable lengths, volt drop calculations.
Earthing Single line diagrams.
Electrical equipment data sheets.
Hazardous area equipment certification.
Site and manifold Hazardous area classification drawings.
High Voltage yards structural equipment design and foundation drawings.

Mechanical Documentation
General Arrangement/ 3D CAD views of Piping, Structural Steel & Mechanical.
Layout Drawings/ 3D model Isometric views
Underground Drawings
Piping – Analysis, Calculations, Studies, Reports

Civil/Site Layout & Survey Documentation
Trenching and Services Layout Diagrams
Earthing Reticulation Diagrams
Cable Routing Reticulation Diagrams
Structural Arrangement Drawings
Structural Fire Protection Drawings
Structural Steel Detail Drawings
Foundation Drawings
Pipe/ Ducting Support Drawings
Weight Reports
Structural Analysis Design Reports

5.14.2.2.3. SPECIAL DOCUMENTATION

- Operators Manual/s describing the equipment, system or plant from an operational viewpoint. This shall include any special or supervisory facilities.

- Technical Manual/s which describe the overall configuration of the system, capabilities of the system, how changes are to be made to the configuration of the system and all maintenance and special procedures necessary for Transnet Pipelines to maintain the equipment installed. This manual/s shall encompass both software and hardware requirements and shall be project orientated. Drawings (ie. Wiring diagrams, dimensioned mechanical components/equipment etc.), excluding basic illustrations contained in manuals – Copies of these drawings are to be supplied separately with the "As-built" drawings and registered in the appropriate drawing index.

5.14.2.3. FINAL CONTRACT DOCUMENTATION COPIES. (See also 5.16 for specific requirements for the supply of "As-built" documentation.

Unless stipulated elsewhere in a Contract Document, the Contractor shall provide as a minimum the following number of copies of Final Contract Documentation:

- Master Control Centre – one full set in soft format (CD, DVD, Hard Drive)
- Drawing Office/Library – one MASTER set in soft format (CD, DVD, Hard Drive)
- Workshops – one full set in soft format each (CD, DVD, Hard Drive)
- Depot – one full set in soft format (CD, DVD, Hard Drive)
- Project Manager and those designated - one full set in soft format (CD, DVD, Hard Drive)

5.14.2.4. Before being submitted to Transnet Pipelines, all Final Contract Documentation and in particular AS BUILT Drawings shall be examined for compliance with onsite detail by the Contractor and signed as such.

5.14.2.5. All documentation (inclusive of hard copies and software) shall be supplied with a comprehensive Indexing system, to enable ease of access to drawing files. This index shall include as a minimum, the file names, drawing title, brief description, Contractor's/consultant's name and Drawing number, pipeline name etc. Transnet Pipelines shall provide a Microsoft Excel spreadsheet with the correct headings within the appropriate columns. Where possible, indexes shall be integral to the packages used; where not possible, indexes shall be presented in a Microsoft compatible database format.

5.14.2.6. Final Contract Documentation shall be submitted to the Engineer within eight weeks of the Contract completion date.

5.14.3. SOFTWARE PLATFORMS.

5.14.3.1. The following Software Platforms are used by Transnet Pipelines and are required to be utilised by the Contractor for compilation of all Engineering Documentation as follows:

Word Processing	Microsoft Word for Microsoft Windows XP.
Spreadsheets	Microsoft Excel for Microsoft Windows XP.
Database	Microsoft Access for Microsoft Windows XP.
Draughting	AutoCAD 2016 or Later.
Survey	ESRI ArcGIS.

5.14.3.2. The following Engineering Design Documentation types are currently installed on software platforms as detailed below, within Transnet Pipelines. Contractors will be required to provide the under mentioned documentation on the same software platforms.

Process Drawings	
Piping & Instrumentation Diagrams	AutoCAD
Process Flow Diagrams	AutoCAD
Hazardous Area Classification Diagrams	AutoCAD
Metering & Instrumentation	
Instrument Schedules	MS Excel
Instrument Data Sheets	MS Excel
Instrument Hook-up Diagrams	MS Excel (Embedded AutoCAD)
Instrument Location Diagrams	AutoCAD
Loop Drawings	AutoCAD
Panel GA / Layout Diagrams – Internal & External	AutoCAD
Panel Wiring Diagrams	AutoCAD
Cable Schedules	AutoCAD
Cable Block Diagrams	AutoCAD
Cable Routing Diagrams	AutoCAD
Cable Interface Wiring Diagrams	AutoCAD
Electrical Documentation	
Electrical Load & Fault Calculations	MS Excel
Single Line Diagrams	AutoCAD
Panel GA / Layout Diagrams – Internal & External	AutoCAD
Electrical Schematic & Wiring Diagrams	AutoCAD
Cable Schedules	AutoCAD
Cable Block Diagrams	AutoCAD
Cable Routing Diagrams	AutoCAD
Cable Interface Wiring Diagrams	AutoCAD
Protection settings schedule and curves	MS Excel
Cable schedule to include – de-rating factor philosophy / Calculations, cable lengths, voltdrop calculations	MS Excel
Earthing Single line diagrams	AutoCAD
Electrical equipment data sheets	MS Excel
Hazardous area equipment certification	AutoCAD

Site and manifold Hazardous area classification Drawings	AutoCAD
High Voltage yards structural equipment design and foundation drawings	AutoCAD

Mechanical Documentation

General Arrangement/ 3D CAD views of piping	AutoCAD
Layout Drawings/ 3D model Isometric views	AutoCAD
Underground Drawings	AutoCAD
Piping – Analysis, Calculations, Studies, Reports	As required

Civil/Site Layout Drawings

Trenching and Services Layout Diagrams	AutoCAD
Earthing Reticulation Diagrams	AutoCAD
Cable Routing Reticulation Diagrams	AutoCAD
Structural Arrangement Drawings	AutoCAD
Structural Fire Protection Drawings	AutoCAD
Structural Steel Detail Drawings	AutoCAD
Foundation Drawings	AutoCAD
Pipe/ Ducting Support Drawings	AutoCAD
Weight Reports	As required
Structural Analysis Design Reports	As required

Survey Drawings/Diagrams	ESRI ArcGIS / AutoCAD
Drawing Index	Microsoft Excel

5.14.4. OWNERSHIP AND COPYRIGHT

5.14.4.1. The Contractor shall be required to grant to Transnet Pipelines a non-exclusive copyright, in accordance with the provisions of Section 22 of the Copyright Act 1978:

To copy any plan, diagram, drawing, specification, bill of quantities, design calculation, application software or similar document generated for and on behalf of Transnet Pipelines

- To make free and unrestricted use thereof for its own purposes, modify the same or have it modified by a third party for any reason
- To provide copies thereof to a third party (contractors or consultants) of Transnet Pipelines for the purposes of Tendering or Consultancy
- No separate or extra payment shall be due by Transnet Pipelines in respect of any non-exclusive licence granted in terms of this clause.

5.14.4.2. The Transnet Pipelines emblem included in the title block is subject to copyright law, and therefore, must in no way be altered, distributed, defaced or tampered with, or handled in any way that will be an infringement on the copyright thereof.

5.15. ALIGNMENT SHEETS

5.15.1. TYPE

5.15.1.1. Aerial Photo strip type alignment sheets shall be supplied

5.15.1.2. A minimum of 500 m of photographed area is to be recorded on either side of the pipeline

5.15.2. SCALE

5.15.2.1. Horizontal 1:5000

5.15.2.2. Vertical 1:500 (Profile / long section)

5.15.3. MEDIA

5.15.3.1. Hardcopy: Paper Minimum size A2 – 2 copies.

5.15.3.2. Electronic: 1 copy "PDF" Format
1 Copy in AutoCAD
1 Copy in Native format. (Where applicable)

5.15.3.3. Paper - Bond or similar – Min 80 gsm

5.15.3.4. Max size A0 (841 mm x 1189 mm)

5.15.4. CONTOURS

5.15.4.1. Contours at 2 m intervals are to be marked up on the alignment sheets

5.15.5. L.O. SYSTEM

5.15.5.1. Relevant co ordinate grids must be marked up on all alignment sheets

5.15.5.2. L.O. systems used must correspond with those used on the servitude diagrams produced by the Land Survey Office.

5.15.5.3. L.O. systems used must be noted in the title block or on the grid lines

5.15.5.4. Each alignment sheet shall bear an accurately determined North indicating arrow

5.15.6. PROFILE (LONG SECTION)

5.15.6.1. Each alignment sheet shall have a relevant land and piping profile drawn at the bottom of the sheet.

5.15.7. BOUNDARIES

5.15.7.1. All boundaries are to be recorded on alignment sheets, including, cadastral and municipal boundaries, and property boundaries adjoining the pipe servitude.

5.15.7.2. All farm names and numbers, lots, subs, erfs etc. are to be recorded on alignment sheets

5.15.8. CROSSINGS

5.15.8.1. All crossings of existing services are to be recorded on the alignment sheets, indicating the type of service e.g. road, 22 kV overhead power lines, rivers, etc. (roads must be identified by name and/or number).

5.15.8.2. Existing services crossed, are to be reference coded as ES1, ES2, ES3 etc.

5.15.8.3. Copies of all documentation with regard, to the crossing of existing services, such as, deeds, agreements, and way leaves etc., are to be bound into book form and indexed to correspond with the reference codes on the alignment sheets

5.15.8.4. Lengths and diameters of sleeves or culverts are to be indicated on the alignment sheets.

5.15.8.5. Any crossing reference drawing numbers are to be recorded in the space provided

5.15.9. MARKERS

5.15.9.1. The exact position of all route, distance, offset and street markers are to be recorded on alignment sheets

5.15.9.2. Route markers are to be numbered from the preceding distance marker e.g. between the origin of the pipeline and the first distance marker (km1) the route markers shall be numbered M0/1, M0/2, M0/3 etc. and between distance markers km13 and km14, the route markers shall be numbered M13/1, M13/2 etc.

5.15.9.3. Distance markers are to be placed so as to indicate the actual length of pipe

5.15.9.4. Distance markers are to be numbered sequentially from the origin, with the origin being 0 km

5.15.9.5. Offset markers are to be clearly marked as such, and their actual position, with relation to the centre line of the pipe, indicated.

5.15.10. PIPE PROTECTION

5.15.10.1. All pipe protection measures are to be indicated on the alignment sheets (e.g. wrappings, rock shield etc.), as to the full extent of such pipe protection

5.15.11. WALL THICKNESS

5.15.11.1. The pipe wall thickness is to be marked on each alignment sheet.

5.15.11.2. Changes in pipe wall thickness shall be clearly and accurately marked on the alignment sheets

5.15.12. BLOCK VALVES

5.15.12.1. Block valves will be numbered sequentially starting with BV1.

5.15.13. CATHODIC PROTECTION EQUIPMENT

5.15.13.1. The position of all cathodic protection equipment shall be clearly and accurately recorded on alignment sheets (e.g. rectifiers, test points, cross bonds, cable routes, anode beds etc.)

5.15.13.2. Rectifiers are to be numbered sequentially as, R1, R2, R3 etc., with R1 being the closest rectifier to the origin

5.15.13.3. Test points are to be numbered sequentially from the block valves e.g. the test point at block valve 3 shall be numbered 3/1 and the next test point between block valves 3 and 4 shall be numbered 3/2 etc.

5.15.14. GENERAL

5.15.14.1. Any reference drawings shall be noted in the space allocated on the alignment sheets

5.15.14.2. The type and position of all pipefittings is to be accurately recorded on the alignment sheets e.g. thread o rings, pig signals, stopple fittings etc.

5.15.14.3. Any cable routes (e.g. pig signal cables etc.) are to be accurately recorded on the alignment sheets

5.15.14.4. Each alignment sheet shall have a key to the symbols used on it

5.15.14.5. All road and river names, where affected by the pipeline, are to be recorded on the alignment sheets

5.15.14.6. All alignment sheets shall have "cut lines" at both ends, to enable the matching up of consecutive alignment sheets

5.15.14.7. Key plans of the pipe route shall be supplied on 1:50 000 scale topo cadastral maps. (Transparencies)

5.16. SPECIFIC REQUIREMENTS “AS-BUILT” DOCUMENTATION

5.16.1. SPECIFIC REQUIREMENTS

5.16.2. General: All Manuals (technical, operating etc.), Standards and Specifications:

ELECTRONIC COPY REQUIREMENTS:

One Electronic copy of the “As-built”/ Final in PDF Format (must be able to print copies), plus one Electronic copy in the Native original format (where applicable) in which it was produced. Both copies to be accessible (with the necessary controls) from the Electronic Document Management System provided for the specific project. E.g. SAP, Aconnex etc.

5.16.3. ALL DRAWINGS AND DIAGRAMS:

ELECTRONIC COPY REQUIREMENTS:

One Electronic copy of the “As-built”/Final in PDF Format (must be able to print copies), plus one Electronic copy in “AutoCAD 2016 or later” (where applicable) and one Electronic copy in the Native original format (e.g., MS Office formats, AutoCAD drawings, etc.) in which it was produced. All copies to be accessible (with the necessary controls) from the Electronic Document Management System provided for the specific project. `E.g. SAP, Aconnex etc.

5.16.4. MECHANICAL ENGINEERING DOCUMENTS:

Certificates, tests and data packs

The original signed document of Conformance certificates, Test certificates, Material certificates and Data packs must be supplied together with one scanned copy in PDF format.

Manuals

Any Technical, Operating, Equipment or Maintenance Manuals received from Vendors in original Hardcopy (published, not scanned) format must be supplied in that format (4 originals) together with a scanned copy in PDF Format.

Any Technical, Operating, Equipment or Maintenance Manuals received from Vendors in original electronic format (i.e. published in electronic format) must be supplied as one electronic format copy and one printed copy. (Suitably bound and referenced

5.16.5. ELECTRICAL ENGINEERING DOCUMENTS:

Certificates

The original signed documents of “Certificate of Compliance” and “Hazardous area equipment certification” must be supplied together with one scanned copy in PDF format.

Manuals

Any Technical, Operating, Equipment or Maintenance Manuals received from Vendors in original Hardcopy (published, not scanned) format must be supplied in that format (4 originals) together with a scanned copy in PDF Format.

Any Technical, Operating, Equipment or Maintenance Manuals received from Vendors in original electronic format (i.e. published in electronic format) must be supplied as one electronic format copy and one printed copy. (Suitably bound and referenced).

Drawings and Diagrams

In addition to 5.16.3, the following site / pump station specific documentation must be supplied (2 As-Built Hardcopy Prints).

1. Single Line Diagrams.
2. Panel GA / Layout Diagrams – Internal & External.
3. Electrical Schematic & Wiring Diagrams.
4. Cable Block Diagrams.
5. Cable Routing Diagrams.
6. Earthing Single line diagrams.
7. Site and manifold Hazardous area classification drawings.

5.16.6. Handover of As-Built and Other Documents from Transnet Pipelines Technical Projects to Transnet Pipelines Drawing Office must be as per TPL-TECH-DO-WI-001. (See Appendices C).

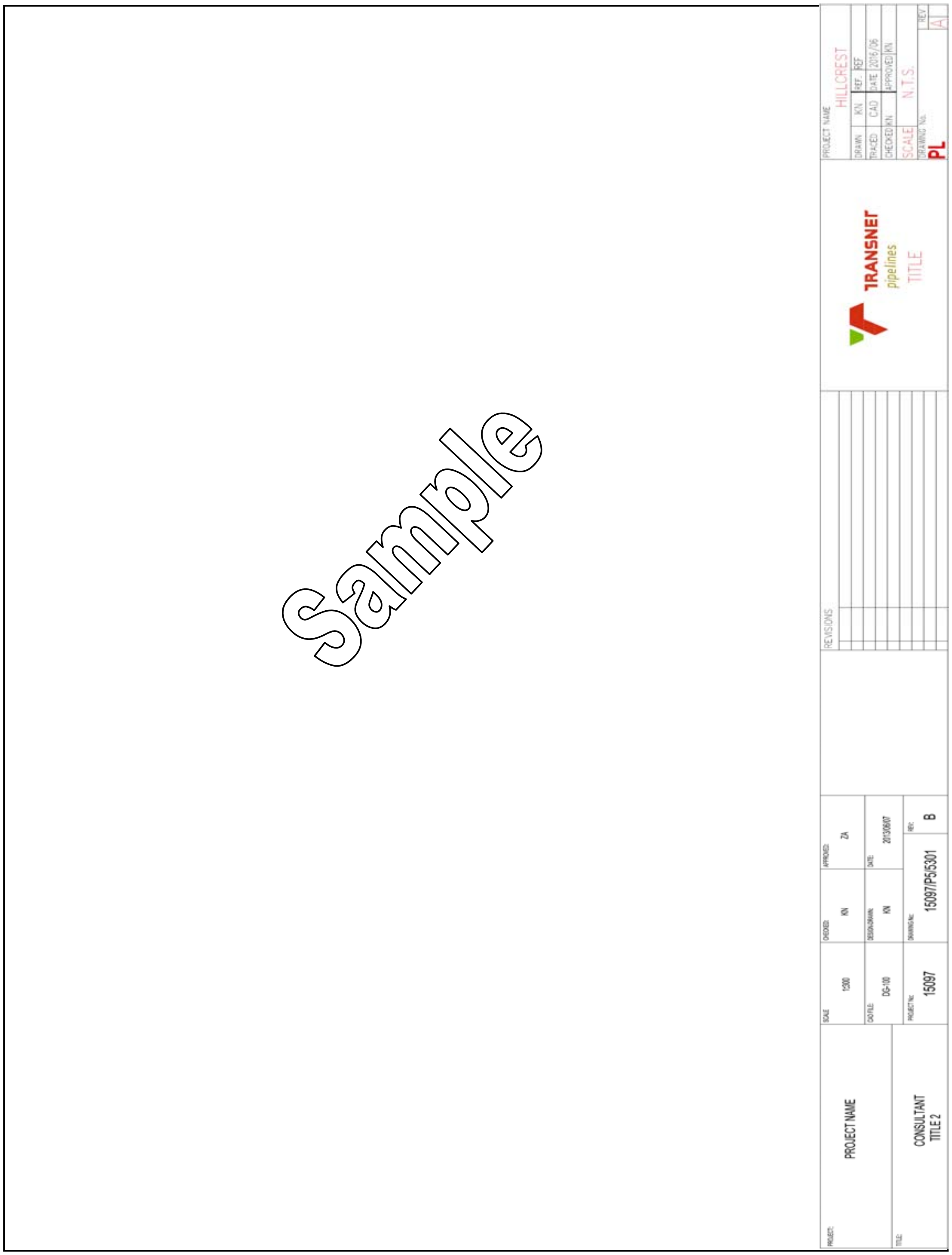
6. DOCUMENT CHANGE HISTORY:

The owner of this document is responsible for the revision and control of the document, including updating of the table below, which contains the history of the document with details of each revision.			
Date	Previous Rev No.	New Rev No.	Details of Revision
15.01.99	00	01	Document approved for distribution.
30.07.99	01	02	Additions made to Scope of Supply.
01.08.07	02	03	Additions made to Scope of Supply & deliverables. Transnet Pipelines logo added.
22.07.10	03	04	Additions made to Scope of Supply & deliverables. Specific requirements added.
12.06.2012	04	05	New Transnet Standard Template Adopted
07.06.2016	05	06	Document review & New Template

This table summarises what has been changed in the document so that it is easy to keep track of the effected changes.

7. APPENDICES

A Sample Title Block



APPENDICES B:
DRAWING OFFICE STANDARD PL100

APPENDICES C:
HANDOVER OF AS-BUILT
AND
OTHER DOCUMENTS FROM
TECHNICAL PROJECTS TO DRAWING OFFICE

Handover of As-Built and Other Documents from Technical Projects to Drawing Office Work Instruction

DOCUMENT APPROVAL PROCESS

NAME		POSITION/MEETING NO.	SIGNATURE	DATE
Originator:	Sheldon Moonusamy	Document Controller		13/06/16
Approver:	Zandile Moloi	Drawing Office Manager		14/06/16
Original date: 13 June 2016				
Effective date: 13 June 2016				

TABLE OF CONTENT

1. PURPOSE:

This standard outlines the documentation requirements that are to be implemented by the project managers for the preparation, submission, receipt, review and collection of Technical and (or) deliverable Documentation and Hand over of Documents to the Drawing Office.

2. SCOPE AND APPLICABILITY:

Handover of As-Built and Other Documents from Technical Projects to Drawing Office.

3. HEALTH AND SAFETY PRECAUTIONS

All Relevant Health and Safety Issues Covered By the Acts and Regulations.

4. ROLES & RESPONSIBILITIES:

- **Technical Project Managers** – Ensure that the contractor certifies that all final documentation in each of the foregoing areas reflects the 'As-built' status of the facility by ensuring all changes.
- **Document Controller** – Receives all information from Technical Project Managers and verifies information with Drawing Office Team.
- **Drawing Office Manager** – Custodian of As-built and Technical Documentation.

5. TERMS AND DEFINITIONS:

None

6. EQUIPMENT/MATERIAL REQUIRED:

None

7. PROCEDURE:

7.1 Documentation Submission

7.1.1 **Document Submission Format** – All Documentation shall be submitted under a cover of a Transmittal Note.

7.1.2 **Electronic Transmission** – All electronic documentation shall be transmitted on DVD/CD ROM unless otherwise agreed. *Please Note: Documentation submitted on DVD/CD ROM must be correctly indexed and submitted with an electronic register (MS Excel).*

7.1.3 **Hard Copy Transmission** – Documentation shall be submitted in printed hard copy format only on request by Project Manager and or by Drawing Office Manager.

7.1.4 **Transmittal Notes** - All documentation shall be submitted under cover of the Transmittal Note indicating all Contract references (i.e., Project No, Contract No, etc.), Project Documentation Number(s), Revision Number, Title and Chronological listing of transmitted documentation. The Transmittal Note shall state the purpose / issue reason for the documentation submission. The Transmittal shall be signed, date stamped and returned to the Project Manager by Document Control. *Please note: Documents must be checked by Project Manager. The Document Controller from the Drawing Office will assist the Project Manager in creating a transmittal note.*

7.1.5 **Formats and Quantities of Technical and Non-Technical Documentation –** The required number of copies and formats of documents / drawings. A typical example of quantities and formats would be as follows: -

- Preliminary / Pre-Construction – Hard copy and PDF
- Construction – Hard copy and PDF
- Red Lined – Hard copies and PDF formats
- Certified As-Built / Final – Hard copies and DVD/CD ROMs containing 'Native' file (Drawing in .DWG) and PDF file formats.

7.2 **Final and As-Built Documentation Hand Over –** Upon completion of a Project. The Project Manager is to collect all final and As-Built Documentation from contractors and hand over documentation and drawing to the TPL Drawing Office. Project Managers as to notify the Document Controller or Drawing Office Manager the status of the documentation received. Once Project Manager is ready to hand over documentation the document submission requirements must be adhere to.

8. QUALITY CONTROL

None

9. RECORDS:

- ISO 9001:2000 – Quality Management Systems Requirements.
- SANS 10111 – Code of Practice for Engineering Drawings.
- SANS 10143 – Building Drawing Practice.
- Drawing Office Standard

10. REFERENCES:

- Document Transmittal Note (Attached)

Document Transmittal Note

TO :	(Company)	DATE :	(Current Date)
LOCATION :	(Address)	FROM :	(Sender)
ATTENTION :	(Name of Reciever)	PROJECT NO.	(Contract/ Project Number)
		PROJECT DESCRIPTION	(Name of Project)
		TRANSMITTAL NO. :	(Next Sequential Number given by Doc Controlle

PURPOSE OF ISSUE *(indicate with an "X" in the appropriate block)*

- [ ] APPROVED FOR CONSTRUCTION
- [ ] APPROVED FOR DESIGN
- [ ] FOR TENDER PURPOSES / ENQUIRY
- [ ] FOR CONTRACT / PURCHASE / SERVICES
- [ ] FOR APPROVAL
- [ ] FOR INFORMATION ONLY
- [ ] FOR REVIEW / COMMENTS
- [ ] RETURN OF DOCUMENTATION
- [ ] AS - BUILT
- [ ] FINAL HANDOVER
- [ ] OTHER

ADDITIONAL REMARKS BY ORIGINATOR *(if applicable)*

- [ ] ALL DOCUMENTS OR DRAWINGS HANDOVER
- [ ] PART OF DOCUMENTS OR DRAWINGS HANDOVER

Status of documentation

DOCUMENT NUMBER	REV.	DESCRIPTION	COPY QTY	FORMAT E or H
			1	H

DISTRIBUTION :

NAME

E = Electronic
H = Hardcopy

Sent by :		Received by :		Date :	/ /
Signature :		Signature :		Time :	

PLEASE CONFIRM RECEIPT BY SIGNING ONE COPY OF THE TRANSMITTAL AND RETURN TO TECHNICAL DOCUMENT CONTROL AS SOON AS POSSIBLE (SHELDON MOONUSAMY)

INTERNAL PURPOSE ONLY (DRAWING OFFICE) *(indicate with an "X" in the appropriate block)*

- [ ] CREATE CHANGE MASTER
- [ ] UPLOADED ONTO SAP

CHANGE MASTER REFERENCE

Name:		Signature :		Date :	/ /
				Time :	

A35:Y68

11. DOCUMENT CHANGE HISTORY:

The owner of this document is responsible for the revision and control of the document, including updating of the table below, which contains the history of the document with details of each revision.			
Date	Previous Rev No.	New Rev No.	Details of Revision
13/06/2016	00	00	New Template

This table summarises what has been changed in the document so that it is easy to keep track of the effected changes.

CABLING, RACKING, TRENCHING & EARTHING INSTALLATION CODES OF PRACTICE

PL 727

REV. 011

APPROVAL

RESPONSIBILITY	DESIGNATION	SIGNATURE	DATE
COMPILED BY	Designation : Name :		
APPROVED BY	Technical Manager		
ACCEPTED BY	Technical Manager – M & I SD Technical Manager – M & I ND Technical Manager – M & I HO		
ACCEPTED BY	Technical Manager – Elec SD Technical Manager – Elec ND Technical Manager – Elec HO		

DISTRIBUTION

COPY	ISSUED TO ORGANISATION / DESIGNATION	INDIVIDUALS NAME
MASTER	Transnet Pipelines Library	
1.	Technical Manager M & I – Head Office	
2.	Technical Manager M & I – Southern Districts	
3.	Technical Manager M & I – Northern Districts	
4.	Technical Manager Electrical – Head Office	
5.	Technical Manager Electrical – Southern Districts	
6.	Technical Manager Electrical – Northern Districts	

AMENDMENT RECORD

REV	REV DATE	CHG REQ NO.	CHANGE SUMMARY	PAGES AFFECTED
003	30/10/95	n/a	Document approved for distribution	All
004	07/05/99	n/a	Document revised to incorporate Project Tele (PYP233) Standards	All
005	06/10/99	n/a	Document revised to incorporate Pipeline Crossing/Instr Install/Cable Strap specs	All
006	21/09/00	n/a	Document revised to incorporate Core Identing and Cable Tagging specs	All
007	12/04/01	n/a	Document revised to incorporate additional Core Identing and Cable Tagging specs	All
008	01/09/02	n/a	Document revised to incorporate additional clarification, Field JB wiring and Plant Earthing specifications	All
009	01/08/07	n/a	Document revised to incorporate various changes. Added Transnet Pipelines logo.	All
010	06/12/09	n/a	Reference documentation updated, Fibre Optic Cable Identification Standards added (NMPP).	All
011	25/01/10	n/a	Rev 10 has been rev'ed up to Rev 11 to resolve NMPP Alliance documentation handling issues.	All

TABLE OF CONTENTS

1. INTRODUCTION

The objective of this Cabling, Racking, Trenching & Earthing Installation Standard is to establish codes of practice that shall be required to be adhered to by both Contractor and Client in the supply and installation of Electrical and Instrument Cabling, Racking, Trenching and Earthing Reticulation on all Transnet Pipelines Sites.

2. SCOPE

2.1 General

This document defines as a minimum, the general responsibilities for the provision of all Electrical and Instrument Cabling, Racking, Trenching and Earthing Reticulation on all Transnet Pipelines sites, whether by the Client or Contractor, for and on behalf of Transnet Pipelines. In this regard, contractors are required to familiarise themselves with all applicable Standards and Codes of Practice listed herein, and to ensure compliance in the execution of any work in terms of this document. Failure to comply may render the contractor liable for corrections at his own cost.

These Standards and Codes of Practice should be read in conjunction with all other Specifications and drawings as issued for a particular contract. Where discrepancies occur, these must be brought to the attention of Transnet Pipelines in writing before commencement of work. In the event of any conflict between the contents of any documents forming part of a contract (as listed in the Schedule of Contract Documents) and this document, the former shall prevail.

2.2 Application to Work Activities

The Standards and Codes of Practice contained herein apply to all installations requiring Electrical and Instrument Cabling, Racking, Trenching and Earthing Reticulation and includes amongst others the following standards:

- Supply of electrical and instrument cable trenches
- Supply, installation of electrical and instrument ladder racking reticulation
- Supply, installation of electrical and instrument dropper reticulation
- Supply, installation and termination of electrical and instrument cabling
- Cable Tagging and Core Identing standards for electrical and instrument cabling
- Supply, installation of instrument and electrical earthing

3. REFERENCE DOCUMENTATION

3.1 The requirements of the materials, design, layout, fabrication, assembly, erection, examination, inspection and testing of equipment and facilities on site shall be in accordance with the relevant sections of codes: -

a) ASME/ANSI.B31.3 - Chemical Plant and Petroleum Refinery Piping

b) ASME/ANSI.B31.4 - Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia and Alcohols

c) SANS 10089-2:2002 - The Petroleum Industry Part II: Electrical Code

d) SANS 10142 - Code of Practice for Wiring of Premises

e) SANS 10198:2004 - The Selection, Handling and Installation of Electric Power Cables of rating not exceeding 33 kV

f) API RP 2003 - Protection against ignitions arising out of static, lightning and stray currents

g) SANS 10313 - The Protection of structures against lightning.

h) SANS 10086 - The Installation and Maintenance of Electrical Equipment used in explosive atmospheres. Refer to Section 2 for hazardous area classifications.

i) SANS 97:2001 - Electric Cables: Impregnated Paper-Insulated Metal Sheathed cables for rated voltage 3.3kV:3.3kV to 19kV/37kV.

j) SANS 1507:2007 - Electrical Cables with extruded solid dielectric insulation for fixed installations (300/500V to 1900/3300V)
Part 1: General
Part 3: PVC Distribution Cables
Part 4: XLPE Distribution Cables

k) SANS 1274 - Coatings applied by the Powder Coating Process

l) DIN 41494 - Specification for Panel Mounting Racks

m) DIN 24185 - Specification for Air Filters used in General Ventilation

n) Government, local authorities or other statutory bodies' regulations, laws, requirements or customs which are more stringent than those specified in this project specification.

3.2 The following standard specifications are to be used for reference purposes and need to be noted by Contractors in order to signify familiarity and compliance with the requirements. It is expected of Contractors that they be familiar with the applicable clauses and that these will be adhered to in the execution of any work in terms of this specification. Contractors will be required to confirm that they are able to meet these requirements.

a) SANS 10108: 2005 The Classification of hazardous locations and the selection of electrical apparatus for use in such locations

b) The Occupational Health & Safety (OHS) Act No. 85 of 1993

c) SANS 60079-1 Flameproof Enclosures for Electrical Apparatus

d) SANS 60079-25 Intrinsically Safe Systems

e) API Manual of Petroleum Measurement Standards Chapters 4 to 12
IP Chapter 10 and Papers 2 and 3

f) SANS 60529 Degrees of protection provided by enclosures (IP Code)

g) Safety Regulations for Contractors

h) Technical Instruction No. 16 - Contractors Work Permit Procedures.

3.3 Where no specific rules, regulations, codes or requirements are contained in this specification nor covered by the above mentioned codes, the contractor shall, in consultation with Transnet Pipelines, adhere to internationally accepted modern design and engineering practices in the Petroleum Industry.

4. SPECIFICATIONS

4.1 The following standard specifications are to be read in conjunction with this document and require separate statements of compliance, which should be included in the tender documents.

Specification for Equipment Cabinets to house Electronic Equipment	PL711
Specification for Low Voltage Switchgear and Distribution Boards	PL631
Specification for Medium Voltage Switchgear	PL632
Safety Regulations for Contractors	

5. ABBREVIATIONS & DEFINITIONS

5.1 For the purpose of understanding these Standards, the following abbreviations apply.

ANSI	American National Standards Institute
C & I	Control and Instrumentation
IEC	International Electrotechnical Commission
ISA	Instrument Society of America
SABS	South African Bureau of Standards

5.2 The following Definitions are consistent with the Transnet E5 Agreement and General Conditions of Contract and apply to this specification in its entirety.

CHIEF EXECUTIVE (Transnet Pipelines) means the officer appointed as Chief Executive (Transnet Pipelines) of Transnet Limited or any person lawfully acting in that capacity.

ENGINEER means any officer in the office of the Chief Executive (Transnet Pipelines) deputed by the Chief Executive (Transnet Pipelines) to supervise and take charge of the contract.

PLANT means any machine, excluding a tool, and any vehicle, excluding a passenger vehicle, used on site for the carrying out of the Works.

EQUIPMENT means any device not forming a permanent part of the Works, used on site for the carrying out of the Works, and also any temporary building which is required for the carrying out of the Works and which is erected on site.

TOOL means any instrument, powered or otherwise, which is accepted as a hand tool by the industry concerned and which is normally used in a manual operation by an individual labourer, artisan or workman.

MATERIAL means any constructional substance or ingredient which shall form part of the permanent Works and the substances in excavations and earthworks.

DRAWINGS means the drawings referred to in any specifications, schedule of quantities and prices and any alterations of such drawings made or approved in writing by the Engineer and such other drawings as may from time to time be furnished or approved in writing by the Engineer.

SITE means the land and any other place on, under, over, in or through which the Works are to be executed or carried out and any other land or place made available by Transnet in connection with the Works.

WORKS means the works to be executed in accordance with the Contract.

6. TRENCHING RETICULATION CODES OF PRACTICE

This specification details standards and codes of practice to be adhered to in the supply of Electrical and Instrument Cable Trenching Reticulation at all Transnet Pipelines Sites.

The requirements of the materials, design, layout, fabrication, assembly and erection shall, where relevant, be in accordance with the following approved Installation Typicals forming part of this Specification: -

Cable Marker Specification	727/001/cblmarker

6.1 General

6.1.1 The Contractor must familiarise himself with the requirements for conducting excavations in hazardous areas.

6.1.2 The Contractor will be required to submit proposed Trench Route Reticulation Diagrams to Transnet Pipelines for approval, prior to commencement of work. In this regard, contractors will be required to have studied all relevant Site Layout drawings and familiarised themselves as to the nature and location of all existing services, both buried and visible. Contractors are to note that approval of trench routing by the client in no way absolves the contractor of his responsibilities regarding damage to and rectification of existing services. **All damages to existing services, inclusive of cabling and piping shall be required to be rectified at the Contractor's cost.**

6.1.3 The Contractor must advise the client of any uncharted services encountered during excavations.

6.1.4 During trenching operations the Contractor must ensure that all precautions are taken to prevent damage to underground services.

6.1.5 The Contractor shall advise the client immediately if any damage is caused to underground services; inclusive of cabling, water mains etc.

6.1.6 Approval must be given by the client for the removal of obstructions.

6.1.7 Excavations across oil pipelines shall not be done without the authorised personnel present on site. The client must be advised 14 days in advance when such excavations will take place.

6.1.8 Cable crossings of oil pipelines shall only be at right angles.

6.1.9 Contractors are to note that where cable sleeves are not installed, all cable trenches are required to remain open until the end of the Commissioning Phase of the project, unless instructed otherwise. Provision for the possible erosion of the backfill / collapsing of trenches shall be made by Tenderer's in their Offers. Contractors are to note that where requested by Transnet Pipelines Operational Staff, platforms/bridges shall be required to be provided by the Contractor for the crossing of open trenches and provision shall be made in the Tenderer's Offer accordingly. Trenches across road, access ways or foot-paths shall not be left open for a period longer than eight hours.

6.1.10 **Power driven mechanical excavators shall not be used for excavations, without prior permission from the client.**

6.1.11 Trenches shall be as straight as possible with the bottom of the trench firm and smooth without sharp dips or rises, which may cause tensile forces in the cable during backfilling.

6.1.12 Trenches shall have no sharp objects, which may cause damage to the cable during laying or backfilling.

6.1.13 The width of the trench at any bend or place where cable slack is required shall be such as to allow the bending radius of the cable not to be less than is specified in SABS 97 and SABS 1339 for that particular cable.

6.1.14 The Contractor shall remove any accumulated water or liquid from the trenches and dispose of it without creating a nuisance or hazard.

6.1.15 The client reserves the right to alter any cable route or portion thereof prior to the laying of cables.

6.1.16 The Contractor shall supply and install cable markers at all locations that mark either a change in direction of a cable trench, the location of a cable joint or the location of a draw box. Cable Markers shall comply fully with all provisions detailed in Drawing 727/001/Cblmrk (latest revision), attached to this Specification.

6.2 Trench Specifications

Separate Trenches shall be supplied to cater for the following cable types:

6.2.1 ELECTRICAL HV/MV TRENCHES

Trench Dimensions	: 1000 mm deep by 500 mm wide (two cables), add 300mm width for additional cables
River Sand Bedding	: PVC Piping – 75 mm above pipe, 50mm under pipe : Direct Burial – 100 mm
Identification	: PVC or Concrete Interlocking Tiles at a depth of 350mm
Cable Markers	: Concrete with engraved anodised aluminium ID plates Cable Marker Colour – Brilliant Green
Cabling	: Medium and High Voltage Power Cabling > 400 VAC
Separation	: 500 mm (LV cabling), 1000mm (Instrument cabling)

6.2.2 ELECTRICAL LV TRENCHES

Trench Dimensions	: 750 mm deep by 300 mm wide
River Sand Bedding	: PVC Piping – 75 mm above pipe, 50mm under pipe : Direct Burial – 100 mm
Identification	: Polythene Marker Tape (150mm wide, yellow and marked with the words "Electric Cable/Elektriese Kabel") at a depth of 350mm
Cable Markers	: Concrete with engraved anodised aluminium ID plates. Cable Marker Colour – Black
Cabling	: Low Voltage Power Cabling 400 VAC/230 VAC (e.g. Actuators, Aux Motors, DB circuits)

	: Control Cabling (e.g. MV Breaker Inter-tripping cables, Actuator control signals, Aux Motor local stop/start panels etc.)
Separation	: 500 mm (HV/MV cabling), 1000mm (Instrument cabling)

6.2.3 INSTRUMENT TRENCHES

Trench Dimensions	: 500 mm deep by 300 mm wide
River Sand Bedding	: PVC Piping – 75 mm above pipe, 50mm under pipe : Direct Burial – 100 mm
Identification	: PVC Tiles / Polythene Marker Tape (150mm wide, yellow and marked with the words “Electric Cable/Elektriese Kabel”) at a depth of 350mm
Cable Markers	: Concrete with engraved anodised aluminium ID plates Cable Marker Colour – Light Blue
Cabling	: Instrument Multi-core & Single Pair Cabling (IS and non IS)
Separation	: 1000mm (HV/MV/LV Electrical cabling)

6.2.4 CABLE SLEEVING

6.2.4.1 Electrical LV and Instrument Cables shall where possible, be run in buried Cable Sleeves on the following routes (to facilitate pulling of new cables in the future):

- From the Switchgear Room to the manifold
- From the Control Room to the manifold
- From the Switchgear Room to the Control Room (where the buildings are located apart from each other)

6.2.4.2 Electrical LV and Instrument Cables may dependant on distances, be direct buried or run in buried Cable Sleeves on the following routes:

- From the Switchgear Room to Station Block Valve Chambers, Guard Huts
- From the Control Room to Station Block Valve Chambers, Guard Huts

6.2.4.3 All areas subject to vehicle traffic, rail crossings and paved areas shall be sleeved.

6.2.4.4 Sleeves shall be designed so as to ensure 25 % spare capacity.

6.2.4.5 Sleeve Specifications

Material	: PVC or PHD Polyethylene
Dimensions	: 100 mm OD min
Standards	: DIN EN50086-2, BS EN50086-2-4:1994

6.2.5 DRAW BOXES

Where cable sleeves are utilised and to facilitate the hauling of cables, brick draw boxes shall be provided at all trench junctions, complete with concrete slab, as detailed below:

Draw Box Dimensions (min)	: Internal 450 mm square, 3 courses of stock brick deep
Base & Top	: Concrete 50mm thick

6.3 Excavation & Backfill Specifications.

6.3.1 Areas subject to Vehicle Traffic utilising sleeved access (PVC piping).

The bottom of the trench shall be levelled, compacted and a 50mm depth of bedding material placed and compacted. The bedding material shall have a PI of less than 8 and a compatibility factor within the range 0 to 0,4. The bedding material shall have a grading as follows;

a) No particles retained on the 19mm sieve.
b) No more than 55 by mass shall be retained on the 13,2mm sieve.
c) More than 40% by mass shall be retained on the 0,6mm sieve.

Following the laying of the pipe a further 75mm of suitable bedding material shall then be placed around and above the pipes and compacted.

Backfilling shall then proceed in layers of not greater than 150mm and compacted to 90% Mod AASHTO density up to a level of finished road surface minus 450mm.

From –450mm to –300mm the backfill shall consist of selected quality material and compacted to 93% Mod AASHTO density.

From –300mm to –150mm the backfill shall consist of a stabilised sub base compacted to 95% Mod AASHTO density, stabilised with 2 pockets of OP cement per m^3.

In the case of concrete surface roads, from –150mm to –75mm, backfill shall consist of crushed stone compacted to 98% Mod AASHTO density. The final 75mm shall consist of in situ concrete of 30 MPa, vibrated and floated at the finished road surface. No vehicle traffic shall be permitted to cross the new concrete for a period of 7 days.

In the case of tarmac surface roads, from –150mm to –55mm, backfill shall consist of crushed stone compacted to 98% Mod AASHTO density. The final 50mm shall consist of TPA medium cold mix tarmac laid on a CAT 60 prime coat.

A DCP test result of not more than 5mm per blow, when averaged out of 150mm will be considered acceptable. This result shall be obtained over the top two layers of 150mm.

A CBR reading of 50 or greater shall be required to be obtained with the above DCP results.

All backfilling shall be completed using a mechanical trench rammer. A water cart shall be available on site to wet the backfill materials. Scales, sieves and DCP equipment shall be made available on site for use by Transnet Pipelines staff in the conducting of any of the above-mentioned tests.

6.3.2 Rail Crossings utilising sleeved access (PVC piping).

The excavation, backfilling and pipe laying across rail tracks shall be in accordance with Transnet specification CSE-516/1 (January 1985).

The bottom of the trench shall be levelled, compacted and a 50mm depth of bedding material placed and compacted. The bedding material will have a PI of less than 8 and a compatibility factor within the range 0 to 0,4. The bedding material shall have a grading as follows;

a) No particles retained on the 19mm sieve.
b) No more than 55 by mass shall be retained on the 13,2mm sieve.
c) More than 40% by mass shall be retained on the 0,6mm sieve.

Following the laying of the pipe a further 75mm of suitable bedding material shall be placed around and above the pipes and compacted.

Backfilling shall then proceed in layers of not greater than 150mm and compacted to 95% Mod AASHTO density up to a level of finished formation level. The backfill shall consist of excavated material mixed with OP cement in the ration of 2 pockets of cement per 1 cubic meter of backfill.

The DCP test result of not more than 5mm per blow, when averaged out of 150mm will be considered to be acceptable. This result shall be obtained over the top two layers of 150mm.

A CBR reading of 50 or greater shall be required to be obtained with the above DCP results.

All backfilling shall be completed using a mechanical trench rammer. A water cart shall be available on site to wet the backfill materials. Scales, sieves and DCP equipment shall be made available on site for use by Transnet Pipelines staff in the conducting of any of the above-mentioned tests.

6.3.3 Paved Areas not subject to Vehicle Traffic utilising sleeved access (PVC piping).

The bottom of the trench shall be levelled, compacted and a 50mm depth of bedding material placed and compacted. The bedding material shall have a PI of less than 8 and a compatibility factor within the range 0 to 0,4. The bedding material shall have a grading as follows;

a) No particles retained on the 19mm sieve.
b) No more than 55 by mass shall be retained on the 13,2mm sieve.
c) More than 40% by mass shall be retained on the 0,6mm sieve.

Following the laying of the pipe a further 75mm of suitable bedding material shall be placed around and above the pipes and compacted.

Backfilling shall then proceed in layers of not greater than 150mm and compacted to 90% Mod AASHTO density up to a level of finished road surface minus 300mm.

From –300mm to –150mm, the backfill shall consist of selected excavated material compacted to 93% Mod AASHTO density while the last 150mm shall be compacted to 95% Mod AASHTO density.

A DCP test shall be required to give an average of not more than 11mm per blow averaged over the last 150mm of backfill, thus approximating a CBR value of over 20, which is considered acceptable for backfilling in trenches subject to pedestrian traffic.

All backfilling shall be completed using a mechanical trench rammer. A water cart shall be available on site to wet the backfill materials. Scales, sieves and DCP equipment shall be made available on site for use by Transnet Pipelines staff in the conducting of any of the above-mentioned tests.

6.3.4 Common Areas not subject to Vehicle Traffic utilising sleeved access (PVC piping).

The bottom of the trench shall be levelled, compacted and a 50mm depth of bedding material placed and compacted. The bedding material would have a PI of less than 8 and a compatibility factor within the range 0 to 0,4. The bedding material shall have a grading as follows;

a) No particles retained on the 19mm sieve.
b) No more than 55 by mass shall be retained on the 13,2mm sieve.
c) More than 40% by mass shall be retained on the 0,6mm sieve.

Following the laying of the pipe a further 75mm of suitable bedding material shall be placed around and above the pipes and compacted.

Backfilling shall then proceed in layers of not greater than 300mm and compacted to 90% Mod AASHTO density up to a level of finished road surface minus 300mm.

From –300mm to finished ground level; backfill shall consist of selected excavated material and compacted to 93% Mod AASHTO density.

A DCP test shall be required to give an average of not more than 15mm per blow averaged over the last 150mm of backfill, thus approximating to a CBR value of over 15 which is considered acceptable for backfilling in trenches subject to pedestrian traffic

All backfilling shall be completed using a mechanical trench rammer. A water cart shall be available on site to wet the backfill materials. Scales, sieves and DCP equipment shall be made available on site for use by Transnet Pipelines staff in the conducting of any of the above-mentioned tests.

6.3.5 Common Areas not subject to Vehicle Traffic utilising direct burial.

The bottom of the trench shall be levelled, compacted and a 50mm depth of bedding material placed and compacted. The bedding material would have a PI of less than 12. The bedding material shall have a grading as follows:

a) No particles retained on the 10mm sieve.

Following the laying of the cable a further 50mm of suitable bedding material shall be placed around and above the cable.

Backfilling shall then proceed in layers of not greater than 300mm and compacted to 90% Mod AASHTO density up to a level of finished road surface minus 300mm.

From –300mm to finished ground level; backfill shall consist of selected excavated material and compacted to 93% Mod AASHTO density.

A DCP test shall be required to give an average of not more than 15mm per blow averaged over the last 150mm of backfill, thus approximating to a CBR value of over 15, which is considered acceptable for backfilling in trenches subject to pedestrian traffic

All backfilling shall be completed using a mechanical trench rammer. A water cart shall be available on site to wet the backfill materials. Scales, sieves and DCP equipment shall be made available on site for use by Transnet Pipelines staff in the conducting of any of the above-mentioned tests.

6.4 Pipeline Crossings.

6.4.1 All work performed outside of Transnet Pipelines Pump Station perimeters and within Transnet Pipelines pipeline servitudes shall conform to all requirements as laid down by the Transnet Pipelines Pipeline Crossings Manual (as amended), inclusive of the following:

6.4.2 Excavations across oil pipelines shall not be done without the authorised Transnet Pipelines personnel present on site. The client must be advised 14 days in advance when such excavations will take place.

6.4.3 All Cable Trenches (inclusive of both Instrument and Electrical Trenches) are to be trenched to a depth of 1.0 metre.

6.4.4 Crossing of pipelines shall be kept to an absolute minimum and shall require prior approval by Transnet Pipelines. Crossings shall be at right angles to the pipeline. All cabling shall be taken underneath the pipeline at a depth of 500 mm below the pipe surface. All damage to existing services, inclusive of piping and wrapping, shall be required to be rectified at the cost of the Contractor.

6.4.5 Power driven mechanical excavators shall not be used for excavations, without prior permission from Transnet Pipelines. Trenching in or near to pipeline servitudes shall be performed by hand, unless prior permission is otherwise granted by Transnet Pipelines.

6.4.6 When trenching in Transnet Pipelines servitudes and prior to commencement of trenching, actual position of the pipeline within the servitude is required to be located and clearly marked. The use of existing pipeline markers will not be considered as sufficient indication of the route of a pipeline.

6.4.7 All pipeline crossings will be performed in accordance with the Transnet Pipelines Pipeline Crossings Policy, Excavations Policy and Crossing Instructions (Instructions 1 through 5).

7. RACKING RETICULATION CODES OF PRACTICE

This specification details standards and codes of practice to be adhered to in the supply of Electrical and Instrument Cable Racking Reticulation at all Transnet Pipelines Sites.

The requirements of the materials, design, layout, fabrication, assembly and erection shall, where relevant, be in accordance with the following approved Installation Typicals forming part of this Specification: -

Typical for Instrument Stands - double	727/002/Instand
Typical for Instrument Stands - single	727/003/Instand
Typical for Angle Iron Droppers	727/007/Rack_Droppers
Typical for Racking Layouts incl. over Bund Walls	727/009/Rack_Typical
Typical for Junction Box stands	727/010/Junction Box Stand

7.1 General

7.1.1 The Contractor shall allow for the supply and installation of all cable racking and droppers where specified, including all supporting steelwork, accessories, clamps, fixing materials, deviations, bends, angles, tees, reducers and all other components required, to make cable racking and droppers complete and ready for the laying of cables.

7.1.2 All racking (inclusive of ladder racks and droppers) will be cut, fabricated, formed and then hot-dip galvanised (mild steel) prior to installation. Material of manufacture shall be mild steel unless specified otherwise in the Scope of Works attached to an Order.

7.1.3 All clamps, fixing materials and accessories, including nuts, bolts, washers etc. shall be manufactured from 316 Stainless Steel or chrome plated, to prevent corrosion. Fixing screws shall comprise of Pan head screws and nuts.

7.1.4 All welding must comply with SABS 044 Code of Practice for Welding and BS 1856 General Requirements for the Welding of mild steel. Tack or point welding of joints/seams is not considered acceptable practise.

7.1.5 In cases where galvanised cable racks or other steelwork are cut or drilled, all such cuts or holes shall be treated with an approved cold galvanising paint within 12 hours after cutting or drilling.

7.1.6 Holes larger than 7mm in diameter shall not be drilled in the structural steelwork without prior consent of the Consulting Engineer.

7.1.7 Separation of a minimum of 1000mm will be maintained between all instrumentation cable racking and parallel running electrical cable racking reticulation. Instrument cable racking having to cross electrical cables will do so at 90 degrees to minimise noise and interference.

7.1.8 All cable racking will be installed in a neat and straight manner and will be adequately supported with brackets attached to joists, walls or floors by the Installation Contractor following agreement with the Engineer. Horizontal racking runs will be level, vertical racking runs will be upright (90 deg), and shall be determined by use of spirit level. All ends will be free of jagged edges and will be neatly rounded.

7.1.9 All cable racking reticulation shall be **continuous and mounted in the vertical plane** and shall be positioned so as to avoid obstruction to walkways and access routes. All cable racking shall be installed in such a way so as to provide no obstruction to mechanical fitting or maintenance procedures (associated with vessels, flanges, valves, actuators etc). Where access to walkways and equipment has been obstructed, it shall be the Contractor's responsibility to provide the necessary access via catwalks or stairs. Pricing for the aforesaid shall be deemed to have been included in the Tenderer's Offer.

7.1.10 Bonding straps, comprising of 10mm insulated (green/yellow) cable and lugged at both ends, shall be installed across all fish plates joining ladder racks together, in compliance with SABS 0142. All cable racks and supports (including angle iron where used in place of cable racks) shall be earthed to the station earth at two designated earth test points within the manifold. Note that angle iron droppers may be excluded from this provision.

7.2 Supports

7.2.1 Adequately sized Concrete Plinths shall be required to be provided by the contractor and incorporated into Tenderer's Offers under the following circumstances:

- All Cable Racking and Droppers supported at any height off of floor level, outside of concreted bund areas.
- All Cable Racking and Droppers supported at a height of greater than 1 000 mm off of floor level, within concreted bund areas.
- All Field Junction Box supports, whether within or outside of concreted bund areas.
- All Instrument Stands, installed outside of concreted bund areas

Plinths shall be sized and racking supports provided to ensure no lateral movement ie. no noticeable deflection of the rack/dropper between support points when fully loaded. Allowance shall be made for additional loading where cable racks are not fully occupied. The Contractor will be required to submit proposed Plinth and Support Bracket Diagrams to Transnet Pipelines for approval, prior to commencement of work. Provision for the supply and installation of concrete plinths and adequate supports shall be included in all Tenderer's Offers. The use of gussets of height less than 300mm shall be permitted to provide lateral support for Racking stands. Note however that the use of stays to provide support shall not be permitted. Racking stands shall be mounted vertically and grouting used to level with the bund floor, where required. **All support brackets shall be fastened to the concrete plinths by means of chemical anchors.**

7.2.2 Cable Racking and Droppers supported at a height of less than 1 000 mm off of floor level within concreted bund areas, and Instrument support brackets installed within concreted bund areas shall be fastened to the bund floor via means of adequately sized support brackets to ensure no lateral movement ie. no noticeable deflection of the rack/dropper between support points when fully loaded. Allowance shall be made for additional loading where cable racks are not fully occupied. The Contractor will be required to submit proposed Racking Support Diagrams to Transnet Pipelines for approval, prior to commencement of work. Provision for the supply and installation of adequate supports shall be included in all Tenderer's Offers. The use of gussets of height less than 300mm shall be permitted to provide lateral support for Racking stands. Note however that the use of stays to provide support shall not be permitted. Racking stands shall be mounted vertically and grouting used to level with the bund floor, where required. **Support brackets shall be fastened to the bund floor by means of chemical anchors.**

7.2.3 All supports, inclusive of racking reticulation and field junction box supports shall be installed in such a way so as to be both easily accessible and yet unobtrusive.

7.3 Dropper Reticulation (Electrical & Instrument)

7.3.1 Angle Iron Droppers shall be supplied and installed as cable supports to all instrumentation and valves, for all unsupported cable runs exceeding 1 000 mm in length.

7.3.2 Fabricated angle iron runs, with associated brackets and supports, will be supplied and installed for all individual instruments/electrical equipment, by the Installation Contractor, as required.

7.3.3 All bends and tees will be formed with a minimum inner radius capable of accommodating the minimum bend radius of the associated cable specifications. All bends shall be formed/swept – angled bends are not permissible.

7.3.4 All individual Instrument/Electrical Cable Droppers will be manufactured from angle iron with the following dimensions:

25x25x3mm or 40x40x5mm as required.

7.3.5 Angle Iron Droppers shall be sized to support an appropriate number of cables. In this regard, no more than three cables shall be supported on any one dropper.

7.4 Ladder Racking Reticulation (Electrical & Instrument)

7.4.1 **Pre-fabricated, heavy duty, hot dip galvanised ladder** racking reticulation, equivalent to the "O Line" support system, with all associated brackets and supports, will be supplied and installed for all instrument/electrical cabling requirements, by the Installation Contractor, as required.

7.4.2 In this regard O Line OL76 Type (Medium Duty) or equivalent racking may be utilized under the following circumstances:

- Racking to be installed at a height of less than 1 m from bund floor level
- Racking supports be spaced at a maximum width of 1.5 m apart, to lend additional support.

All racking installed at heights of greater than 1m from bund floor level must comply with O Line PS75 Power Span (or similar). The above concession in no way alleviates the Contractor of the responsibility to ensure that racking installed is not subject to lateral movement or sagging when fully loaded. In such cases, the Contractor will be required to rectify the fault at no additional cost to Transnet Pipelines.

7.4.3 All ladder racking shall be supported by adequate brackets and supports, a maximum width of 3m apart. In addition, all racks shall be supported at every change of direction of cable rack route. The cross stays of the ladder racking shall be installed with a maximum width of 500mm apart. All bends and tees will be formed with a minimum inner radius capable of accommodating the minimum bend radius of the associated cable specifications.

7.4.4 All bends and tees shall be formed/swept, with a minimum inner radius capable of accommodating the minimum bend radius of the associated cable specifications. Reducers shall be used when converting from one racking size to another, including right angle joints.

8. CABLING RETICULATION CODES OF PRACTICE

This specification details standards and codes of practice to be adhered to in the supply, installation, termination, cable tagging and core identing of Electrical and Instrument Cable and Wiring Reticulation at all Transnet Pipelines Sites. The Installation Contractor will supply, install and terminate all instrumentation and electrical cabling to be run from the central Control System, via field marshalling cabinets up to and including connection to field instrumentation as well as from the Switchgear/PLC Room up to including electrical equipment, as specified in the Scope of Works attached to an Order.

The requirements of the materials, design, layout, fabrication, assembly and erection shall, where relevant, be in accordance with the following approved Installation Typicals forming part of this Specification: -

Typical Instrument Loop Drawing	727/005/InstrLoop
Typical Valve Loop Drawing	727/006/VlvLoop

8.1 General

8.1.1 Cable Supply

8.1.1.1 All Electrical and Instrument cabling shall be in compliance with the specifications as stated in the Scope of Work attached to an Order. Contractors are to note that the provisions of SANS 10198 ("The Selection, Handling and Installation of Electric Power Cables of rating not exceeding 33 kV") must be strictly adhered to in regard to the supply, installation and termination of all electrical and instrument cabling.

8.1.1.2 Sizing of multiple twisted pair cabling will accommodate the grouping of instrumentation terminations in each individual marshalling cabinet.

8.1.1.3 All Control and Instrument multi-core cables will include 25% spare capacity, unless otherwise specified in the Scope of Work attached to an Order.

8.1.1.4 The Installation Contractor shall be responsible for undertaking whatever preliminary engineering is required to verify cable core and quantity requirements. Contractors are to note that Transnet Pipelines will accept no liability for the accuracy of quantities specified in Contract Bills of Quantity. All excess material and off cuts not installed shall remain the property of the Contractor on completion of the contract i.e. payment shall be based on the quantity of material installed.

8.1.2 Cable Installation

8.1.2.1 Strapping

All instrument and electrical cables shall be installed on cable racking (whether in the vertical or horizontal orientation) and held to the racking at maximum intervals of 2 metres using approved cable ties/straps. Strapping intervals shall be determined by taking into account the mass of the cabling, length of the run and number of cables to be strapped together. Note that the maximum interval permitted between strapping is 2 metres. No more than 3 cables will be permitted per individual Cable Tie/Strap. All cable ties/straps shall comply with the following specification, unless otherwise specified in the Scope of Work attached to an Order:

- 316 Stainless Steel Bandit or Runlock (4 mm, 6 mm, 8mm width)

All Cabling shall be fastened securely and tightly to the Cable Racking Reticulation using the specified Cable Ties/Straps, in order to prevent cable sagging from occurring. In this regard and where necessary, Cable Droppers shall be drilled or slotted in order to ensure secure contact between Cable Tie and Cables installed. **No packing shall be allowed.**

8.1.2.2 Joints

No cable joints shall be permitted without the prior permission of Transnet Pipelines.

8.1.2.3 Cable Laying

Cable drums shall be supported on jacks and shall be rolled in the indicated direction to prevent twisting, tension or mechanical damage to the cable. Cable shall be drawn into position using sufficient rollers and labour to avoid damage by excessive bending and dragging. Particular care must be exercised when drawing cables through pipes and ducts to avoid abrasion, elongation and distortion of any kind.

Where cables come out of a trench or pass through a floor, they shall be protected by suitable mechanical protection, extending from 50mm to 1000mm above ground/floor level.

Where cables are cut and not immediately made off, the ends are to adequately sealed to the satisfaction of the Engineer and without delay, to prevent the ingress of moisture.

8.1.2.4 Cable Duct Preparation

All cable ducts, including those entering bundwall areas, buildings and panels shall be sealed against the ingress of water, fire and vermin (rodents). The use of Intumastic Sealant (or similar) is recommended for fire proofing of all cable duct entries.

8.1.3 Cable Termination

8.1.3.1 Glanding

All instrument and electrical cables will be glanded at both ends using the appropriate sized gland and will include associated adaptors, washers, ferrules, bands, etc. Provision for all glands, adaptors, washers, ferrules, bands etc. shall be included in the Tenderer's offers. All cable glands shall comply with the following specification, unless otherwise specified in the Scope of Work attached to an Order:

Dekabon Armoured and unarmoured Cabling (Instrumentation)
Increased Safety Ex"e" rated compression gland (CCG Posi Grip EExe or similar), IP68 rated, in accordance with SABS 1031. All adaptor/reducers and blanking plugs are to be FLP.

PVC SWA Cabling (Instrument Multicore, Ex"e" rated motors)
Increased Safety Ex"e" rated non-compression gland, IP68 rated, complete with SWA protection (CCG Ex Armortex EExde IIC or similar), in accordance with SABS 1031. All adaptor/reducers and blanking plugs are to be FLP.

PVC SWA Cabling (Ex"d" rated motors, actuators)
Flameproof Ex"d" rated non-compression gland, IP68 rated, complete with SWA protection (CCG Armortex Exde I/IIC or similar), in accordance with SABS 808. All adaptor/reducers and blanking plugs are to be FLP.

PVC SWA Cabling (Electrical and PLC Panels located within buildings rated as Safe Areas in terms of Hazardous Area Classifications SANS 10108)
Non-Flameproof rated, non-compression gland, IP68 rated, complete with UV resistant (black) shroud where required (CCG BW with shroud for SWA cables, CCG A2 Compression with shroud for non-SWA cables, or similar).

All glands will be waterproof and in the case of Hazardous Areas, correctly rated in terms of the Explosion Proof Classification of the equipment housings to which they are installed.

It shall be the responsibility of the Installation Contractor to ensure that all excess gland entries into both panels and equipment (e.g. valve actuators, instruments) are plugged by means of suitably rated gland plugs. In hazardous areas, this will require the use of EEx d/e rated plugs. The use of "push-out" blanking inserts to plug cable entries shall not be permitted.

8.1.3.2 Termination

All cables will be terminated at field instrumentation, electrical equipment, field junction boxes, switchgear panels and control room marshalling cabinets according to manufacturers specifications, instrument hook-up diagrams and control system specifications as provided/approved by Transnet Pipelines.

Instrument Dekabon Cabling

- Outer Dekabon armouring shall be stripped back to the entry point into the associated termination/junction box. Protrusion of cable sheath/armouring into the termination/junction box (through the compression gland) shall be a minimum of 15mm and a maximum of 50mm.

- Cable pair inner aluminium foil shall be stripped back to the point at which the individual cores leave the PVC Trunking to be terminated onto the respective terminal rails. Ends of the inner foil shall be neatly taped/heat shrunk so as to prevent unravelling.

- Individual cable ends shall be sealed with the use of heat shrink tubing applied over the cable sheath/armouring at the point of entry into the termination/junction box/panel, in order to protect the cable and prevent the ingress of moisture.

- Both cable overall (drain wire) and individual screens shall be insulated with the use of appropriately sized green coloured sleeving, to prevent inadvertent contact with metallic surfaces.

- All individual cable cores (including spares) will be left long enough to accommodate 200mm slack, i.e. taking into account the routing via the trunking.

- Excess lengths of individual cable cores will be neatly folded and tied within the trunking provided. All spare cores shall be terminated into terminals so provided.

- Termination of individual cable cores in the termination strips will be such that all Control System related cabling will be terminated to one side of termination strips, whilst all field instrumentation/equipment cabling will be connected to the other side of termination strips.

In the case of Field Junction Boxes with dual terminal strips, multi-core cabling will be glanded in the centre of the gland plate and terminated into terminal rails provided, running from the centre PVC Trunking outwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the outermost PVC Trunking inwards. In the case of dual terminal rails, discrete signals will be terminated on the LHS terminal rail, and analogue signals on the RHS terminal rail. Where PLC and Metering signals are terminated into the same Field Junction Box, PLC signals will be terminated on the LHS terminal rail, and Metering signals on the RHS terminal rail.

In the case of Field Junction Boxes with single terminal strips, multi-core cabling will be glanded on the right side of the gland plate and terminated into terminal rails provided, running from the right hand side of the panel inwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the left hand side of the panel inwards.

- All cables connected to individual instruments/equipment will be provided with a single loop of minimum diameter of 150mm. All loops will be neatly strapped.

- All cores (including spares) will be terminated into allocated termination strips/rails in the respective Instrumentation, Termination and Field Junction Boxes

Instrument PVC SWA Multi-core Cabling

- Cable SWA armouring shall be stripped back to the entry point into the associated marshalling cabinet/junction box and shall be glanded in such a manner so as to ensure electrical continuity with the gland. When terminated in hazardous areas, cable armouring shall be bonded to the panel equi-potential bonding system via means of earthing rings provided as an integral part of the gland. Contact between the gland and the gland plate shall not be considered as sufficient for bonding purposes.

- Protrusion of cable inner PVC sheaths into the marshalling cabinet will be a minimum of 25mm and a maximum of 50mm.

- Cable inner aluminium foil shall be stripped back to the point at which the individual cores leave the PVC Trunking to be terminated onto the respective terminal rails. Ends of the inner foil shall be neatly taped/heat shrunk so as to prevent unravelling.

- Cable ends shall be sealed with the use of heat shrink tubing applied over the cable inner sheath at the point of entry into the termination/junction box/panel, in order to protect the cable and prevent the ingress of moisture.

- Both cable overall and individual screens shall be insulated with the use of appropriately sized green coloured sleeving, to prevent inadvertent contact.

- All individual cable cores (including spares) will be left long enough to accommodate 200mm slack, i.e. taking into account the routing via the trunking.

- Excess lengths of individual cable cores will be neatly folded and tied within the trunking provided. All spare cores shall be terminated into terminals so provided.

- Termination of individual cable cores in the termination strips will be such that all Control System related cabling will be terminated to one side of termination strips, whilst all field instrumentation/equipment cabling will be connected to the other side of termination strips.

  In the case of Field Junction Boxes with dual terminal strips, multi-core cabling will be glanded in the centre of the gland plate and terminated into terminal rails provided, running from the centre PVC Trunking outwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the outermost PVC Trunking inwards. In the case of dual terminal rails, discrete signals will be terminated on the LHS terminal rail, and analogue signals on the RHS terminal rail. Where PLC and Metering signals are terminated into the same Field Junction Box, PLC signals will be terminated on the LHS terminal rail, and Metering signals on the RHS terminal rail.

  In the case of Field Junction Boxes with single terminal strips, multi-core cabling will be glanded on the right side of the gland plate and terminated into terminal rails provided, running from the right hand side of the panel inwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the left hand side of the panel inwards.

- All cores (including spares) will be terminated into allocated termination strips/rails in the respective Instrumentation, Termination and Field Junction Boxes

Electrical Power and Control Cabling (Low Voltage)

- Cable SWA armouring shall be stripped back to the entry point into the associated equipment housing/termination box/panel and shall be glanded in such a manner so as to ensure electrical continuity with the gland. When terminated in hazardous areas, cable armouring shall be bonded to the panel equi-potential bonding system via means of earthing rings provided as an integral part of the gland. Contact between the gland and the gland plate shall not be considered as sufficient for bonding purposes.

- (Option 1) Cable inner PVC sheath shall be cut back at the point of entry into the equipment housing/termination box/panel, protrusion of the inner sheath into the associated switchgear cabinet/equipment housings shall be a minimum of 25mm and a maximum of 50mm. Heat shrink tubing shall be applied at the point of entry into the equipment housing/termination box/panel, in order to protect the cable and prevent the ingress of moisture.

  (Option 2) Where cables are glanded into panels, cable inner PVC sheaths may be taken directly into trunking/marshalling arrangements, with the inner PVC sheaths cut back at point of termination. Note that in this instance, heat shrink need not be applied at the point of entry into the cabinet.

- All individual cable cores (including spares) will be left long enough to accommodate 200mm slack, i.e. taking into account the routing via the trunking.

- Excess lengths of individual cable cores will be neatly folded and tied within the trunking provided.

- Termination of individual cable cores in the termination strips will be such that all Starter related cabling will be terminated to one side of termination strips, whilst all field cabling will be connected to the other side of termination strips.

- All cables connected to individual instruments/equipment will be provided with a single loop of minimum diameter of 150mm. All loops will be neatly strapped.

8.1.3.3 Cable Identification

All instrument and electrical cables will be marked with an identification number /cable tag at both ends. Identification numbers will be approximately 10 characters and will comprise of the following specification:

All Field Cabling:
Grafoplast Targa Metal TGT System (Carrier Rail length: 58mm for 7 characters, 82mm for 11 characters, 106mm for 15 characters) 316 Stainless Steel Markers, with punched text 6 mm height minimum, fastened onto the cable at both ends via means of Stainless Steel cable ties or
Laser engraved 316 Stainless Steel Markers, of length 90mm, height 10mm and text height 6mm. Note that the marker should have slots cut at the ends for attaching cable ties. Tags shall be fastened onto the cable at both ends via means of Stainless Steel cable ties.

Note that selection as to which cable-tagging system to use shall be made on a site basis i.e. a mix of both systems on one site will not be accepted.

Cable Tags associated with instrument and electrical cabling entering or leaving termination/junction boxes in the field will be attached to the cable outside of the marshalling cabinet i.e. below the gland plate and within 150mm of the entry point to the cabinet.

Cabling installed within buildings:

1. Where Cable Tags are fixed to the cable within Electrical / PLC Panels:

Grafoplast Trasp Series 130 Gull-wing transparent PVC sleeves (30mm in length), with printed text black on white background, fastened onto the cable via means of Stainless Steel cable ties. Text height to be 3mm minimum.

2. Where Cable Tags are fixed to the cable outside of Electrical / PLC Panels:

Grafoplast Targa Metal TGT System (Carrier Rail length: 58mm for 7 characters, 82mm for 11 characters, 106mm for 15 characters) 316 Stainless Steel Markers, with punched text 6 mm height minimum, fastened onto the cable via means of Stainless Steel cable ties or

Laser engraved 316 Stainless Steel Markers, of length 90mm, height 10mm and text height 6mm. Note that the marker should have slots cut at the ends for attaching cable ties. Tags shall be fastened onto the cable at both ends via means of Stainless Steel cable ties.

Note that selection as to which cable-tagging system to use shall be made on a site basis i.e. a mix of both systems on one site will not be accepted.

For details on Cable Identification Standards, refer to Section 8.5 of this Specification.

8.1.3.4 Cable Core Identification

All individual instrument and control cable cores (including spares) will be marked with an identification number at both ends. Identification numbers will be approximately 10 characters in length and will comprise of the following specification:

- Instrumentation - Grafoplast Printed (Black lettering on white background)
- Electrical - Power - Crutchley
- Electrical - Control - Crutchley

Identification characters will be sized to correspond to the overall diameter of the individual cores, i.e. ID tag sheaths will be sized and provided with a good fit (not loose) over the core ends.

Identification tags will be so located as to leave cable core/pair lettering/numbering visible. Individual core labelling will, in this respect, be approximately 11 characters per label. Text on core idents shall be black on white or yellow background, except for Trip “T” idents which shall be black on red background.

For details on Cable Core Identification Standards, refer to Section 8.6 of this Specification.

8.1.3.5 Cable Core Lugging

All individual cable cores will be neatly terminated. Appropriately sized lugs will be attached to all core ends, using the appropriate crimping tool (not side cutters or ordinary pliers). The colouring of crimps will match the size of the associated cable core. All cable lugs utilised shall comply with the following specification, unless otherwise specified in the Scope of Work attached to an Order:

- Instrument Cables - bootlace ferrules
- Electrical Power Cables - spade lugs for compression terminals, ring lugs for screw terminals (pin lugs are not acceptable)
- Electrical Control Cables - spade lugs for compression terminals, ring lugs for screw terminals (pin lugs are not acceptable)

8.1.3.6 Cable Screening – Instrument Cabling

Individual Screens

All Individual Instrument Cable Pair Screens shall be terminated into terminals provided within the Instrument Termination Boxes as well as the Field Junction Boxes, and shall be grounded to a common insulated earth rail to be provided in each of the Control System Marshalling Cabinets, alongside the Termination Rails provided. Individual Screens shall be terminated in such a manner so as to be continuous from the Instrument/Instrument Termination Box to the Control System Marshalling Cabinets i.e. individual instrument cables as well as multi-pair cables.

Individual screen terminals shall be insulated in the Termination Boxes and Field Junction Boxes provided, thus ensuring that the individual cable pair screens are not grounded at instrument/equipment ends, i.e. to prevent common mode noise. Where Instrument Cables terminate directly into Instrument housings, individual screens shall be cut back and insulated within the Instrument housing using heat shrink sleeving, to prevent inadvertent contact with any conducting surfaces.

All individual screen earth rails in the Control System Marshalling Cabinets will be connected to the existing panel Instrument Earth bar via means of a 25mm insulated earth cable, which shall in turn be connected at two points via means of PVC Cu 70mm2 insulated earth cables (Yellow/Green in colour), to the Instrument Earth bar located within the control room.

Overall Screens

All Instrument Cable Overall Screens/Drain wires shall be terminated to insulated earth bars provided within the Field Junction Boxes, and shall be earthed to a common electrical earth bar to be provided in each of the Control System Marshalling Cabinets. Overall Screens /Drain Wires shall be cut back and insulated within the Instrument Termination Boxes and Instrument housings (where applicable) to prevent inadvertent contact with the Termination Box housing, utilising heat shrink sleeving. Overall Screens shall be terminated in such a manner so as to be continuous from the Instrument Junction Box to the Control System Marshalling Cabinets.

The electrical earth bar shall be earthed to the Cabinet Frame, and connected at two points via means of PVC Cu 70mm2 insulated earth cables (Yellow/Green in colour), to the Electrical Earth bar located within the control room.

8.1.3.7 Cable Screening – Electrical Cabling (Power & Control)

All electrical cable screens/drain wires (where applicable) will be grounded to a common electrical earth bar to be provided in each of the Control System Marshalling Cabinets/Switchgear Cubicles. The electrical earth bar shall be earthed to the Cabinet Frame, and connected at two points via means of PVC Cu 70mm2 insulated earth cables (Yellow/Green in colour), to the Electrical Earth bar located within the control and switchgear rooms.

8.1.3.8 Cable Testing – Low Voltage Cables (< 1 kV)

Each individual core of all cables (including spares) will be checked for continuity and insulation breakdown, in accordance with SANS 1507:2007 (PVC):

- Insulation Resistance shall be measured with a 1000V Megger and the readings tabulated and certified.
- Similarly, earth continuity resistance shall be measured and recorded.
- All cables will be checked for correct termination.

8.1.3.9 Cable Testing – Medium Voltage Cables (< 22 kV)

Each section of laid and jointed cable shall be tested, in accordance with SANS 97:2001 (PILC/SWA):

- Insulation Resistance shall be measured with a 1000V Megger, followed by the relevant pressure test. Readings shall be tabulated and certified.

- AC test voltage must be applied to each phase in turn for one minute, or alternatively the DC test voltage for fifteen minutes. Leakage current shall be measured and recorded for each test.
- All cables will be checked for correct termination.

8.2 Instrumentation Cabling

Instrument Cabling as defined within this and other Transnet Pipelines Specifications includes the following types of cabling:

1. PVC SWA Multicore instrument cables running between Instrument Junction Boxes in the field and PLC Cabinets (IS and non-IS rated)
2. PVC SWA Multicore instrument cables running between instruments in the field and PLC Cabinets (IS and non-IS rated)
3. Dekabon armoured instrument cables running between Junction Boxes in the field and the instruments themselves (IS and non-IS rated)

8.2.1 All Instrumentation Cabling will comply in all respects to the specifications as contained in the Scope of Work attached to an Order. In the absence of cable specifications being detailed in the Scope of Work attached to an Order, the following cable specifications will apply.

8.2.2 Instrument cabling will be marshalled on Instrument racking and trenching as defined elsewhere within this specification.

8.2.3 Instrument multi-core cabling running between the Field Junction Boxes and the Control System Marshalling Cabinets will comprise of steel wire armoured, PVC Insulated, individual and overall screened multi-core cable. Note that Transnet Pipelines has standardised on 1 pair, 2 pair, 8 pair and 16 pair cable – prior approval from Transnet Pipelines will be required to deviate from these specifications.

Conductors:

Core Size : 1.0 mm2
Stranded untinned copper, 7 strands minimum
PVC Insulated, Insulation Breakdown Voltage between conductor-earth, conductor-screen and screen-earth to withstand 500V 50Hz RMS for a 1 min
Insulation Colours : Black and White
Multipair cores to be numbered (numeric on both conductors of the pairs)
Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Shield/Screen

Individual & overall screened – plasticised aluminium foil (100%) coverage
Stranded tinned copper drain wire 0.5 mm2

Inner Jacket

Extruded fire retardant black PVC with rip cord for jacket removal.
Minimum thickness 1.2mm up to 8 pair, 1.5 mm for 16 to 36 pair

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – UV resistant (Carbon Black added)

Jacket thickness 1.5mm up to 8 pair, 2.0 mm for 16 to 36 pair.
Jacket to be totally bonded to a steel wire armoured sleeve.

IS Circuits: Jacket color light blue   Non IS Circuits: Jacket color black.

8.2.4 Individual Instrument cabling running between the Field Junction Boxes and the individual field mounted Instruments will comprise of Dekabon armoured, PVC Insulated, individual and overall screened multi-core cable. Note that Transnet Pipelines has standardised on 1, 2, 4 and Triad cable – prior approval from Transnet Pipelines will be required to deviate from these specifications.
(Note that this specification only applies to cabling running on racks above the ground, all Instrument cables running in trenches will need to comply with the Instrument Multi-core Cable Specifications detailed above).

Conductors.

Core Size : 1.5 mm2
Stranded untinned copper, 7 strands minimum
PVC Insulated, Insulation Breakdown Voltage between conductor-earth, conductor-screen and screen-earth to withstand 500V 50Hz RMS for a 1 min
Insulation Colours : Black and White
Multipair cores to be numbered (alphanumeric on both conductors of the pairs)
Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Shield/Screen

Individual & overall screened – plasticised aluminium foil (100%) coverage
Stranded tinned copper drain wire 0.5 mm2

Inner Jacket

Extruded fire retardant black PVC with ripcord for jacket removal.
Minimum thickness 1.2mm

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – UV resistant (Carbon Black added)
Jacket thickness 1.5mm.
Jacket to be totally bonded to an inner waterproof aluminium sleeve.

IS Circuits: Jacket color light blue   Non IS Circuits: Jacket color black.

8.3 Electrical Cabling

Electrical Cabling as defined within this and other Transnet Pipelines Specifications includes the following types of cabling:

1. HV Power Cabling (88 kV to 11 kV) running between points of supply, MV Substations and associated transformers.
2. MV Power Cabling (6.6 kV to 3.3 kV) running between points of supply, MV Substations and associated transformers.
3. LV Power cabling (230/400 VAC) running between electrical equipment in the field and LV Panels, Valve Panels and Distribution Boards

4. LV Control Cabling running between field equipment, and between field equipment and LV Panels, Valve Panels and Distribution Boards. This will include valve actuator control signals, motor start/stop panels, supply breaker inter-tripping signals etc.

8.3.1 All HV & MV Power cabling shall be in compliance with the specifications as stated in the Scope of Work attached to an Order.

8.3.2 Unless otherwise specified, MV Power Cabling (6.6/3.3 kV) shall conform to the following specifications:

- PVC Insulated, PVC Bedded, SWA PVC Sheathed, 6.6/3.3 kV, 3 core cable manufactured to SANS 1507:2007. Fire retardant, UV resistant, low-toxic fume emitting plastics to be used for outer jacket.

8.3.3 All LV Power & Control cabling will be marshalled on LV Electrical racking and trenching as defined elsewhere within this specification.

8.3.4 All LV Power Cabling (230/400 VAC) will comply in all respects to the specifications as contained in the Scope of Work attached to an Order. In this regard, Contractors are to note that the responsibility for correct cable core sizing shall remain at all times with the contractor.

In the absence of cable specifications being detailed in the Scope of Work attached to an Order, the following cable specifications will apply to all cabling of voltage 600 V/1000 V or less: (In full compliance with SABS 1507).

8.3.4.1 Electrical LV Power cabling running between Equipment located in the field, LV Panels or Motor Control Centre Panels, Valve Panels and Distribution Boards will comprise of steel wire armoured, PVC Insulated, four core cable, as follows:

Conductors.

Core Size : 4 core - Rated as per application (SABS 10142-1)
Stranded untinned copper, 7 strands minimum
PVC Insulated, Insulation Breakdown Voltage to withstand 2 kV 50Hz RMS for a 1 min period
Insulation Colours : Colored RD-BL-YE/WT-BK (not numbered)
Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Inner Jacket

Extruded fire retardant black PVC with rip cord for jacket removal.
Minimum thickness 1.2mm

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – fire retardant and UV resistant.
Jacket thickness 1.5mm.
Jacket to be totally bonded to a steel wire armoured sleeve.

Fire retardant, low halogen (20% Halogen, Blue Stripe) plastics to be used in non-ventilated areas. Fire retardant, high halogen (100% Halogen, Red Stripe) plastics may be used in ventilated areas. Fire retardant, no halogen (0% Halogen, White Stripe) plastics not required to be used.

8.3.4.2 Electrical Control cabling running between the Equipment located in the field, Control System Marshalling Cabinets, LV Panels and Incomer Breaker panels will comprise of steel wire armoured, PVC Insulated, multi-core cable, as follows :

Conductors.

Core Size : 7 core – 1.5 mm2 (Valve Actuators)
12 core – 1.5 mm2, 19 core – 1.5 mm2 (Switchgear)
Stranded untinned copper, 7 strands minimum
PVC Insulated, Insulation Breakdown Voltage to withstand 2 kV 50Hz RMS for a 1 min
Insulation Colours : 7 core and less – colored BL-YE/WT-RD-GR-BK-BR-PR/OR (Not numbered)
12 core and more – black, conductors to be numbered
Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Inner Jacket

Extruded fire retardant black PVC with ripcord for jacket removal.
Minimum thickness 1.2mm up to 7 core, 1.5mm for 12 and 19 core

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – fire retardant and UV resistant.
Jacket thickness 1.5mm up to 7 core, 2.0mm for 12 and 19 core
Jacket to be totally bonded to a steel wire armoured sleeve.

Fire retardant, low halogen (20% Halogen, Blue Stripe) plastics to be used in non-ventilated areas. Fire retardant, high halogen (100% Halogen, Red Stripe) plastics may be used in ventilated areas. Fire retardant, no halogen (0% Halogen, White Stripe) plastics are not required to be used.

8.4 Additional Requirements for Ex ia/ib Installations

8.4.1 All I.S. (Ex ia/ib Intrinsically Safe) Installations shall be in strict compliance with IEC 79-14 Electrical Installations in Hazardous Areas, and in particular Chp 12 "Additional Requirements for type protection Instrinsic Safety", inclusive of the under mentioned items.

8.4.2 **Clause 12.2.**
In installations with Zone 1 and 2 classifications, IS apparatus and the intrinsically safe parts of associated apparatus shall comply to at least category "ib". Note that Transnet Pipelines has standardised on category "ia" protection, and permission will need to be sought in writing for relaxation to "ib".

8.4.3 **Cables - General**
Where multi stranded cables are used in a hazardous area, the ends of the conductor shall be protected against separation of individual strands, by means of cable lugs.

Where cable screens are required, these shall be connected to earth at one point only, normally in the non-hazardous area. (Refer to Transnet Pipelines Specification PL727 Section 8.1.3.6 and 8.1.3.7).

Cable armouring shall normally be bonded to the equi-potential bonding system via the cable entry devices (glands), at the end of each cable run. Where interposing Junction Boxes exist or other apparatus, the armouring shall be similarly bonded to the equi-potential bonding system at these points. In this regard and where earthing rings are provided as an integral part of the gland, use of these is recommended in serving this function. Contact between the gland and the gland plate shall not be considered as sufficient for bonding purposes.

Conductors of intrinsically safe circuits and non-intrinsically safe circuits shall not be carried in the same cable.

Conductors of intrinsically safe circuits and non-intrinsically safe circuits in the same bundle or duct shall be separated by an intermediate layer of insulated material or by an earthed metal partition. No segregation is required if metal sheaths or screens are used for intrinsically safe or non-intrinsically safe circuits. Note that Transnet Pipelines has standardised on physical separation regardless of whether the cabling is screened or not, and permission will need to be sought in writing for relaxation.

8.4.4 **Cables - Marking**

Un-armoured Cables containing intrinsically safe circuits shall be marked. If outer sheaths are marked by color, the color used shall be light blue. Note that whilst armoured cabling is not required to be marked in terms of IEC79-14, Transnet Pipelines has standardised on the principle of marking all cable outer sheaths carrying intrinsically safe circuits by color (light blue), whether armoured or not, and that this will need to be complied with in all instances.

8.4.5 **Cable Insulation Tests**

All cables carrying intrinsically safe circuits shall be proven to be capable of withstanding an RMS AC test voltage of twice the normal voltage of the intrinsically safe circuit with a minimum of 500 V between the armouring and screens joined together and the individual conductors. Tests shall be conducted in accordance with manufacturers specifications. Where no such method is available, tests shall be carried out as follows:

- Voltage shall be an ac voltage of sinusoidal waveform at a frequency of between 48 and 62 Hertz
- Voltage shall be derived from a transformer of at least 500 VA output
- Voltage shall be increased steadily to the specified value in a period of not less than 10 seconds and maintained for a period of not less than 60 seconds.

8.4.6 **Cable Termination**

All terminals shall be reliably separated from non-intrinsically safe circuits (for example by a separating panel or gap of at least 50mm). Terminals of intrinsically safe circuits shall be marked as such. Transnet Pipelines has standardised on marking by color - the specified color being light blue. All terminals, plugs and sockets shall satisfy the requirements of IEC79-11 Sections 6.3.1 and 6.3.2 respectively (6mm creepage and clearance rules 4mm to earth).

8.4.7 **Zone 1 Installations - Surge Protection**

All equipment installed in Zone 0 areas and exposed to hazardous potential differences (e.g. lightning surges), shall have a surge protection device installed between each non-earth bonded conductor/core and the local earthed structure as near as is practically possible. The surge protection device shall be capable of diverting a minimum peak discharge current of 10kA (8/20 microsecond impulse according to IEC60-1, 10 operations). The bonding connection between the protection device and the structure shall have a minimum cross sectional area equivalent to 4 mm2 copper.

Note that Transnet Pipelines has extended these requirements to include all analogue transmitters installed in the field, whether in hazardous areas or not, and will need to be complied with in all instances.

8.5 Electrical & Instrument Cable Identification Standards

These standards have been based on the Transnet Pipelines Identification Standard as defined in the Document G52001 – L4017-U101 Sheets 1-4, which is largely based on the DIN 40 719 Standard. Refer to Transnet Pipelines Specification PL 101 Plant & Equipment Tag Numbering Standards.

8.5.1 DEFINITION.

All Cabling (inclusive of Instrument, Electrical Power and Control Cables) are to be tagged as follows:

A – NN XXXX YYY – nn

Where: **A** represents Cable Usage as follows: P = Power C = Control, Instrument

NN XXXX YYY represents the Functional Descriptor of the equipment to which the cable is terminated – either source or destination. (As defined in Transnet Pipelines Standard Dwg G52001-L4017-U101)

nn may be optionally used to provide additional information regarding Cable Function. (e.g. A = Analogue, D = Digital, H = Heater, ES = Emergency Stop). Where two cables of the same functionality are terminated to the same device/equipment, then this identifier may be used in the form of a unique cable number in order to uniquely identify the cables.

8.5.2 RULES OF ASSIGNMENT

8.5.2.1 Cable Usage will be indicated on all cables by utilising the Cable Usage Identifier (P for power and C for Control and Instrument cabling).

8.5.2.2 Cables will be identified using the Functional Descriptor of the device/equipment to which the cable has been terminated. Either source or destination device Functional Descriptors may be used; selection shall be based on the Descriptor that will convey the most information about the cable.

Examples:
In the case of a power cable feeding an auxiliary pump from a LV Panel, the Functional Descriptor of the auxiliary pump shall be used
In the case of a power cable feeding lights and plugs from a DB Board, the Functional Descriptor of the DB Board Feeder shall be used

8.5.2.3 An additional Identifier may be allocated to the Cable Tag to indicate additional information regarding Cable Function. **Note that use of this Identifier is optional and is normally used in the following circumstances:**

Instrument Multi-cores to indicate Signal Type	: A = Analogue, D = Digital
Electrical cables to indicate Function	: ES = Emerg Stop, H = Heater Supply

8.5.3 EXAMPLES / INTERPRETATION

8.5.3.1 INSTRUMENT CABLES

Instrument cables may be divided into two types, namely individual Instrument cabling running from the instrument itself to a Junction Box, and Instrument Multi-core cabling running from the Junction Box to the Marshalling Cabinet located in the Control Room.

In the case of individual Instrument cables, the Functional Identifier used in the Cable Tag always relates to the Instrument to which the cable has been terminated. In the case of Instrument Multi-core Cables, the Functional Identifier used in the Cable Tag always relates to the Junction Box to which the cable has been terminated.

(Examples listed below describe cables located at the Coalbrook Pump Station - hence use of the Pump Station Identifier No. 17).

C – 17JB01 – A	Instrument Multi-core Cable carrying analog signals and running from the Field Junction Box 17JB01 to the PLC Panel 17PLCnn
C – 17JB01 – A/D	Instrument Multi-core Cable carrying both digital and analog signals and running from the Field Junction Box 17JB01 to the PLC Panel 17PLCnn
C – 17TT011	Instrument Cable running from the Instrument TT011 to Junction Box 17JBnn in the field
C – 17VE011	Instrument Cable running from the Vibration Sensor VE011 to Junction Box 17JBnn in the field

8.5.3.2 VALVE ACTUATOR CABLES

Valve Actuator cables may be divided into two types, namely actuator power cabling running from the actuator to the Valve Distribution Panel, and actuator control cabling running from the Junction Box to the PLC Marshalling Cabinet located in the Control Room.

In the case of both actuator power and control cabling, the Functional Identifier used in the Cable Tag always relates to the actuator to which the cable has been terminated.

(Examples listed below describe cables located at the Coalbrook Pump Station - hence use of the Pump Station Identifier No. 17).

P - 17XVR1A	Supply to Valve Actuator R1A, fed from Valve Distribution Panel 17LVnn.
C – 17XVR1A – D	Cable running from Valve Actuator R1A to PLC Panel 17PLCnn in Control Room, carrying digital signals.
C – 17CVP0J – A	Cable running from Valve Actuator P0J to PLC Panel 17PLCnn in Control Room, carrying analogue signals

8.5.3.3 INCOMER BREAKER/ TRANSFORMER / MOTOR STARTER CABLES

Incomer Breaker/ Transformer/ Motor Starter cables may be divided into two types; namely power cabling (e.g. running from the motor to the Starter Panel) and control cabling (e.g. running from E/Stops located in the field to the Starter Panel or running from the Starter Panel to the PLC Marshalling Cabinet located in the Control Room).

In cases where the cable runs directly to the device (or field mounted local operator panels mounted alongside the device e.g. E/Stop pushbutton station), the Functional Identifier used in the Cable Tag always relates to the device to which the cable is terminated. In cases where the cable runs between two Starter/Incomer Panels, the Functional Identifier used in the Cable Tag usually relates to the destination Starter Panel.

(Examples listed below describe cables located at the Coalbrook Pump Station - hence use of the Pump Station Identifier No. 17).

C – 17MVF11	Control cable carrying electrical signals and running to the rear of the Incomer Panel 17MVF11 (associated with Incomer OCB F11)
C – 17MVF11-1	One of two control cables carrying electrical signals and running to the rear of the Incomer Panel 17MVF11 (associated with Incomer OCB F11)
C – 17A1	Control cable running from Aux Transformer A1 to Incomer Panel 17MV nn. **Note:** The cable carries both PLC feedback signals and electrical tripping signals – if the cable carried only digital PLC Feedback signals, the cable would be tagged C-17A1-D.
C – 17MVF11 - ES1	Control Cable running to Incomer Panel 17MVF11 (associated with OCB F11) from Station E/Stop Breakglass No. 1. located in the field.
C – 17MVF11 - ES2	Control Cable running to Incomer Panel 17MVF11 (associated with OCB F11) from Station E/Stop Breakglass No. 2. located in the field.
P – 17LV21-1 P – 17LV21-2	Supply to Constant Voltage Transformer from LV Panel 17LV21 Supply from Constant Voltage Transformer to LV Panel 17LV21
P - 17X01	Supply to Auxiliary Pump X01, sourced from LV Panel 17LV nn.
C - 17X01 - ES	E/Stop associated with Aux Pump X01 and wired to the Starter LVX01 located in LV Panel 17LVnn.
P - 17P01 - H	Heater Supply for Motor P01, sourced from LV Panel 17LV nn.
P – 17MV01 - H	Heater Supply for Incomer Panel 17 MV01 sourced from LV Panel 17LVnn.
C – 17MVP01 - H	Control Cable running between Motor Starter Panel 17MVP01 and LV Panel 17LVnn – used to control the switching of the Heater Supply based on P01 Starter status.
P – 17 E06	Supply cable running from Standby Generator E06 to LV Panel 17LVnn.
C – 17GEN01 – D	Cable running from the Standby Generator Control Panel 17GEN01 to the LV Panel – ET200 PLC, carrying PLC digital feedback signals associated with the Standby Generator.

8.5.3.4 POWER DISTRIBUTION CABLES

Power Distribution Rail identification.
Where multiple Power Distribution Rails are located within panels (e.g. MV, LV, PLC Panels), these are uniquely identified by use of a Distribution Rail Identifier appended to the Panel Identifier, as follows:

NN XXXXYYY B nnn

Where NN XXXXYYY represents the Panel Identifier (As defined in Transnet Pipelines Standard Dwg G52001-L4017-U101)

G nn:	24 VDC	
J nnn:	220 VAC	where nnn is a unique number used to identify
E nnn:	380 VAC	the different power rails within the same panel

Primary Distribution Rail Identification numbers are numbered consecutively from 1 – 99, with sub distribution feeders related to the primary feeder by the addition of a suffix (comprising of a unique consecutive number), in this way identifying the primary feed.

For example, a 24 VDC Distribution Rail located in LV Panel 17ETL01 will have a Distribution Rail ID of 17ETL01.G50. The Distribution Rail in 17ETM01 will have an ID of 17ETM01.G501, thus identifying it as a sub feed of rail G50.

Power Distribution Circuit Breaker identification.
Power Distribution Circuit Breakers are uniquely identified by use of a Distribution Circuit Breaker Identifier appended to the Panel Identifier, as follows:

NN XXXXYYY Q nnn

Where NN XXXXYYY represents the Panel Identifier (As defined in Transnet Pipelines Standard Dwg G52001-L4017-U101)

Q nnn: where nnn is a unique number used to identify the different circuit breakers within the same panel

Primary Circuit Breaker Identification numbers are numbered consecutively from 1 – 99, with sub distribution feeders related to the primary feeder by the addition of a suffix (comprising of a unique consecutive number), in this way identifying the primary feed. For example, if the incomer MCB for a DB Board is labelled Q01, then all MCB's fed from Q01 will be labelled Q10, Q11, Q12 etc. If a MCB is labelled Q21, then all MCB's fed from Q21 will be labelled Q210, Q211, Q212 etc.

Note that MCB's fed from normal supply will be labelled consecutively from Q01 onwards, whereas MCB's fed from Emergency Supply will be labelled consecutively from Q60 onwards.

Where multiple distribution rails exist within a panel, the Distribution Circuit Breaker Identifier will include the Distribution Rail Identifier as a prefix i.e. B nnn.Q nnn.

For example, MCB Q20 fed from DB Board 17DB10, will have an Identifier of 17DB10 .Q20; MCB Q55 fed from LV Panel 17ETL01 Distribution Rail G50, will have an Identifier of 17ETL01.G50-Q55.

Power Distribution Cable identification.

Distribution Feeder Cable Identifiers comprise of two components; namely, the Panel Identifier from which they are fed, and the unique Circuit Breaker ID number allocated to each Feeder.

NN XXXXYYY Qnnn

Where NN XXXXYYY represents the Panel Identifier (As defined in Transnet Pipelines Standard Dwg G52001-L4017-U101)

Qnnn represents the Protection/Circuit Breaker Identifier, numbered from 1 – 999.

(Examples listed below describe cables located at the Coalbrook Pump Station - hence use of the Pump Station Identifier No. 17).

P–17DB01	Cable Tag for a power cable fed from LV Panel 17LVnn and used to feed 380/400 V AC mains to 17DB01. **(Feeder Cable)**
P–17DB01.Q10	Cable Tag for a power distribution cable fed from DB Board 17DB01 MCB Q10. **(Distribution Cable)**
P–17LV31.Q60	Cable Tag for a power distribution cable fed from DB Board 17LV31 (UPS Distribution) MCB Q60 feeding for example PLC Panel 17PLC01. **(Distribution Cable)**
P–17PLC01.J20-Q20	Cable Tag for a power cable fed from PLC Panel 17PLC01, 220 VAC Distribution Rail J20, MCB Q20
P–17PLC01.G55-Q50	Cable Tag for a power cable fed from PLC Panel 17PLC01, 24 VDC Distribution Rail G55, MCB Q50
P–17ETL01.G55-Q50	Cable Tag for a power cable fed from ET Panel 17ETL01, 24 VDC Distribution Rail G55, MCB Q50
P – 17BATT01.Q80	Battery Supply Distribution to field, fed from Battery Charger Panel 17BATT01 MCB Q80 (eg. 110V DC Supply to 3.3 kV Starter Panel).

8.6 Cable Core Identification Standards (Core Identing)

8.6.1 <u>ELECTRICAL CONTROL CIRCUIT WIRING</u>

8.6.1.1 Core Ident Standards as detailed below are required to be adhered to with regards to identification of **control wiring** used in electrical circuits in HV, MV and LV Electrical Panels.

8.6.1.2 All conductors shall be identified by means of a core identification number, in conformity with the approved circuit and connection diagrams. All core ident numbers shall be unique and shall be placed on either end of the conductor. Core Ident numbers shall comprise of solid heavy-duty interlocking ferrules bearing clear permanent engraved black characters on white background. Crutchley core ident markers shall be utilized.

8.6.1.3 All circuit diagrams shall clearly identify all termination/connection points with the appropriate terminal identification numbers.

8.6.1.4 Core Ident numbers shall comply with the following specification:

Y XXX (T)

where

Y--- (T) represents an alphanumeric character to indicate signal type

- "M" denotes AC feed to primary of Voltage Transformer (Primary Supply)
- "H" denotes AC feed (un-rectified) from secondary of Voltage Transformer
- "J" denotes DC feed (rectified) from secondary of Voltage Transformer
- "C" denotes phase wiring from Current Transformers
- "E" denotes phase wiring to panel mounted voltmeters
- "D" denotes phase wiring to panel mounted ammeters
- "S" denotes wiring from Current Transducers (4-20 mA)
- "K" denotes control wiring fed from a DC Control Voltage Supply (e.g 50 VDC, 110 VDC)
- "Kxxx(T)" denotes control wiring with trip functionality. Note that the "T" marker shall comply with white on red background coloring.
- " " denotes control wiring fed from an AC Control Voltage Supply (e.g. 220 VAC)
- "X" denotes status feedback wiring to Control Systems (usually voltage free contacts)
- "U" denotes unused/spare auxiliary contact wiring (usually voltage free contacts)

XXX represents a unique numeric identifier, up to a maximum of three digits

Examples:

K1(T)	Tripping circuit fed from DC Control Voltage Supply (50 VDC/110 VDC)
K10	Control Circuit fed from DC Control Voltage Supply (50 VDC/110 VDC)
501	Control Circuit fed from AC Control Voltage Supply (220 VAC)
U101	Auxillary Switch circuit
X101	Status Feedback to Control System (e.g PLC)
E10, E20, E30	Three phase wiring fed to panel mounted Voltmeter

8.6.2 POWER DISTRIBUTION WIRING

8.6.2.1 Core Ident Standards as detailed below are required to be adhered to with regards to identification of power distribution wiring as follows:

- Power Distribution in PLC and Equipment Panels (24 VDC, 220 VAC)
- Power Distribution in ET200 Panels (24 VDC, 220 VAC). Note this includes ET200 PLC Interface Cubicles located in HV, MV and LV Panels.

8.6.2.2 All Distribution Feeder Wiring shall be core idented using the Functional Descriptor of the feeder/circuit breaker to which the cable has been terminated, as well as the terminal into which the core has been terminated.

AAA . Bnnn - Qnnn - xx

Where - AAA represents Power Type and Distribution Feeder (where applicable) as follows:

0V	: 0V
24V	: 24V positive
110V	: 110V positive
220V	: 220V live
N	: 220V neutral

- Bnnn represents the Distribution Rail ID where assigned (only assigned in panels with multiple power distribution rails)

- Qnnn represents the Protection/Circuit Breaker Identifier

- xx represents the terminal into which the core is terminated

(Refer to PL 727 Section 8.5.3.4 for details on the derivation of Distribution Feeder Functional Identifiers).

Examples:

24V.G55 - Q20 – 10	Core Ident for wiring feeding 24 VDC from Distribution Rail G55 MCB Q20 and terminated into terminal 10.
0V.G55 - 30 – 2-A1	Core Ident for wiring feeding 0 VDC from Distr Rail G55 (associated with MCB Q30) and terminated into terminal 2-A1 (Relay A1)
220V.J20 - Q15 – 5	Core Ident for wiring feeding 220 VAC Live from Distribution Rail J20 MCB Q15 and terminated into equipment terminal 5
N.J20 - 30 – 6	Core Ident for wiring feeding 220 VAC Neutral from Neutral Rail J20 (associated with MCB Q30) and terminated into equipment terminal 6
220V.Q15 – 5	Core Ident for wiring feeding 220 VAC Live from MCB Q15 and terminated into equipment terminal 5 (Distribution Rail Identifier is not required where multiple distribution rails are not in existence)
N. 30 – 6	Core Ident for wiring feeding 220 VAC Neutral from Neutral Rail (associated with MCB Q30) and terminated into equipment terminal 6 (Distribution Rail Identifier is not required where multiple distribution rails are not in existence)

8.6.2.3 Core Ident numbers will be approximately 10 characters in length and will comprise of Grafoplast printed (black lettering on white background) core ident markers. Identification characters will be sized to correspond to the overall diameter of the individual cores, i.e. ID tag sheaths will be sized and provided with a good fit (not loose) over the core ends. Identification tags will be so located as to leave cable core/pair lettering/numbering visible and shall be placed on both ends of the conductor. A sheath length of 30mm has been standardised upon by Transnet Pipelines.

8.6.3 INSTRUMENTATION AND EQUIPMENT PLC INTERFACE WIRING.

8.6.3.1 Core Ident Standards as detailed below are required to be adhered to with regards to identification of all Instrumentation and Equipment PLC Interface wiring (derived from electrical circuits in HV, MV and LV Electrical Panels).

8.6.3.2 Core Ident Standards have been detailed in the following Typical Loop Diagrams attached to this Specification:

- Typical Loop Diagram – Instrumentation	727-005/InstrLoop Rev 0.1
- Typical Loop Diagram – Actuated Valves	727-006/VlvLoop Rev 0.1

8.6.3.3 All individual instrument and control cable cores (including spares) will be marked with an identification number at both ends. Identification numbers will be approximately 10 characters in length and will comprise of printed (black lettering on white background) Grafoplast Ident Markers. A sheath length of 30mm has been standardised upon by Transnet Pipelines.

8.6.3.4 Identification characters will be sized to correspond to the overall diameter of the individual cores, i.e. ID tag sheaths will be sized and provided with a good fit (not loose) over the core ends.

8.6.3.5 Identification tags will be so located as to leave cable core/pair lettering/numbering visible.

9. COMMUNICATION INFRASTRUCTURE IDENTIFICATION STANDARDS

This specification details standards and codes of practice to be adhered to in the identification of Communication Equipment and associated communication cabling Infrastructure. These standards should be adhered to on all Transnet Pipelines Sites.

Diagrammatic Examples of the under mentioned detail may be found in Appendix B of this document.

9.1 Communication Equipment Identification Standards

All Communications Equipment will be identified using the following Functional Descriptors:

=XX YYY nn

Where - XX represents the Station Identifier
- YYY represents the Equipment Type (refer below for details)
- nn is a unique consecutive number

For example: A Comms Panel located at PS1, will have an identifier of =51 COM 01

EQUIPMENT TYPE: (YYY)

Communications Panel = COM

Terminal Bus Scalance Units =	SJT
System Bus A Scalance Units =	SJA
System Bus B Scalance Units =	SJB
CAS Network Scalance Units =	SJC
ST7 Network Scalance Units =	SJS
Electrical Network Scalance Units =	SJE

Cisco Network Routers =	SJR
OTN Network Routers =	SJO
Patch Panels =	X
HUB / Switch =	HB

Sever Panel = SVR

PCS7 Server A =	SVRA
PCS7 Server B =	SVRB
PCS7 Client (Operational) =	OSC
Replay Server =	RPY
Engineering Server =	ENG
KVM Switch =	KVM

OLM FO Convertors: - A xyz e.g. -A 21A

Where A = component designation
x = PLC No
y = OLM Set No
z = channel (A or B)

9.2 Communication Cable Identification

9.2.1 PLC Network Cabling

Cable Ident to be placed on either side of the cable as follows:

Equip A - In/Out e.g. PLC01A-IN, ET21A-OUT

Where Equip = Equipment designation PLCnr, ETnr, Hxy
A = channel (A or B)
In/Out = function (IN or OUT).

9.2.2 Comms Network Cabling

Cable Ident to be placed on either side of the cable as follows:

EquipSource - EquipDest - Channel e.g. OMS-HB1-10

Where EquipSource = Source equipment (eg. SUN, OMS, MUX, PTR)
EquipDest = Destination Equip (eg. HB1)
Channel = Channel No.

10. FIBRE OPTIC INFRASTRUCTURE IDENTIFICATION STANDARDS

This specification details standards and codes of practice to be adhered to in the identification of Fibre Optic Cabling Infrastructure, including cable, manhole and splice identifications. These standards should be adhered to on all Transnet Pipelines Sites.

Diagrammatic Examples of the under mentioned detail may be found in Appendix B of this document.

10.1 Splicing Manhole Identification

10.1.1 Label Text

Format = NL-SSS-DDD-XXY

Where:

N =	Network (i.e. E for the enterprise network – 48 fibre 655.D or P for the process control network – 24 fibre 652.D)
L =	Network link number (i.e. 1=Primary link, 2=Secondary link, etc)
SSS =	Source end of network link per Transnet Pipelines standard abbreviations (see below)
DDD =	Destination end of network link per Transnet Pipelines standard abbreviations (see below)
XX =	Sequential number starting from 01 at source end
Y =	Suffix to permit additional unplanned splices if required - Sequential letter starting from A

The source and destination are aligned with the dominant direction of product flow in the pipeline.

Examples of the above are:

P1-KDL-WAO-01	=	1st Process Control Network Primary Link splicing manhole along the Kendal-Waltloo route
P1-KDL-WAO-03	=	3rd Process Control Network Primary Link splicing manhole along the Kendal-Waltloo route
P1-KDL-WAO-24A	=	1st unplanned splice between splice 23 and splice 24

10.1.2 Splicing Manhole Label Text

50mm high text etched in black stenciled on the manhole cover

10.2 Cable Ident Identification

Grafoplast Targa Metal TGT System (Carrier Rail length: 106mm for 15 characters) 316 Stainless Steel Markers, with punched text 6 mm height minimum, fastened onto the cable at both ends via means of Stainless Steel cable ties or
Laser engraved 316 Stainless Steel Markers, of length 90mm, height 10mm and text height 6mm. Note that the marker should have slots cut at the ends for attaching cable ties.

Tags shall be fastened onto the cable at both ends via means of Stainless Steel cable ties. Cable Tags are attached to the cable outside of the express joint or ODF cabinet and within 150mm of the entry point to the cabinet or express joint housing.

10.2.1 Cable Ident Text

Format = NL-SSS-DDD-XXYZ

Where:

N =	Network (i.e. E for the enterprise network – 48 fibre 655.D or P for the process control network – 24 fibre 652.D)

L = Network link number (i.e. 1=Primary link, 2=Secondary link, etc)
SSS = Source end of network link per Transnet Pipelines standard abbreviations (see below)
DDD = Destination end of network link per Transnet Pipelines standard abbreviations (see below)
XX = Sequential cable number starting from 01 at source end
Y = Suffix to permit additional unplanned splices if required - Sequential letter starting from A (i.e. 24A for a unplanned splice between splice 23 and splice 24)
Z = Suffix X is added for numbering express joint cables (i.e. cable leaving/returning to the main cable)

The express joint cable to the MOBV ODF carries the number of the cable it is spliced to but with an X suffix (e.g. P1-KDL-WAO-03X)

The express joint cable from the MOBV ODF carries the number of the cable it is spliced to but with an X suffix (e.g. P1-KDL-WAO-04X)

A cable runs from a termination or splice point to the next splice or termination point, i.e. if a 4km cable is spliced at any point along its length, the cable sections either side of the splice are numbered as separate cables.

Examples of the above are:
P1-KDL-WAO-01 = 1st Process Control Network Primary Link cable along the Kendal-Waltloo route (i.e. running between the ODF at Kendal and the first splice point outside Kendal)
P1-KDL-WAO-03 = 3rd Process Control Network Primary Link cable along the Kendal-Waltloo route (i.e. running between the 2nd and 3rd splice point manholes)
P1-KDL-WAO-34X = Process Control Network Primary Link express joint cable running from express joint P1-KDL-WAO-34 (spliced to cable P1-KDL-WAO-34) to a motorised block valve along the Kendal-Waltloo route
P1-KDL-WAO-35X = Process Control Network Primary Link express joint cable running to express joint P1-KDL-WAO-34 (spliced to cable P1-KDL-WAO-35) from a motorised block valve along the Kendal-Waltloo route

10.3 Express / Splice Joint Identification

Grafoplast Targa Metal TGT System (Carrier Rail length: 106mm for 15 characters) 316 Stainless Steel Markers, with punched text 6 mm height minimum or
Laser engraved 316 Stainless Steel Markers, of length 90mm, height 10mm and text height 6mm. Note that the marker should have slots cut at the ends for attaching cable ties.

Cable Tags are fastened onto the express joint housing via means of Stainless Steel cable ties.

10.3.1 Express / Splice Joint Text

Format = NL-SSS-DDD-XXY

Where:
N = Network (i.e. E for the enterprise network – 48 fibre 655.D or P for the process control network – 24 fibre 652.D)
L = Network link number (i.e. 1=Primary link, 2=Secondary link, etc)
SSS = Source end of network link per Transnet Pipelines standard abbreviations (see below)

DDD =	Destination end of network link per Transnet Pipelines standard abbreviations (see below)
XX =	Cable number feeding the express joint
Y =	Suffix X is added for numbering express joint cables (i.e. cable leaving/returning to the main cable)

11. EARTHING CODES OF PRACTICE

This specification details standards and codes of practice to be adhered to in the supply, installation and termination of earthing systems on all Transnet Pipelines Sites.

11.1 National Standards

11.1.1 The requirements of the materials, design, layout, fabrication, assembly, erection, examination, inspection and testing of an earthing system on site shall be in accordance with the relevant sections of codes: -

- SABS 089 Part 2 — 1965 — Electrical Code for Petroleum Industry
- SABS 0121 — 1977 — Cathodic Protection of Buried and Submerged Structures
- SABS 0123 — 1976 — The Control of Undesirable Static Electricity
- SABS 0198 Part 12 — 1988 — Installation of Earthing System
- SABS 0199 — 1985 — The Design and Installation of and Earth Electrode
- SABS 0200 — 1985 — Neutral Earthing in Medium Voltage Industrial Power Systems
- SABS 0292 — 1999 — Earthing of Low Voltage (LV) distribution systems
- SABS 0313 — 1999 — Protection of Structures against Lightning
- SABS 1063 — 1998 — Earth Rods and Couplers
- SABS IEC 61000-5-2 — 1997 — Electromagnetic Compatibility (EMC) Part 5: Installation and mitigation guidelines Section 2: Earthing and Cabling
- SABS IEC TS 61312-2 — 1999 — Protection against Lightning Electromagnetic Impulse (LEMP) Part 2: Shielding of structures, bonding inside structures and earthing
- SABS IEC 61024-1 — 1990 — Protection of Structures against Lightning Part 1: General principles
- SABS IEC 61024-1-1 — 1993 — Protection of Structures against Lightning Part 1: General principles

		Section 1: Guide A – Selection of protection levels for lightning protection systems
• SABS IEC 61024-1-2	1998	Protection of Structures against Lightning Part 1-2: General Principles Guide B – Design, Installation, maintenance and inspection of lightning protection systems
• SABS IEC 61312-1	1995	Protection against Lightning Electromagnetic Impulse Part 1: General principles
• SABS IEC 61312-4	1998	Protection against Lightning Electromagnetic Impulse Part 4: Protection of Equipment in existing structures
• SABS IEC 61643-1	1998	Surge Protective Devices Connected to Low Voltage Power Distribution Systems Part 1: Performance requirements and testing methods
• SABS IEC TS 61312-2	1999	Protection against Lightning Electromagnetic Impulse (LEMP) Part 2: Shielding of structures, bonding inside structures and earthing

11.1.2 Statutory Requirements

a) The Contractor shall ensure that the installation satisfies the requirements of all relevant South African Statutory Regulations

b) Where applicable, equipment items shall carry the SABS mark to demonstrate compliance with the regulations.

11.1.3 The requirements of the materials, design, layout, fabrication, assembly and erection shall, where relevant, be in accordance with the following approved Installation Typicals forming part of this Specification: -

Instrument Earthing Schematic	727/004/Instr_Earth
Earthing Concept Drawing	727/008/Earth_Concept

11.2 Technical Requirements

11.2.1 General

a) A common integrated station earthing system shall be provided for electronic and electrical systems equipment, static and lightning protection in accordance with the requirements of this document.

b) A soil resistively survey shall be carried out by a specialist earthing consultant/contractor. The consultant/contractor shall prepare a detailed report on the conditions identified and provide the survey data recordings together with proposals, for a basis of the earthing system design.

c) Major electrical equipment such as switchgear, transformers, lighting boards, floodlight towers on poles, control panels etc. and associated metallic support frameworks, shall be connected to the station safety earth via Electrical Earth bars located nearby.

Use of embedded conductors within a power cable (spare core earth) may be utilised as the primary equipotential bonding system provided the following conditions are met: (SABS 086-1:2001)

- The embedded conductor has a cross-sectional area equal to those of the live and neutral conductors or equal to the values in Table 1 of SABS 0142)

In addition, a second visual earth connection shall be provided to each item of electrical equipment, to prevent the potential to earth of such equipment rising above spark potential. (SABS 089-2:2000)

d) The neutrals of generators and transformers shall be connected to the main earth grid either directly or via an earthing resistor, as required. Where neutrals of transformers are connected directly to earth, this shall be done via means of connections to both an individual earth rod located nearby as well as to the station earth mat by means of Electrical Earth bar located within the Switchgear Room.

e) Frames of motors shall be connected to the earthing system in accordance with the following table:

Motors kW Rating	Minimum Earth Conductor Size
Up to 30	16 mm^2
37 – 132	50 mm^2
150 – 175	70mm^2

Note:
In order to minimize the number of different sizes of earth conductor, the above three sizes only shall be used throughout, unless specifically stated otherwise.

f) Cables supplying lighting fixtures shall be 3 core for single-phase supplies and 5 core for 3 phase supplies, of which one core shall be used as the earth conductor.

g) Plant Infrastructure such as manifold piping, tanks and metallic support frameworks, shall be connected to the station safety earth, either directly or by means of Electrical earth bars located nearby.

h) Flanged joints in metallic pipelines shall be considered inherently continuous provided the surfaces of one of the bolts are cleaned and identified for earthing. Flanges of metallic pipelines that have insulated linings for purposes other than cathodic protection shall be bonded to ensure electrical continuity.

Pipelines shall only be connected to the earthing system where they enter and leave the battery limits.

i) Storage tanks that are not cathodically protected shall be earthed through at least two separate connections to the tank. Tanks shall be earthed in accordance with the relevant SABS code.

Electrically continuous structural steel columns may be used as down conductors by means of which elevated tanks, vessels, etc. shall be deemed to be connected to the earthing system.

All tank covers, gauge floats and stirrers etc. as well as all pipes entering the tanks shall be earthed.

The steel roof shall be in a direct electrical contact with, or bonded to the tank shell.

Earthed grids, gauges, gratings and the like placed in or across the inlets of tanks are not to be used as a means of static discharge. Individual bonding shall be made to the earthing system.

j) Cable trays and cable racks (including angle iron where used for this purpose) shall have continuous earth continuity. This shall be ensured by installing 10mm^2 earth straps across the racking fishplates (joints). Cable Trays shall be connected to the earthing system in two places - where they enter and leave the battery limits.

k) Earthing connections to all equipment and process plant shall comprise of welded earth bosses in compliance with SABS 089 Part II:1965 regulation 5.1.4K with properly provided terminations i.e. 10mm diameter earth studs. Anchor bolts shall not be used.

Earth connections to all equipment shall be effectively bolted, using crimped lugs. All cable connections shall be fitted with a "star" or serrated washer in addition to the backnut, to ensure good earth contact.

l) All earthing connections between the station earth system and respective earth bars/lightning protection systems shall where possible be made above ground, by means of bolts, crimped lugs and PVC taped.

All cable connections shall be fitted with a "star" or serrated washer in addition to the backnut, to ensure good earth contact.

Earth connection points shall be clearly labelled.

In cases where earth connection points are required to be made underground (e.g. to earth rods), inspection wells shall be provided comprising of pre-cast concrete/PVC surrounds complete with covers, to facilitate periodic inspection.

m) Earthing conductors rising through paving or other concrete work shall be run in suitable protective sleeves which shall project above finished level.

n) Earthing and bonding conductors shall be sized and installed in compliance with regulations detailed in the current SAIEE Standard Regulations for the Wiring of Premises and in SABS 03 as applicable.

o) Extendable earthing rods shall be manufactured from stainless / copper clad / galvanized steel (dependant on soil acidity and chlorides and existence of cathodic protection systems) 16mm diameter, 1200 mm long sections, and shall have molecular bond between the two metals to prevent moisture ingress. Where it is necessary to join earth rods together, a non-ferrous corrosion resistant coupling device shall be used which shall prevent the ingress of moisture into the joint.

p) Lightning and static earthing protection shall be provided for all tall steel, masonry and concrete structures, towers, vessels, tanks etc, as well as all buildings used to house sensitive electrical/electronic equipment. Lightning protection systems shall be connected both to individual earth rods as well as bonded to the station earth mat. Where possible, the mesh method (as defined in SABS 0313: 1999 Section

5.2.4) should be utilised in the protection of buildings against lightning strikes i.e. the use of masts and catenary conductors are to be avoided.

Tall steel structures such as towers or structure columns, provided they are electrical continuous, shall be considered inherently protected against lightning by their connection to the earth.

q) **The resistance of the common earthing system to the general mass of earth shall not exceed 1 Ohm.**

r) Where a separate system is installed for other than electrical equipment in remote locations, e.g. storage tanks; its resistance to the general mass of earth shall not exceed 7 Ohms. (Note: This applies only for Lightning Protection and remote valve chambers that are not connected to the Station Earth).

11.2.2 Station Safety Earth

In cases where a new Station Safety Earth Mat is required to be provided, the following specifications shall apply:

The **Earth Mat** shall consist of a completely buried, lattice network of 40x3mm, bare copper tape. All the crossover points of the lattice shall be braised or cadwelded and protected with PVC insulation tape. Buried joints or splices shall not be clamped or bolted. The earth mat shall be buried, 1000mm minimum, below finished grade.

The interconnecting conductors shall be radially interconnected to form a common earthing system, for all electrical equipment, lightning protection and static earthing in accordance with relevant SABS requirements.

If required, additional earth electrodes may be installed to achieve the specified resistance, of the common earthing system to the general mass of earth. Where earth rods are paralleled in a group to reduce the earth resistance to the permissible value, they shall be spaced apart for a distance at least equal to their buried depth length.

11.3 Switchgear Room Building and Equipment

11.3.1 A Main Safety/Electrical Earth Bar comprising of a copper bar, 50mm x 5mm min shall be installed in the basement/false floor of the Switchgear Room. Where possible, this Earth Bar shall be designated as the Primary Test Point for the station earthing system with the following equipment directly connected:

- **Station Earth Mat**. Where possible, a minimum of four separate connections shall be taken into the Switchgear Room via separate routes from the Earth Mat, by means of 40mm x 3mm Cu Earth tape. Connection to the Main Safety Earth bar shall be made in two places by means of 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductor, to facilitate testing of the Earth System.
- **Transformers**. By means of 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductor
- **MV/LV Panels**. By means of dual 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductors
- **Generator**. By means of 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductor

- **Instrument Earth**. By means of dual 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductors
- **Manifold Earth**. By means of dual 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductors

Note that on existing sites, the earth mat has been connected to the station earthing system in multiple places (namely; the Switchgear Room, Control Room and Manifold), and thus designation of a single Primary Test point is not possible. Multiple test points have thus been defined as follows: Switchgear Room, Control Room and Manifold Mainline Pumps 1 & 4 (where possible).

11.3.2 All secondary earthing within the substation shall be attached to this station earth bar at appropriate demarcated points.

11.4 Control Room Building and Equipment

11.4.1 A secondary Safety/Electrical Earth Bar comprising of a copper bar, 50mm x 5mm min shall be installed in the basement/false floor of the Equipment/Control Room in an easily accessible position. Where possible, this Earth Bar shall be directly connected to the Main Safety/Electrical Earth bar located in the Switchgear Room, by means of dual 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductors.

Note that all marshalling and equipment panels shall have an electrical earth bar, separate from an insulated instrument earth bar, installed and to which all electrical equipment earths shall be connected.

11.4.2 An Instrument Earth Bar comprising of a copper bar, 50mm x 5mm min shall be installed in the basement/false floor of the Equipment/Control Room in an easily accessible position. Where possible, this Earth Bar shall be directly connected to the Main Safety Earth bar located in the Switchgear Room, by means of dual 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductors.

Note that all marshalling and equipment panels shall have an insulated instrument earth bar, separate from the electrical earth bar, installed and to which all clean/instrument earths shall be connected.

11.4.3 Instrument and Electrical Earth systems shall be clearly labelled.

11.5 Manifold Area and Equipment

11.5.1 All manifolds shall have an insulated manifold earthing system installed, comprising of the following specifications:

- 40mm x 3mm min flat copper tape, to run the entire length of the main electrical racking reticulation and supported off of insulators at distances of no more than 2m apart. Use of existing electrical racking reticulation supports shall be permitted. All joints will require to be braised. Earthing reticulation shall be installed in such a manner so as to be unobtrusive and yet accessible and shall be positioned so as to avoid obstruction to walkways and access routes.
- The Manifold Earth bar shall be connected to the main safety/electrical earth located in the Switchgear Room, by means of dual 70mm^2, 600-volt class, green colored, PVC insulated, stranded copper conductors.

Note that on existing sites, the earth mat has been connected to the earthing system in multiple places (namely; the Switchgear Room, Control Room and Manifold), and thus designation of a single Primary Test point is not possible. Secondary test points have thus been defined where possible as follows: Switchgear Room, Control Room and Manifold Mainline Pumps 1 & 4.

11.5.2 All process plant and equipment located within the manifold area shall be attached to this manifold earth bar at appropriate demarcated points, via appropriately sized insulated PVC copper cable (green/yellow colored insulation), as follows:

- All electrical equipment shall be earthed via two separate earths, namely via the power cable earth core back to the respective Starter Panel electrical earth bar, and secondly via a separate visual earth from the motor frame to the manifold earth bar. Use of cable armouring as an earth conductor is not acceptable.

- All instrument stands and field junction boxes shall be separately earthed via means of an insulated 16mm2 min PVC copper cabling.

- All process vessels (tanks, vessels and piping) and racking reticulation shall be earthed via insulated 70mm2 min PVC copper cabling in two separate places.

All earth conductors utilized shall comprise of stranded, PVC insulated copper conductors with crimped cable lugs. All connections shall be fitted with a “star” or serrated washer in addition to the backnut, to ensure good earth contact.

11.6 Earth System Identification Standards

11.6.1 Earth Bar Labels

Earth bars shall be clearly labelled according to their functionality (e.g. “EB xx” to denote an electrical earth bar, “IB xx” to denote an instrument earth bar, where xx denotes a unique consecutive number). The Functional Identifier “EB 00” shall always denote the Station Earth Mat.

In addition, earth bars designated as Test Points shall be labelled accordingly.

Labels shall comprise of the Traffolyte engraved type, and fixed by means of stainless steel screws. Finish shall comprise of black letters against a white background, with text 40mm height.

Labels shall be readable/visible after the wiring has been done.

11.6.2 Earth cable Identification

Earth cables may be divided into two types, namely primary earth cabling running from subsystem earth bars directly or indirectly to the main station earth (and used for testing purposes), and secondary earth cabling running between the subsystem earth bars and equipment or infrastructure.

Only Primary earth cabling (i.e. those used for testing purposes) is required to be identified, by means of a Functional Identifier denoting both source and destination earth bars.

Identification numbers will comprise of the following specification:

- Grafoplast Targa Metal TGT System (Carrier Rail 58mm in length) 316 Stainless Steel Markers, with punched text 6 mm height minimum, fastened onto the cable at both ends via means of Stainless Steel cable ties

Examples:

EB01 – EB00	Cable Identifier for Earth cable running between Electrical Earth bar EB01 and the Station Earth Mat
IB01 – EB00	Cable Identifier for Earth cable running between Instrument Earth bar IB01 and the Station Earth Mat

11.7 Testing

11.7.1 Earth Resistivity and Electrode Testing

It will be the Contractors responsibility to carry out all necessary earth resistivity tests on site, where applicable. Tests will be in accordance with the requirements of BS 1013 as amended.

After all earth electrodes/trench earth's have been installed, an earth megger shall be used to test the earth resistance at the earth bar or connection point to the main station earth and the results recorded. Note that all ECC connections, and any other bonding material shall be disconnected from the earth connection point whilst the earth is being tested.

Earth Continuity Testing.

Earth continuity readings shall be measured and recorded from the earth bar to each item of equipment and process plant, and shall include all piping, vessels, transformers, motors, actuators, switchgear cabinets, marshalling enclosures and instrumentation.

11.7.2 The following are the maximum acceptable earth electrode resistances:

Electrical Earth
a) Main substation - 1 ohm
b) Miniature substations and kiosks - 2 ohms
c) Highmasts - 5 ohms.

Instrument Earth
a) Instrument Earth - < 1 ohm

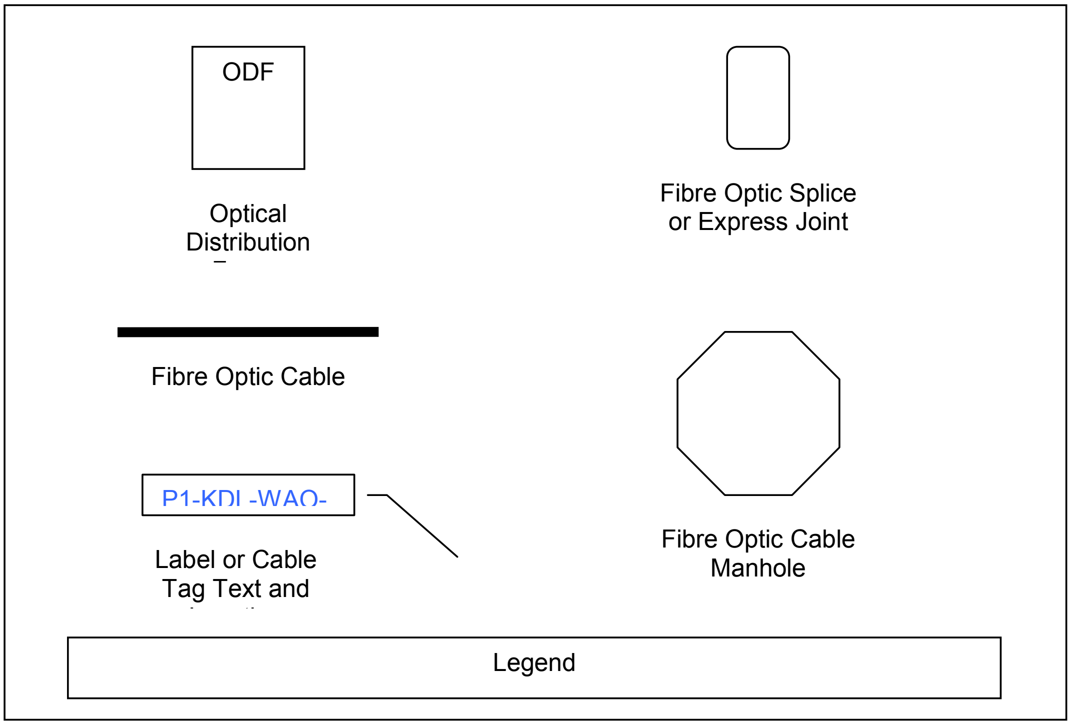
---------------- End of Document ---------------

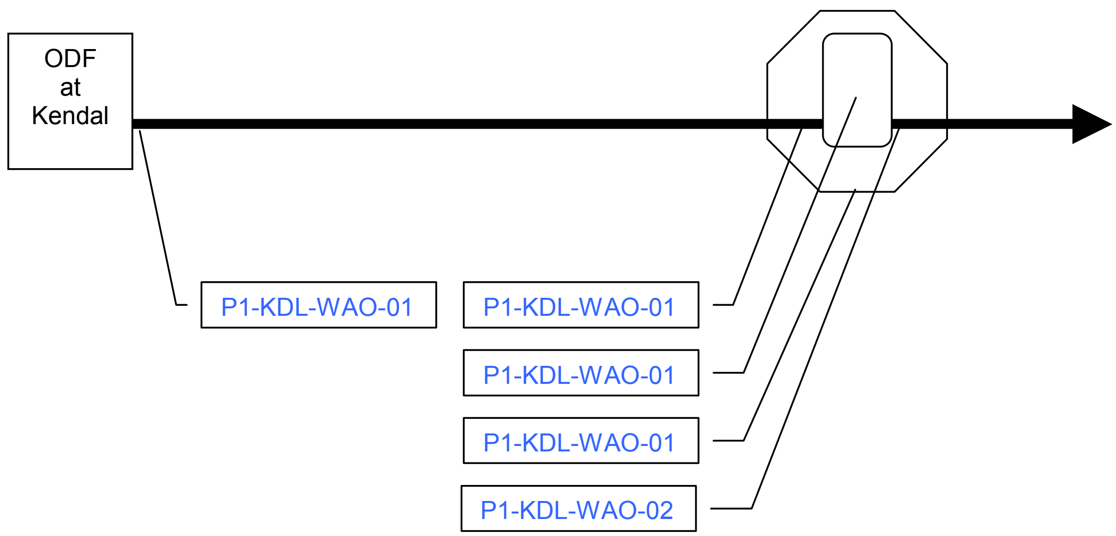
APPENDICES

A1. Drawings.

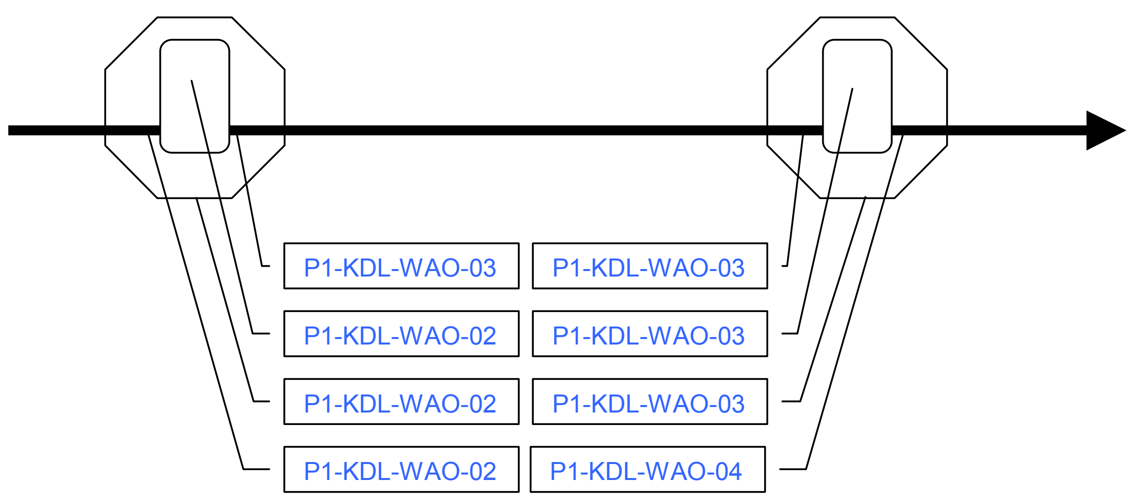
Cable Marker Specification	727/001/cblmrk
Typical for Instrument Stands - double	727/002/Instand
Typical for Instrument Stands - single	727/003/Instand
Instrument Earthing Schematic	727/004/Earth_Instr
Typical Instrument Loop Drawing	727/005/InstrLoop
Typical Valve Loop Drawing	727/006/VlvLoop
Typical for Angle Iron Droppers	727/007/Rack_Droppers
Earthing Concept Drawing	727/008/Earth_Concept
Typical for Racking Layouts incl. over Bund Walls	727/009/Rack_Typical
Typical for Junction Box stands	727/010/Junction Box Stand

A2. FIBRE OPTIC INFRASTRUCTURE IDENTIFICATION STANDARDS – TYPICAL DRAWINGS

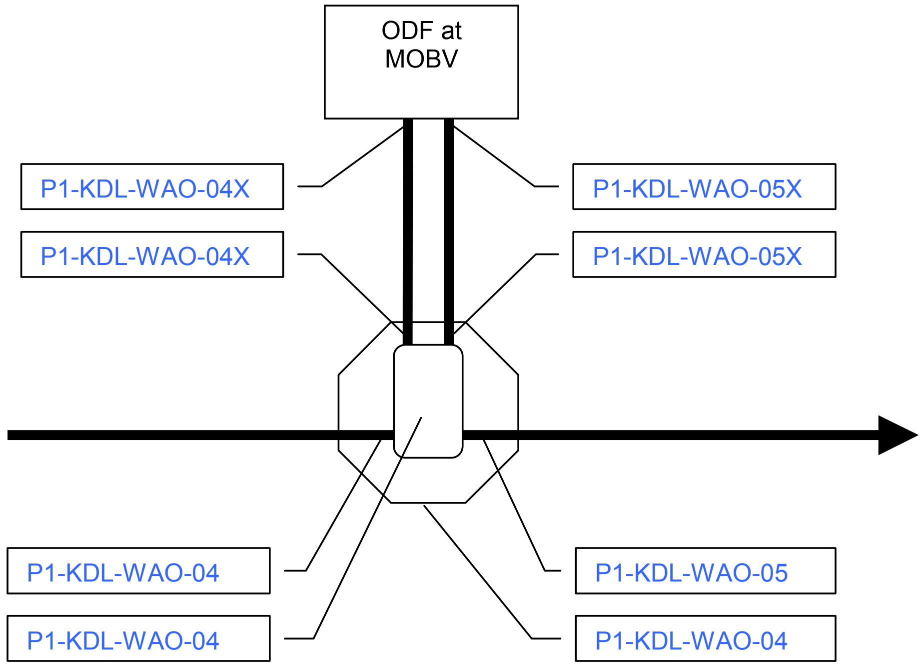




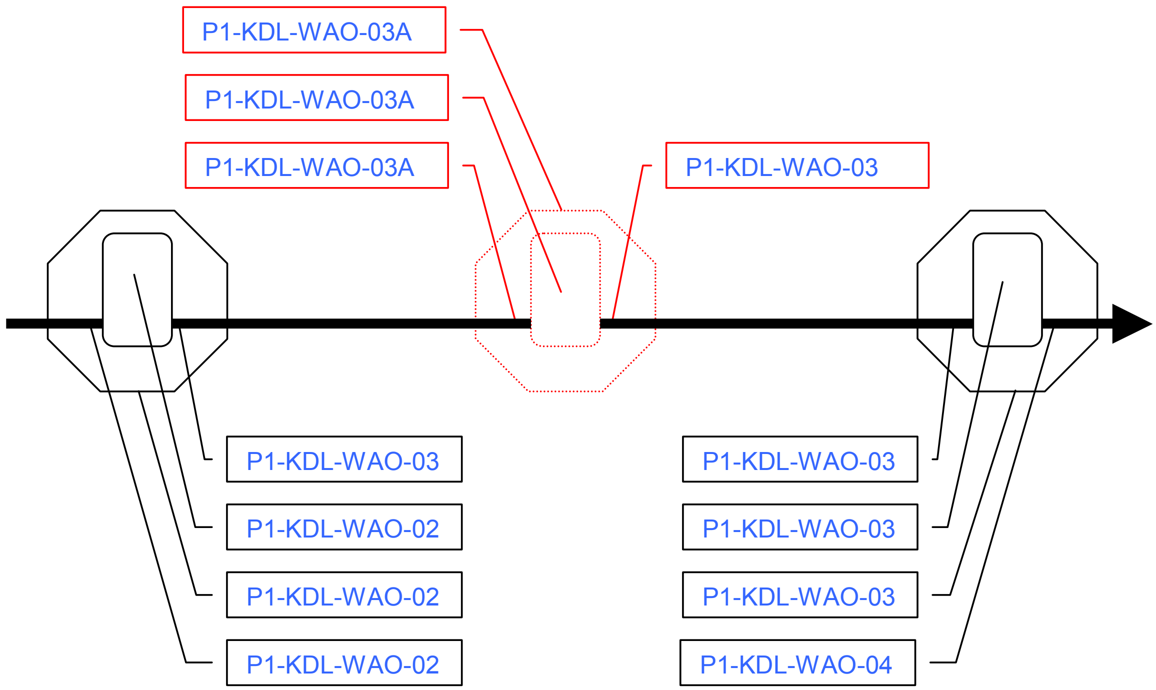
Start of Cable Run and Planned Manhole with Splice



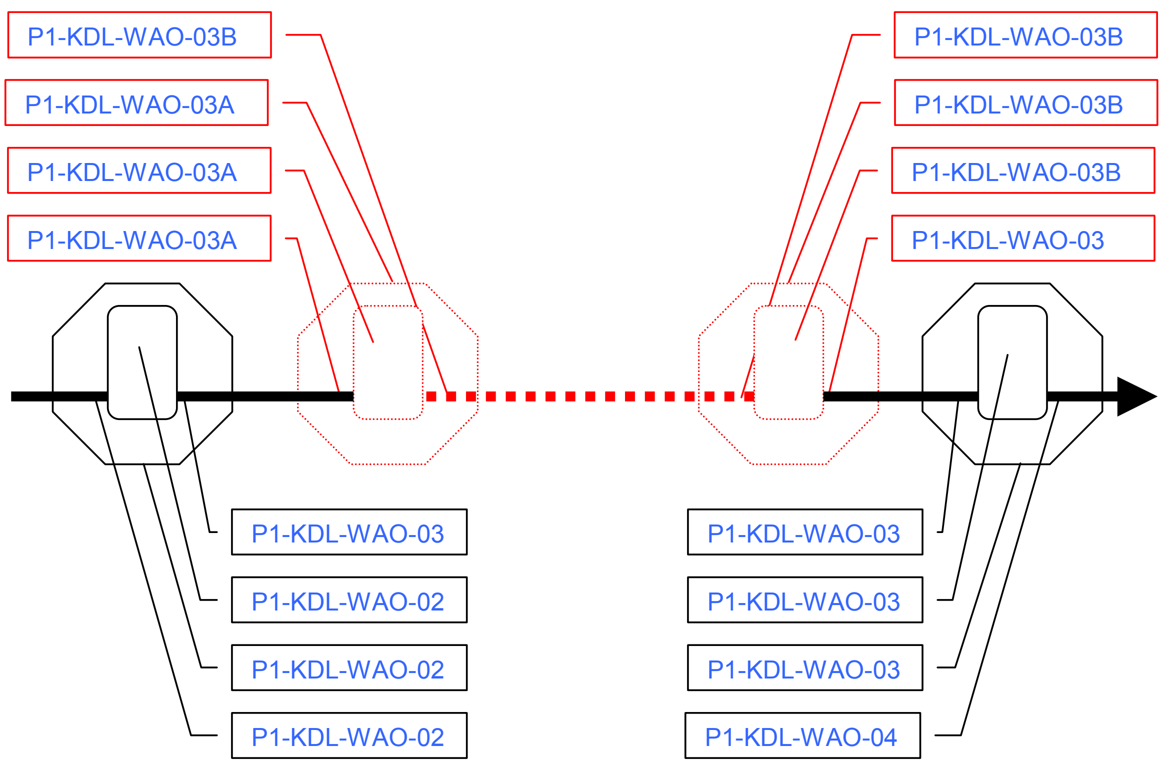
Planned Manholes with Splices



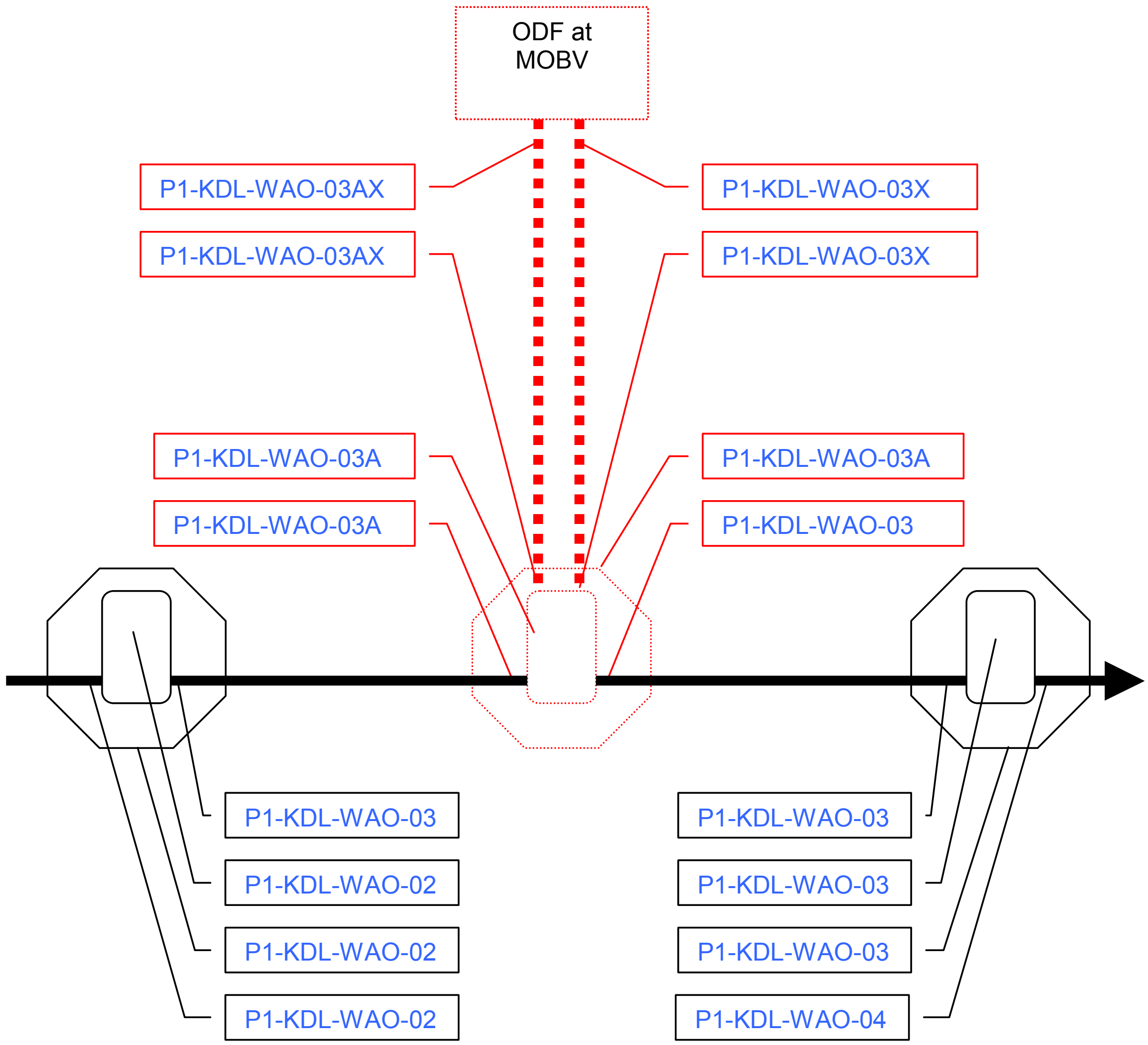
Planned Manhole with Express Joint to Motorised Block Valve Chamber



Unplanned Manhole with Splice Added Between 2nd and 3rd Manholes



Unplanned New Cable Section with Two Manholes and Splices Added



Unplanned Manhole with Express Joint to Motorised Block Valve Chamber Added

SPECIFICATION FOR LOW VOLTAGE SWITCHGEAR AND DISTRIBUTION BOARDS

PL 631

REV. 009

DOCUMENT APPROVAL PROCESS

NAME		POSITION/MEETING NO.	SIGNATURE	DATE
Originator:				
Approver:		Chief Technical Officer		
Original date: 17/06/1999				
Effective date: 29/02/2016				

1. DOCUMENT CHANGE HISTORY:

The owner of this document is responsible for the revision and control of the document, including updating of the table below, which contains the history of the document with details of each revision.			
Date	Previous Rev No.	New Rev No.	Details of Revision
17/06/99	001		Document distributed for comment
17/08/99	002		Document approved for Distribution
26/04/2000	003		Revised as per Phase II
10/05/00	004		Revised as per Phase II – Siemens comments added
21/09/00	005		Earthing Requirements/Wiring Codes of Practice/Labelling Standards added
10/04/01	006		Fault Level ratings reviewed
01/09/02	007		Panel labelling, cable termination assemblies reviewed
01/08/07	008		SABS 10142:2003 Requirements added. Transnet pipeline Logo added.
10/02/2016		009	Document Updated

TABLE OF CONTENTS

2. INTRODUCTION

The objective of this Specification is to establish standards and codes of practice that are required to be adhered to by both Contractor and Client in the design, supply and installation of LV Switchgear and Distribution Boards, on all Transnet Pipelines Sites.

3. SCOPE

3.1 General

This document describes as a minimum, the technical requirements and general responsibilities regarding the safety, design, supply, manufacture, population, type-testing, performance, constructional and routine testing, delivery to site, site erection, site testing and commissioning requirements for 50 Hz LV Distribution Switchgear and Controlgear ASSEMBLIES for voltages up to 660 V. Contractors are required to familiarise themselves with all applicable Standards and Codes of Practice listed herein, and to ensure compliance in the execution of any work in terms of this document. Failure to comply may render the contractor liable for corrections at his own cost.

These Standards and Codes of Practice should be read in conjunction with all other Specifications and drawings as issued for a particular contract. Where discrepancies occur, these must be brought to the attention of Transnet Pipelines in writing before commencement of work. In the event of any conflict between the contents of any documents forming part of a contract (as listed in the Schedule of Contract Documents) and this document, the former shall prevail.

3.2 Application to Work Activities

The Standards and Codes of Practice contained herein apply to all installations involving the safety, design, supply, manufacture, population, type-testing, performance, constructional and routine testing, delivery to site, site erection, site testing and commissioning requirements for 50 Hz LV Distribution Switchgear and Controlgear ASSEMBLIES for voltages up to 660 V, and includes amongst others the following activities:

- Design, supply and installation of LV Distribution Panels for voltages up to 660 V
- Design, supply and installation of Motor Control Centres for voltages up to 660 V

The ASSEMBLIES shall be required for distribution, motor control & /or a combination of these functions, for floor or wall mounting and for indoor or outdoor use as detailed in the project specification. All boards shall be totally enclosed.

4. NORMATIVE REFERENCES

4.1 The following national and international specifications and standards shall be read in conjunction with this Specification.

Where reference is made to a Code, Specification or Standard, the reference shall be taken to mean the latest edition of the Code, Specification or Standard, including addenda, supplements and revisions thereto, in content or numbering.

General:	
API 2003	Protection against ignitions arising out of static, lightning and stray currents
SABS ISO 9000:	Quality management systems
SANS 10086-1	The installation, inspection and maintenance of equipment used in explosive atmospheres
SANS 10089-2 (2007)	The petroleum industry Part 2: Electrical and other installations in the distribution and marketing sector
SANS 10142-1 (2012)	The wiring of premises Part 1: Low-voltage installations
SANS 10198 - 2004	The Selection, Handling and Installation of Electric Power Cables of rating not exceeding 33 KV
SANS 10313	The Protection of structures against lightning.
Equipment :	
SANS 1700	ISO metric black bolts, screws and nuts (hexagon and square)
SANS 1019 - 2014	Standard voltages, currents and insulation levels for electricity supply
SANS 1091 - 2012	National colour standards
SANS 1195	Busbar Systems
SANS 1274- 2014	Coatings applied by the powder-coating process
SANS 1507	Secondary Wiring
SANS 1973-1	Low-voltage switchgear and controlgear ASSEMBLIES Part 1: Type-tested ASSEMBLIES with stated deviations and a rated short-circuit withstand strength above 10 kA
SANS 1973-3	Low-voltage switchgear and controlgear ASSEMBLIES Part 3: Safety of ASSEMBLIES with a rated prospective short-circuit current of up to and including 10 kA
SANS 60269 (2014)	Low-voltage fuses
SANS 60439-1	Low-voltage switchgear and controlgear assemblies
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60947-1 (2012)	Low-voltage switchgear and controlgear Part 1: General rules
SANS 60947-2 ((2014)	Low-voltage switchgear and controlgear Part 2: Circuit-breakers
SANS 60947-3 (2012)	Low-voltage switchgear and controlgear Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units

SANS 60947-4 (2013)	Low-voltage switchgear and controlgear Part 4 -1;-2;-3: Contactors and motor-starters
SANS 60947-5	Low-voltage switchgear and controlgear Part 5: Control circuit devices and switching elements
SANS 61439	Low-voltage switchgear and controlgear assemblies
SANS 61558	Safety of power transformers, power supplies, reactors and similar products
SANS 61643-1	Low-voltage surge protective devices Part 1: Surge protective devices connected to low-voltage power distribution systems - Requirements and tests
SANS 61643-12	Low-voltage surge protective devices Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application principles
SANS 61869-1	Instrument transformers
BS 142	Electrical protection relays
BS 159	Busbars and busbar connections
BS 5486	Low voltage switchgear and controlgear assemblies
BS 1433	Copper for electrical purposes. Rod and bar.
BS 3693	Design of scales and indexes. Part 1.
BS 3938	Current transformers
BS 4794	Control switches. (Switching devices, including contractor relays, for control and auxiliary circuits, for voltages up to and including 1000 V AC and 1200 V DC.) Part 2.20.
BS 5472	Low voltage switchgear and control gear for industrial use. Terminal marking and distinctive numbering. General rules.
DIN43620	Low voltage high rupturing capacity fuses with blade contacts.
NRS 002	Graphical symbols for electrical diagrams
VDE 0660	Regulations for low voltage power fuses (NH fuses) Part 4
Government, local authorities or other statutory bodies' regulations, laws, requirements or customs which are more stringent than those detailed in this specification.	

4.2 The following standard specifications are to be used for reference purposes and need to be noted by Contractors in order to signify familiarity and compliance with the requirements. It is expected of Contractors that they are familiar with the applicable clauses and that these will be adhered to in the execution of any work in terms of this specification. Contractors will be required to confirm that they are able to meet these requirements.

The Occupational Health & Safety (OHS) Act No. 85 of 1993.	
SANS 10108: 2014	The Classification of hazardous locations and the selection of electrical apparatus for use in such locations
SANS 60079	Explosive atmospheres: Part 14: Electrical installations design, selection and erection; Part 17: Electrical installations inspection and maintenance; Part 25: Intrinsically safe electrical systems

API	Manual of Petroleum Measurement Standards Chapters 4 to 12 IP Chapter 10 and Papers 2 and 3
SANS 60529	Degrees of protection provided by enclosures (IP Code)
BS 5490	Classification of degrees of protection provided by enclosures
BS 229	Flameproof enclosures for electrical apparatus
BS 1259	Intrinsically safe electrical apparatus and circuits for use in explosive atmospheres
BS 4683	Electrical apparatus for explosive atmospheres
Safety Regulations for Contractors	
Technical Instruction No. 16 – Contractors Work Permit Procedures.	
VDE Standards	

4.3 Where no specific rules, regulations, codes or requirements are contained in this specification nor covered by the above mentioned codes, the contractor shall, in consultation with Transnet Pipelines, adhere to internationally accepted modern design and engineering practices in the Petroleum Industry.

5. TRANSNET PIPELINES SPECIFICATIONS

5.1 The following Transnet Pipelines standard specifications are to be read in conjunction with this document and require separate statements of compliance, which should be included in the tender documents.

PL727 Specification for Cable, Racking, Trenching & Earthing Reticulation Codes of Practice

PL711 Specification for Equipment Cabinets to house Electronic Equipment Safety Regulations for Contractors

6. ABBREVIATIONS & DEFINITIONS

6.1 For the purpose of understanding these Standards, the following abbreviations apply.

AC	Alternating current
ACB	Air Circuit-breaker
ANSI	American National Standards Institute
BS	British Standard
BSI	British Standard Institution
C&I	Control and Instrumentation

CT	Current Transformer
DC	Direct Current
DCS	Distributed Control System
EDS	Engineering Design System
EMC	Electro magnetic compatibility
FAT	Factory Acceptance Test
fn	Rated frequency
HEM	High Efficiency Motor
HRC	High Rupturing Capacity
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronic Engineers
IP	Ingress Protection
ISO	International Organisation for Standardisation
ISA	Instrument Society of America
LV	Low Voltage
mcb	Miniature Circuit-breaker
MCC	Motor Control Centre
MCCB	Moulded-Case Circuit-breaker
OEM	Original Equipment Manufacturer
OHS Act	Occupational Health and Safety ACT
PE	Protective Conductor
PEN	Combined Protective Earth & Neutral
PTTA	Partially Type-tested ASSEMBLY
RCC	Regulatory Certificate of Compliance
RDF	Rated diversity factor
SAT	Site Acceptance Test

SABS	South African Bureau of Standards
SANS	South African National Standards
SCPD	Short Circuit Protective Device
SPD	Surge Protection Device
TPL	Transnet Pipelines
TTA	Type-tested ASSEMBLY
UPS	Uninterruptible Power Supply
Ue	Rated operational voltage
Uimp	Rated impulse withstand voltage
Un	Rated voltage
VT	Voltage Transformer

6.2 The following Definitions are consistent with the Transnet E5 Agreement and General Conditions of Contract and apply to this specification in its entirety.

CHIEF EXECUTIVE (Transnet Pipelines) means the officer appointed as Chief Executive (Transnet Pipelines) of Transnet Limited or any person lawfully acting in that capacity.

ENGINEER means any officer in the office of the Chief Executive (Transnet Pipelines) deputed by the Chief Executive (Transnet Pipelines) to supervise and take charge of the contract.

PLANT means any machine, excluding a tool, and any vehicle, excluding a passenger vehicle, used on site for the carrying out of the Works.

EQUIPMENT means any device not forming a permanent part of the Works, used on site for the carrying out of the Works, and also any temporary building, which is required for the carrying out of the Works, and which is erected on site.

TOOL means any instrument, powered or otherwise, which is accepted as a hand tool by the industry concerned and which is normally used in a manual operation by an individual labourer, artisan or workman.

MATERIAL means any constructional substance or ingredient that shall form part of the permanent Works and the substances in excavations and earthworks.

DRAWINGS means the drawings referred to in any specifications, schedule of quantities and prices and any alterations of such drawings made or approved in writing by the Engineer and such other drawings as may from time to time be furnished or approved in writing by the Engineer.

SITE means the land and any other place on, under, over, in or through which the Works are to be executed or carried out and any other land or place made available by Transnet in connection with the Works.

WORKS means the works to be executed in accordance with the Contract.

6.3 General Definitions

In addition to the definitions of SANS 10142-1; SANS 1973-1; SANS 1973-3 and SANS 60439-1, the following apply:

Approval — Written agreement or authorization by Transnet Pipelines. All requests for approval shall be submitted in writing and any proposed deviation from specified requirements shall be fully justified and agreed by Transnet Pipelines.

Barrier — A part providing protection against direct contact from any usual direction of access (minimum IP2X) and against arcs from internal arc faults, if any.

Cable way — A section of the ASSEMBLY that provides a platform for the routing and termination of cables.

Collection Busbars — A type-tested intermediate busbar arrangement between the main busbars to distribute power to especially mcb's which are connected in cascaded circuit arrangements.

Data Sheets — All drawings, tabulations, sketches, and relevant documentation which Transnet Pipelines shall submit with an enquiry, to clearly indicate to a bidder or supplier the technical, electrical and physical requirements of the completed equipment.

Distribution Feeder — A functional unit supplying power to another low voltage ASSEMBLY either through a cable or step-down transformer.

Equalizing Busbars	Busbars to which the incoming or outgoing power electric cables are connected to enable an even distribution of current to the terminals of the protective gear.
Fault-Free Zone	Zone in ASSEMBLY or section of an ASSEMBLY that comprises the conductors (including distribution busbars) between the main bursars and the supply side of functional units, in which, under normal operating conditions, the occurrence of a short-circuit fault is only a remote possibility.
Padlocking facility (Padloackable)	Part of the ASSEMBLY or component that allows one to insert a padlock for locking purposes during maintenance.
Type-Tested ASSEMBLY with stated deviations	An ASSEMBLY System which has been verified by a comprehensive range of tests of worst case scenarios and documented in accordance with an approved Engineering Design System with all type-tests performed in accordance with the requirements of SANS 10142-1, SANS 1973-1 and SANS 60439-1.
Intelligent Electronic Device (IED)	Microprocessor-based device with the protection, control, monitoring and communication functionalities.
Incomer Unit	A functional unit through which electrical energy is fed into the ASSEMBLY.
Modular Design	An ASSEMBLY System which accommodates a variety of section sizes, sub-section sizes, and busbar and cable compartment sizes in such a way that the different combinations has been subjected to all type-tests as prescribed by SANS 1973-1.
Partition	A part of the enclosure of a compartment separating it from other compartments.

Protective Gear	Individual or combinations of circuit-breakers and or switch-disconnectors and or fused switch-disconnectors
Stated Deviations	Deviations from a type-tested ASSEMBLY which is documented in the Engineering Design System and supported by type-test reports.
Withdrawable Unit	A functional unit which can be moved from the connected position to the isolated position and to a test position, if any, whilst remaining mechanically attached to the ASSEMBLY.

8. SITE CONDITIONS

8.1 The equipment shall be designed to operate continuously at its rated capacity, at the specified ambient temperature and site elevation conditions as detailed in the datasheets. Typically these conditions are tabulated below:

Ambient operating temperature	-5 to 40 °C (Daily average +35 °C)
Maximum relative humidity	0 to 95 %
Maximum altitude	0 to 2000 above sea level
Lightning conditions	Severe, max ground flash density 11 flashes per km² per annum
Exposure conditions	Salt laden as well as industrial atmosphere

8.2 Electrical Conditions.

8.2.1 The system of supply shall be 3 phase, 4 wire, 50 Hz alternating current with earthed neutral at a nominal voltage of 400/230 Volts.

8.2.2 The voltage may vary within the range of 95% to 105% of the nominal. All equipment installed shall be suitably rated.

8.2.3 The Switchgear Panel, switchgear components, busbar systems and cables shall be adequately rated for prospective fault level ratings. Prospective system fault level requirements shall be obtained from the relevant supply authority, and used to determine switchboard fault levels after making allowances for circuit impedance of associated cables and transformers. It will be the Contractor’s responsibility to provide for supply authority requirements when compiling their Offers.

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

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

8.2.6 All components and electric conductors fitted to the ASSEMBLY shall be certified as safe by means of a valid Regulatory Certificate of Compliance (RCC) in accordance with SANS 10142-1 Table 4.2 or an SABS Mark of approved performance.

8.2.7 ASSEMBLIES shall be fit-for-purpose type-tested low-voltage free-standing metal-enclosed switchgear and controlgear ASSEMBLIES with stated deviations in accordance with the requirements of this Specification, SANS 10142-1, SANS 60439-1, SANS 1973-1 and /or SANS 1973-3. The ASSEMBLIES shall also meet the Transnet Pipelines requirements in terms of safety, operation and maintenance requirements.

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

8.2.9 The manufacturer shall have conducted full type tests and specified special tests as required at a Third Party Test House accredited by an internationally recognized Accreditation Authority in terms of ISO 17025 in accordance with SANS 60439-1, Table 7 for a reference design and shall be in possession of valid type test report/s not older than 5 years that reflects a reasonable and true outcome of the results. In addition, the type tests shall comply with the latest revisions of the applicable standards. In case a certificate is older than 5 years, proof shall be provided that the design and materials used match that of the type tested ASSEMBLY.

8.2.10 A valid "scope of testing" certificate issued by the Accreditation Authority shall be submitted.

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

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

9. DRAWINGS AND INSTRUCTIONS

9.1 The Contractor shall issue to the Engineer, documentation as per specific contract requirements. Where not specified, the Contractor shall provide one set of sepias, 3 copies of drawings and 1 electronic media of "As Built" drawings, in their native format, of equipment which have been installed on site.

9.2 Handbooks, spares lists and maintenance instructions shall be issued to the Engineer in triplicate at the time of handing over the equipment.

9.3 All Documentation issued shall be in full compliance with Transnet Pipelines Specification PL100 Drawing Standard and in particular:

- **PL101** Plant & equipment Tag numbering Standards
- **PL102** Equipment, Instrument & Electrical Symbology Standard
- **PL103** General Drawing Standards

9.4 The requirements of the materials, design, layout, fabrication, assembly and erection of Low Voltage Panels / Motor Control Enclosures shall, where relevant, be in accordance with the following Transnet Pipeline approved drawing Typicals forming part of this Specification: -

- LV Panel GA – External Arrangement
- LV Panel GA – Internal Arrangement
- LV Panel Single Line Diagram Typical
- LV Panel Schematics – DOL Starter
- LV Panel Schematics – Star Delta Starter
- LV Panel Schematics – VSD Starter

9.4.1 General arrangement drawings

General arrangement drawings shall be completely dimensioned, showing:

a) Arrangement of equipment
b) Top, front, and side views and cross-sections of the ASSEMBLY.
c) Position of each functional unit and their compartments.
d) Clearances for opening doors.
e) Locations of busbars and distributions.
f) Details on the required openings for the power cables
g) Incoming and outgoing cable termination positions and details.
h) Cable slot positions.
i) The height of all cable glands above floor level
j) Instrument transformers (i.e. VT's and CT's) physical positions.

k) Terminal block locations.
l) Earthing or bonding connections.
m) Mass of transportable sections of equipment
n) Details and position of the holding down bolts
o) Magnitude and disposition of all loads imposed on foundations

9.4.2 Single line diagram

Single line diagram shall show the following:

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

9.4.3 Schematic Drawings

Schematic wiring diagrams shall show the following:

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

9.5 All cable and wire sizes, values of resistance, breaking capacity of switches and ratings of equipment shall be clearly specified on a drawing.

9.6 All Electrical symbols shall comply with NRS 002-2000 Graphical Symbols for Electrical Diagrams.

9.7 Prior to commencement of manufacture, design approval shall be obtained from the Engineer. Design approval shall entail as a minimum, the submission of the following documentation:

a. Single Line Drawings.
b. Circuit diagrams of power, control, alarm and indication circuits.
c. Layout of equipment in or on panels, boards and cubicles.
d. Internal wiring diagrams of panels, boards and cubicles showing cable connections to associated equipment.
e. Internal wiring diagrams of any individual specialized components.
f. Equipment and material lists.
g. Panel Fault Level calculations.

9.8 The Contractor should take note that approval of submitted drawings does not relieve the Contractor of any responsibility for errors in design or obvious errors in drawings supplied to him by the Engineer.

10. STANDARD OF WORK, EQUIPMENT & MATERIALS

10.1 All work, equipment and materials shall conform to the requirements of the latest edition and amendments of SANS 10142-1 Code of Practice for the Wiring of premises and all other specifications detailed herein.

10.2 All equipment and material used shall be of high quality and the work shall be of a high standard of workmanship, carried out by qualified staff under proper supervision by experienced and competent officers.

10.3 If special tools are required for installation and maintenance, one set per site shall be supplied by the manufacturer.

11. CONSTRUCTION OF SWITCHBOARD / DISTRIBUTION PANELS

11.1 General

11.1.1 Rated operating voltage: 230/400VAC, 50Hz -5% to +5% of nominal voltage

11.1.2 Control Voltage:
24V DC for ET200 I/O, and all field devices
24V AC for Specialised IT security equipment
230V AC MCC control voltage,
230V AC UPS supply to PLC, PC CPUs.

11.1.3 Type of MCC: Individual fixed cubicles, single sided MCC's with rear access.

11.1.4 Fault level minimum: Design 15kA for 1 second Main Busbars
Actual: Refer to specific requirement.

11.1.5 Manufacturer shall supply SABS test certificates validating the short circuit strength of the Factory Built Assembly according to SANS 60439-1.

11.1.6 MCC to be limited to a peak 400V AC load of 850 Amp unless otherwise specified.

11.1.7 Metal-enclosed Low Voltage (LV) Switchgear and Controlgear ASSEMBLIES shall be designed, manufactured, type-tested, and routine tested in accordance with this Specification, the switchgear schedule accompanying any enquiry document to detail TPL's requirements, and in accordance with the reference documents referred to in Section 3 of this specification.

11.1.8 MCC Construction:

All items shall be made with cold rolled steel.

Frames:	Minimum thickness:	**2.5mm**
Doors:	Minimum thickness:	**2.0mm**
Covers:	Minimum thickness:	**2.0mm**
Gland Plates	Minimum thickness:	**2.0mm**

11.1.9 All doors with cut-outs are to be from 2.0mm thick material, with stiffeners where required.

11.1.10 Unless otherwise specified, all equipment shall be painted and finished using a powder coating process in accordance with SANS 1274- 2014; Table 2 - type 2 (minimum thickness 35 micron).

11.1.11 In general, the following colour standards shall be used, but shall require to be confirmed with the Engineer prior to manufacture:

Non-essential switchboards	Light Orange (Colour B26) – SANS 1091
Essential switchboards	Signal Red (Colour A11) – SANS 1091
Uninterruptible Power UPS Mounting Plates Gland Plates	Purple White Zinc Passivated

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

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

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

11.1.15 All boards, panels and cubicles provided shall be vermin and dust proof with the minimum degree of ingress protection to SANS 60529 being as follows:

i) Inside substation and motor control rooms: IP 42

ii) All other locations: IP 55.

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

11.1.17 Particular attention shall be given to the ventilation of panels, to eliminate build-up of excessive heat caused by the sun or internal heat generation. All necessary precautions shall be taken to ensure that the temperature of the air in any portion of the assembly does not rise more than 15°C above ambient air temperature.

11.1.18 All boards shall be so designed to ensure easy access to all control units, wiring etc. Access shall be possible by means of hinged or removable panels, secured to the framework by captive type screws or latches.

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

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

11.1.21 Doors shall have not less than the following points of hinging:
up to 450mm - 2 hinges,
up to 800mm - 3 hinges
more than 800mm - 4 hinges.

11.1.22 All doors shall be secured by 6mm square key latches as follows:
up to 450 mm - 2 latches,
up to 800 mm – 3 latches and
more than 800 mm – 4 latches
Any other proven design shall be submitted to TPL for approval.

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

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

11.1.25 Every door shall have a suitable gasket incorporated into the frame to ensure that the arrangement is in accordance with the required degree of protection. Sealing strips and gaskets shall be made of durable, non-hardening rubber, neoprene or other synthetic material, suitably fixed to the door or frame to ensure that the seal does not become dislodged during normal operation.

11.1.26 No circuit breaker toggles shall be permitted to project through the outside of the doors.

11.1.27 Traffolyte Identification labels shall be attached to the front of each door on the panel and will include the equipment Functional and Location Identification tag, descriptor and rating of the equipment located within.
Refer to Section 18 for details on Panel Label Specifications.

11.1.28 Due care shall be taken to ensure that the live side of the MAIN SWITCH is suitably protected so that no live conductors are exposed when the panel door is opened or the panel cover is removed. Barriers between power terminals shall be robust with high impact strength and made of material that is self-extinguishing or resistant to flame propagation.

11.1.29 All hinges and door handles shall be of the bolted on variety, shall be manufactured from non-ferrous materials or stainless steel, suitably finished and treated against corrosion by an electro-plating process and shall ensure effective electrical bonding to the enclosure is maintained. All hinges are to be of the lift off variety

11.1.30 Where possible the lock and door catch shall comprise of a combination unit. Door latching and delatching operations shall be smooth and quick, whilst ensuring proper compression of the sealing gaskets. Repeated opening and closing of the hinged doors and operations of the door locks and catches shall not cause chipping or scratching of the painted surfaces or any other blemishes to the finished boards. At least the center square key latch shall be padlockable.

11.1.31 Bolts, nuts and washers used throughout the board shall be of stainless steel or brass zinc passivated plated, with the exception of busbar bolts, nuts and lock washers which shall be of stainless high tensile steel or phosphor bronze material. The method of fastening the latches and hinges shall be such that it will not wear loose due to vibration or rough handling of the door.

11.1.32 Lifting lugs shall be provided for equipment lifts heavier than 150 kg.

11.1.33 Removable gland plates shall be provided.

11.1.33.1 These gland plates shall be of adequate thickness or construction for the cables to be terminated without distortion of the gland plate, and shall not be less than 2mm mild steel (zinc passivated).

11.1.33.2 Gland Plates shall not be mounted less than 300mm above ground floor level, alternatively a base frame of suitable depth may be provided.

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

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

11.2 CABLE ENTRY/CABLES

11.2.1 Panels shall be generally of the wall or floor standing cubicle type, suitable for cable entry from the bottom for both power and control cables. Cables shall to be glanded in the rear of the panels in cable compartments (on an individual MCC tier basis) provided. Panels shall be mounted on plinths of height minimum 100mm, sized to accommodate cable bend radius.

11.2.2 Panels shall incorporate rear cable compartments per MCC tier with the exception of the main Incomer tiers.

11.2.3 Cabling running in the rear cable compartments shall be supported at regular intervals. Spacing of these cable supports shall not be larger than the height of the smallest MCC tier.

11.2.4 Conductors passing through holes in compartments shall be protected by means of robust neoprene grommets. Bevelling of steel sheet as a substitute is not acceptable.

11.2.5 Conductors carrying currents in excess of 100 A and passing through metal shall either be all three phases (both poles of DC conductors) or the metal barrier shall be split.

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

11.2.7 Stripping of insulation shall not result in damage to the conductors, shall result in 90 degrees clean cut and insulation is not damaged.

11.2.8 Power and control terminals are to be mounted in the rear of the panel in vertical orientation.

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

11.3 INCOMER PANEL

11.3.1 The MCC Incomer panel shall be used to house fixed pattern Air Circuit breakers.

11.3.2 Main Incomer cables shall be made off directly onto stub busbars connected to the bottom of the incomer breaker by means of compression lugs.

11.3.3 Panel Incomer front doors shall be earthed and with a minimum of three un-insulated copper braid straps, of not less than 6mm² cross sectional area. The length of these straps shall be kept as short as possible. (<100mm max.). These earth straps shall be connected to the chassis / door with welded studs and without paint between the connection surfaces. (Normally the paint will have to be scraped away).

11.3.4 In an event that more than one core per phase of single or multi-core core cables is terminated in an incomer or feeder compartment, equalising busbars shall be provided to facilitate the connection. The equalising bars shall be adequately rated and braced to withstand the thermal and dynamic stresses under normal, short circuit and internal arc operating conditions and shall have been type tested as part of the assembly for all operating conditions.

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

11.3.6 Access to busbars shall be prevented by sheet steel covers.

11.3.7 Surge Protection Devices shall comply with the requirements of SANS 61643-1 and their selection, connection and application shall be in accordance with SANS 61643-12.

11.3.8 The wiring to the (ZORC) surge protective device shall be kept as short as possible <300mm. The wiring cross section shall be the maximum compatible with the size of the terminal studs and terminal box on the device. A cross section of less than 70mm² (earth cabling included) is not acceptable. Earth cabling shall be terminated directly to the Electrical Earth Bar running the entire length of the LV Panel.

11.4 PANEL COMPARTMENTS

11.4.1 Panel Compartments shall comprise of Chassis (Bucket Type) with cable connections directly onto vertical dropper busbars. The chassis (Bucket type) shall be interchangeable with other units of the same external dimensions. All cabling used shall be approved before use. All cable connections to the busbar droppers are to be suitably braced.

11.4.2 Control and PLC Interface wiring shall be routed between the front chassis (cubicles) and the rear cable compartment via slots cut in each cubicle backplane. All Control and PLC Interface wiring shall be run in suitably sized PVC Trunking in both the rear Cable compartment and individual Cubicles. Grommets shall be used to protect cabling running through panel cut outs/slots.

11.4.3 All LV Starter cubicles shall have an external operating handle interlocked with the cubicle door in order that the handle can be padlocked in the Off Position. A door lock defeat release shall be provided in order that authorised personnel may bypass the interlock when the operating handle is in the On position, for testing purposes.

11.4.4 All Panel compartment doors shall be earthed with a minimum of two un-insulated copper braid straps, of not less than 6mm² cross sectional area. The length of these straps shall be kept to be as short as possible. (<100mm max.). These earth straps shall be connected to the chassis / door with welded studs and without paint between the connection surfaces. (Normally the paint will have to be scraped away)

11.4.5 All Spare Compartments shall be arranged as indicated on approved Panel Layout diagrams, but will not need to be equipped. All accessories for the addition of a Starter unit including hinged doors, vertical busbars shall be provided. Dropper power cut outs shall be covered with steel plates.

11.4.6 Where wiring greater than 10mm² is required to be suitably braced, flexible cable (welding type) shall be used.

11.4.7 Where instruments such as ammeters, voltmeters etc. are required, these shall be mounted flush according to instrument type either on a hinged door section or separate compartment to that of the control circuitry (MCB's, fuses etc.)

11.4.8 All instrument wiring shall be contained in a flexible flame retardant sleeving where hinged sections are utilised, and shall be securely clamped to the hinged door and panel to avoid straining the connections on the instruments. All other wiring shall be loomed neatly in suitably sized PVC cable trunking.

11.4.9 Where holes are required in the chassis plates for access to the terminals in the rear, these shall be of adequate size to accommodate the wiring size and quantity for the application. Provision shall be made for additional capacity of 25 %. All panel cut-outs/slots shall be protected by means of suitably sized grommets, to ensure wiring insulation is protected from damage.

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

11.4.11 Switchgear and control-gear when mounted shall not cause injury during switching.

11.5 INTERNAL ARC CONFINEMENT

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

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

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

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

11.6 BUSBARS

11.6.1 All boards shall be equipped with a set of 3 x phase, neutral and earth busbars running the entire length of the board within a designated busbar chamber located at the top of the cabinet and continuously rated for the full load of the incoming supply switch. Busbars, risers and droppers shall be air-insulated and shall be fabricated from high-conductivity copper. Aluminium busbars will not be permitted.

11.6.2 Busbars shall be rated for a normal current equal to the incoming circuit rating, designed in accordance with the requirements of SANS 1195/BS 159 and shall comprise of a standard modular system, tested to SABS standards. Busbars shall be suitably enclosed in a busbar chamber to protect against inadvertent contact with access panels removed.

11.6.3 Busbar Chambers shall be divided into two sections, namely a rear compartment running the full length of the board and used to house both Mains Supply and Emergency Supply busbars, and a front compartment used to house Control Voltage supplies to the respective MCC Tiers. Busbar and Control Voltage chambers shall be suitably enclosed using sheet steel covers/boxing to protect against inadvertent contact. Access to the Busbar Chamber from within the Control Voltage Chambers will be prevented by the use of either sheet steel or transparent PVC covers.

11.6.4 All interconnections between busbars and control units shall be by means of fully insulated, adequately rated conductors firmly bolted to the busbar and secured to the appropriate terminals of the control units using crimped-on terminal lugs. Solid flat conductors shall be used for ratings in excess of 200 Amps.

11.6.5 Termination Points shall be easily accessible, conveniently located near the incoming and outgoing cable entries and with sufficient clearance and space to enable the incoming and outgoing cables to be connected to their corresponding terminals without difficulty or strain.

11.6.6 Terminals of all incoming and outgoing cables shall be firmly connected to terminals provided by means of crimped on terminal lugs or ferrules, unless the terminals are designed to grip the cable without causing the slaying of the conductor strands

11.6.7 The busbar current density shall not exceed 1,3 A/mm². Where relaxation of SANS 1973 has been given to permit the drilling of holes, the cross sectional area of the busbars shall be reduced by the area of the holes in determining compliance.

11.6.8 Busbars and supports shall be constructed to withstand the forces to be encountered on occurrence of fault currents up to the full fault levels specified without reference to the type or speed of operation of the protective devices used. Porcelain or glass supports are not permissible.

11.6.9 Joints and Tee-off connections in busbars shall be made by means of high tensile bolts, nuts and approved locking washers. A minimum of two such bolts shall be used per joint or tee. The joint contact areas shall be smooth, very flat and polished or silver plated for dry pointing. The joints shall not be taped in order to facilitate visual inspection and checking of bolt tensions.

11.6.10 Busbars shall be provided with phase colour markers, red, white, blue. Such colour identification may take the form of coloured bands at intervals along the busbar run of not more than 800 mm. The combined width of the colour bands per phase shall not be less than 300mm per 800mm-busbar lengths.

11.6.11 All covers, whether hinged or bolted, giving access to busbars and incoming circuits shall have the international dangerous voltage symbols placed thereon. In the event of the cover being reversible, symbols shall be placed on both sides of the plates.

11.6.12 Busbars and droppers shall be torqued after installation on site.

11.7 NEUTRAL BARS

11.7.1 The neutral bar shall be sized and rated in accordance with the provisions contained within SANS 10142-1. In a multiphase circuit the neutral conductor shall be rated to carry the maximum predictable out-of-balance current under normal operating conditions, with a minimum of 50% cross sectional area of the main busbars. The neutral bar shall be mounted on insulators and connected to the earth bar via means of an adequately rated copper connection. The bar shall be marked black at regular intervals so that identification in each panel section is possible.

11.7.2 A minimum of 6 holes per section is to be provided. High tensile phosphor bronze or passivated plated nuts, bolts and lock washers shall be provided through the earth bar at each earthing position, with at least 25% additional holes being provided for future connections, all fitted with nuts and bolts.

11.8 EARTH BARS / EARTHING

11.8.1 Earthing and bonding conductors shall be sized and installed in compliance with regulations detailed in the current SANS 10142 Standard Regulations for the Wiring of Premises and in SANS 10313 as applicable. Conductors shall comprise of multi stranded, PVC insulated cable, of gauge not less than 6mm2, cross sectional area.

11.8.2 All cabinet/cubicle doors shall be earthed to the panel earth using a braided copper conductor of not less than 6mm², cross-sectional area.

11.8.3 Each cabinet shall make provision for a suitable 'electrical earth' to be installed within the busbar chamber and comprising of a solid 50 x 5mm min copper bar running the entire length of the cabinet. The bar shall be bolted to the base framework with a minimum clearance of 40mm from the other busbars.

11.8.4 The following equipment shall be earthed directly to the electrical earth bar, via adequately sized PVC insulated copper cabling (green/yellow):

a. Electrical equipment housings/backplanes. (Where earth terminals have been provided, the earth wiring cross section shall be the maximum compatible with the size of the terminals provided. Where earth studs have been provided, the earth wiring cross section shall be in compliance with manufacturer's recommendations. Where not specified, earth cable cross sectional areas shall not be less than 6mm²).

b. Cable overall screens.

c. Electrical Power cable earth cores.
d. Cabinet chassis.
e. Transorbs. (Earth cable cross-sectional area 70-mm² min).

11.8.5 Where required, cabinets shall make provision for a suitable "instrument earth" to be installed at the bottom of the respective cabinet tier and comprising of a solid copper bar (50mm x 5mm). The bar shall be supported on robust insulated spacers, with a minimum clearance of 40mm to the sheet steel panel, and clearly labelled. The instrument or clean earth shall be insulated from the panel at all times.

11.8.6 The following equipment shall be earthed directly to the instrument earth bar, via adequately sized PVC insulated copper cabling (blue):

a. 24 V DC Power supply common rail.
b. Barrier/Isolator earth (Earth cable cross sectional area 70 mm2 min).
c. Cable individual screens

11.8.7 Earth bar specifications shall comply with the following:

a. Size: 50mm x 5mm x full length of MCC.
b. Marking: Yellow/Green (Electrical) and Blue (Instrument) at regular intervals, so that identification from each panel section is possible.

11.8.8 A minimum of 6 holes per section is to be provided. High tensile phosphor bronze or passivated plated nuts, bolts and lock washers shall be provided through the earth bar at each earthing position, with at least 25% additional holes being provided for future connections, all fitted with nuts and bolts.

11.8.9 Sufficient number of holes to be provided on bus sections for all outgoing circuits & 20% spare for double cables.

11.8.10 All panel cubicles to be bonded to each other and to the Main earth bar.

11.8.11 All metal housings must be earthed.

11.9 CONDUCTORS INSTALLED IN THE "FAULT-FREE" ZONE

11.9.1 Cable installed between the main or distribution busbars and the functional units are deemed to be unprotected "active" conductors and shall be installed and braced in such a manner that a short-circuit is unlikely to occur. The smallest conductor that may be installed in the 'fault-free-zone' is 16 mm^2 for Assemblies >10kA and 10mm^2 for Assemblies ≤10kA a detailed in SANS 1973-1 and SANS 1973-3 respectively.

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

11.9.3 Conductors installed within a fault-free zone, where they could come in contact with conducting parts, shall be protected by supplementary insulation (double insulated).

12. CONTROL TRANSFORMERS / CONTROL VOLTAGE DISTRIBUTION

12.1 Provision shall be made in the LV Panel design for the supply and installation of dual 400/230V 1Ph:1Ph Constant Voltage Transformers of suitable rating in a bypass configuration. Dual 400/230V 3Ph:1Ph CVT's may be provided where load balancing across phases is deemed a requirement.
CVT's shall be installed externally to the LV Panel and shall be fed from the Emergency Busbar / Standby Alternator Supply where available.

12.2 Where MV Starter Control & Tripping Voltage distribution is fed off of Normal/ESKOM Supply in the LV Panel, provision shall be made in the LV Panel design for the supply and installation of 400/230V 1Ph:1Ph Constant Voltage Transformers of suitable rating in a bypass configuration. CVT's shall be installed in the MV Starter Control Voltage Feeder Cubicle within the LV Panel.

12.3 Individual 230V~ Control Voltage distribution (other than Auxiliary Motor Starters) shall be fed from suitably rated double pole MCB's located in the Control Voltage Distribution Cubicle.

12.4 Motor Starter Control Voltage Distribution shall be fed from the Control Voltage Incomer directly to the respective Starter cubicles, via knife-edge disconnect terminals (both Live and Neutral) located in the Control Voltage Busbar compartment at the top of the respective MCC tiers. The control voltage disconnect terminals are to be installed in the starter panel sections only.

12.5 Provision shall be made in the LV Panel design to incorporate a 230V/230VAC UPS of adequate rating in a by-pass configuration (unless specifically stated otherwise in Contract Documentation). This UPS feed shall be used to power all Control System Equipment located in associated MV panels, LV panels and PLC Equipment Panels.

13. TERMINAL / WIRING SPECIFICATIONS

13.1 Terminals used for control and power (where required) marshalling shall be of the Klippon Type RSF1 or equivalent and shall be sized for the cross section of the incoming cable but not less than $4mm^2$. Where power cabling exceeds 10mm2 (and hence RSF1 terminals cannot be used), Klippon SAKD or equivalent terminals may be utilised.
Terminals used for PLC I/O marshalling shall be of the Klippon Type RSF1 or equivalent and shall be sized for the cross section of the incoming cable but not less than $2.5mm^2$.

13.2 Terminal end plates shall be provided on the first and last terminal of a terminal strip.

13.3 End stops shall be provided on the first and last terminal of a terminal strip.

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

13.5 All termination arrangement not in accordance with IP2X shall be provided with separate covers to act as shroud so that accidental contact is impossible when making off adjacent cables.

13.6 A maximum of 1 wire per termination side will be accepted (Except for I/O panels).

13.7 Wires terminated into terminals shall be properly lugged with the correct size lug used for the specific application - bootlace ferrules shall be used for pressure type terminals, with ring and spade lugs used for post type terminals.

13.8 Terminal arrangement and numbering shall be arranged in accordance with approved termination schedules. Terminals shall be numbered on both sides.

13.9 Terminal Rails shall be mounted with bolts or screws with tapped holes.

13.10 Spacing requirements between terminals and PVC Trunking shall be sized to accommodate core idents, with a minimum of 50mm allocated.

13.11 Internal Panel Wiring specifications:

All control wiring to be 600V Insulation.	
Control wiring:	230V AC ≥ 1.5 mm² min multistrand at 600V max.
Direct ET200 I/O	
PLC I/O wiring – from terminals:	0.5-0.75mm² fine multistrand wires at 300V max.
PLC Power Distribution wiring:	230 AC ≥ 1.5 mm² multistrand at 600V max.
	24 DC ≥1.0 mm² multistrands at 300V max.

13.12 All control wiring to be colour coded as follows:

230V AC Supply	
Live	Brown
Neutral	Black
Earth	Green/Yellow

230V Switchgear Control Circuits	
Live	Brown
Neutral	Black
Control Circuit	Grey

Earth	Green/Yellow

24V AC/DC Distribution:	Red and the symbol "+" or 24V AC
	Black and the symbol "-" or 24V AC

PLC and ET200 I/O Distribution:	
Digital Inputs/Outputs	-Grey
Analogue Inputs/ Outputs	-Violet (+)
	-White (-)
Power Earth / Panel Earth	Green / Yellow

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

13.14 Where pre-manufactured plug arrangements are supplied, the manufacturers standard colour may be used.

13.15 Cable Identification Standards: Refer to Transnet Pipelines Specification PL727 Section 8.5.

13.16 Core Ident Standards: Refer to Transnet Pipelines Specification PL727 Section 8.6.

13.17 All AC Input Wiring to D.C. Power Supplies and Transducers shall be twisted.

14. WIRING STANDARDS

14.1 Power Circuits

14.1.1 Connections between all switchgear components and busbars shall comprise of modular PVC insulated laminated high conductivity copper bars or where current and fault ratings allow, heavy duty coloured PVC insulated stranded, annealed copper conductors, complete with crimped bolted lugs.

14.1.2 Colours to be used in all instances shall be red, white and blue for phase connections, black for neutral connections and yellow/green for earth connections.

14.1.3 Conductors for power conductors shall bear the face colour along the entire length of the phase to which they are connected or may be used in a common colour provided they are phase colour coded at each end of the conductor and at every connection point.

14.1.4 All cabling and connections will be sized and rated in accordance with the relevant SANS Specifications, and as a minimum will suit the maximum full load current of the circuit breaker/fuses protecting the circuit. Minimum size of stranded conductors will be 2.5mm².

14.1.5 Unless stipulated elsewhere in Contract Documentation, all field Power cabling, inclusive of phase, neutral and earth connections, shall be terminated directly into adequately rated terminals provided in the rear of the panel cubicles/tiers and from there to the relevant ACB's, MCB's, Fuse Holders, busbars etc. Where cables exceed 70mm², connections shall be made directly onto the relevant ACB, MCB or Fuse Holder. Rating of terminals used shall exceed full load ratings by 50 % minimum.

14.2 **Control Circuits**

14.2.1 Wiring shall be comprise of multistrand, single-core PVC-insulated copper conductors, 660/1000 V grade (minimum), to SANS 1507, sized and derated where required for the currents to be carried. Single-strand conductors shall not be permitted and no conductor shall be less than 1,5mm² cross-sectional area, nor be of less than 7 strands in lay.

14.2.2 All conductors shall be identified by means of a core identification number, in conformity with the approved circuit and connection diagrams. No core ident number shall be used more than once in each panel except where electrically identical. Wires/conductors shall have the same number on either end of the wire and all wires, which are electrically identical, shall have the same wire number.

14.2.3 All circuit diagrams shall clearly identify all wire numbers on all termination/connection points.

14.2.4 Transnet Pipelines have standardised on Crutchley core ident numbering markers for electrical control wiring core identification. Core Idents shall be correctly sized to ensure a snug fit on the conductor.

14.2.5 For details of Transnet Pipelines Core Ident Numbering Standards refer to Transnet Pipelines Specification PL727 Rev 6 Section 8.6.

14.2.6 Common Terminal strips of suitable rating shall be provided at all cable and wiring entry points between Switchgear Cubicles, both front and rear, to accommodate all PVC wiring having a cross-sectional area of up to 70 mm². Allowance shall be made on these terminal strips to accommodate 25 % spare capacity minimum. Where cables exceed 70mm², connections shall be made directly onto the relevant ACB, MCB or Fuse Holder.

14.2.7 Where terminal strips are associated with the same circuit (e.g. wiring running between the front and rear of a cubicle shall be terminated into terminal rails provided), these terminal strips shall be identical in layout and terminal allocation, for ease of maintenance.

14.2.8 Rating of terminals used shall exceed full load ratings of the protection circuit by 50 % minimum. Terminals used shall incorporate spring-loaded clamping arrangements. Transnet Pipelines have standardised on "KLIPPON" type RSF 1 or equivalents.

14.2.9 Wiring for voltmeters shall be arranged in such a way that the ASSEMBLY's Fault-Free Zone integrity will not be impaired, as detailed in section 11.9 of this specification.

14.3 Cable Glanding

14.3.1 Unless stated otherwise, all cabling, inclusive of power, control, data and instrument shall be bottom entry. Cable entry shall be via pre-punched gland plates, and shall be glanded within the cabinet to which the associated cable is terminated. Glanding of cables in cabinets different to that in which the cable is terminated shall not be permitted. Spare cable entries shall be plugged using appropriately sized blanking plugs. The use of "push-out" blanking inserts to plug cable entries shall not be permitted.

14.3.2 Cable identification (panels within buildings) shall be as follows:

a) Where Cable Tags are fixed to the cable within Electrical Panels:
Grafoplast Trasp Series 130 Gull-wing transparent PVC sleeves (30mm in length), with printed text black on white background, fastened onto the cable via means of Stainless Steel cable ties. Text height to be 3mm minimum.

b) Where Cable Tags are fixed to the cable outside of Electrical Panels:
Grafoplast Targa Metal TGT System (Carrier Rail length: 58mm for 7 characters, 82mm for 11 characters, 106mm for 15 characters) 316 Stainless Steel Markers, with punched text 6 mm height minimum, fastened onto the cable via means of Stainless Steel cable ties.

14.4 Screening and EMC Measures

14.4.1 Connecting of Screen Cables:
Electrical and Instrument Overall Cable Screen wires shall be attached to electrical earth/screen bar at point of entry into panel.

14.4.2 All Screen cables shall be routed to the point of connection and may only be stripped back to enable practical connection of the cores. The cable ends with exposed screen braid shall be covered with a suitably sized insulation sleeving to prevent inadvertent contact. Cable ends shall be protected against ingress of moisture using heat shrink sleeving.

14.4.3 Instrument cable pairs shall remain twisted up to the point of connection.

14.4.4 Screen cable and panel wiring routing:

All cabling and panel wiring shall be routed in PVC trunking mounted against a back plate. Unsupported wire connections of more than 50 mm apart shall not be permitted.

14.5 **Trunking**

14.5.1 Sizing of PVC Trunking and related conductors shall comply with SABS 0142 of 1981 code of Practice Reg. 5.4.1 (f). In addition to the above requirements an additional 25% Spare capacity shall be allowed. The manufacturer shall ensure that all trunking is adequately sized.

14.5.2 Allowance shall be made during LV Cabinet Layout design to ensure that a minimum distance of 50mm is maintained between terminals and PVC Trunking, in order to ensure that conductor core idents are visible at all times.
The manufacturer shall also ensure that a space of not less than 50mm shall be maintained between trunking and any component or object.

14.5.3 Transnet Pipelines has standardised on PVC slotted trunking for use in cable and wiring marshalling
(Non IS circuits – grey in colour, IS circuits – blue in colour).

14.6 **Valve Panel Wiring**

14.6.1 Valve cables shall be glanded in the rear of the Valve Panels in gland plates located at the bottom of the panels above the plinth. Cabling shall be marshaled neatly within slotted trunking provided running up the sides of the panel tiers, the full length of the cabinet. Individual cable cores shall be terminated directly into MCB's provided. Inner PVC sheaths shall be removed before the cable enters the PVC trunking.

14.6.2 Wire ways located within the trunking will permit power cabling to pass from the front of the cabinet to the rear and shall be protected from damage via robust neoprene grommets. Bevelling of steel sheet as a substitute is not acceptable.

14.6.3 A minimum of 500mm excess length of cable shall be provided before the cable is glanded, for future re-termination of the cabling.

14.6.4 PVC Trunking shall be sized to handle 25% spare capacity.

14.6.5 For maintenance purposes, padlocking facilities shall be installed for all switch disconnection devices and provided both on the outside and the inside of the section or sub-section to lock the switch-disconnecting device in the isolated position.

14.7 **LV Distribution/Starter Panel Wiring**

14.7.1 Power and control cabling shall be glanded in the rear of the LV Panels in gland plates located at the bottom of the panels above the plinth. Cabling shall be marshaled neatly within slotted trunking provided running up the sides of the panel tiers, the full length of the cabinet. At the point of termination, the individual cable cores shall be terminated into vertically orientated terminals provided. Inner PVC sheaths shall be removed before the cable enters the PVC trunking.

14.7.2 Note that the cables shall be glanded in such a manner so as to ensure that cables do not cross from the point of glanding to the point of termination. A minimum of 500mm excess length of cable shall be provided before the cable is glanded, for future re-termination of the cabling.

14.7.3 Wire ways will permit control and power wiring to pass from the front of the cabinet to the rear - and shall be protected from damage via robust neoprene grommets. Bevelling of steel sheet as a substitute is not acceptable.

14.8 **ET 200 I/O Panel Wiring**

14.8.1 I/O INTERFACE SIGNALS – CONTROL SYSTEM

The following hard wired I/O signals are to be provided for interface with the PLC Control System:

LV PANEL GENERAL:

(Status: F31 breaker open, no voltage; UPS online, no fault; PLC PSU no alarm)

a.	F31 Breaker Closed status	CL	= 0
b.	Loss of supply voltage	UV	= 0
c.	UPS Status - Fault	FLT	= 0
d.	UPS Status - Bypass	BYP	= 1
e.	PLC PSU Status	FA	= 1

14.8.2 Discrete and analogue signals are to be clearly separated and identified in the Cabinets. Termination rails shall be divided into units on the basis of ET I/O Card Rack and Slot position.

14.8.3 Each conductor/core of a cable shall be fitted with an insulated double crimp lug of the correct size. LeGrand bootlace ferrules shall be used for pressure type terminals, with ring and spade lugs used for post type terminals.

14.8.4 Proprietary type wire strippers and crimping tools must always be used.

14.8.5 Each conductor shall be identified by a Core Identification number, which shall include the number of the terminal into which the core is to be terminated.
For details of Transnet Pipelines Core Ident Numbering Standards refer to Transnet Pipelines Specification PL727 Section 8.6.

14.8.6 All terminals shall be numbered on both sides and consecutively in accordance with design documentation. All terminal rails shall be identified by means of a terminal rail label situated at the top of the termination rail. End stops and end plates shall be used to prevent inadvertent contact with conducting surfaces.

14.8.7 All spare cores shall be terminated and identified as "spare".

14.8.8 Surge Protection:
Transnet Pipelines Pump Stations are situated in areas of high risk in terms of lightning strikes and thus adequate Surge Protection shall be required to be provided by the Contractor. Contractors are to note that responsibility for the provision of adequate surge protection lies with the Contractor and that Transnet Pipelines will not regard damage to equipment resulting from a lightning strike or power surge as unavoidable, except in instances of a "direct strike".

15. EQUIPMENT SPECIFICATIONS

Cognisance shall be taken of manufacturers derating tables for equipment located within enclosures and equipment shall be rated accordingly.

15.1 Fuse Switches

15.1.1 Fuse Switches shall be utilised only under circumstances where single phasing may be tolerated. Where single phasing may not be tolerated, only VCB's and MCB's may be utilised.

15.1.2 Combination fuse switches shall comply with SANS 60947-3 and shall be of the individually metal enclosed, triple pole, quick break, dustproof, and withdrawable type, with neutral link. Fuse switches shall afford minimum protection of IP21 or IEC 61032. Combination fuse switches shall be rated for uninterrupted duty and shall be of utilization category AC-23 as detailed in SANS 60947-3.

15.1.3 Fuse Switches shall have a lever or rotary action with a positive spring controlled opening and closing action for making or breaking the circuit under load conditions. Fuse carrier and base contacts shall be designed to give permanent high contact pressure and shall be designed to facilitate location of blown fuses without removal of the carrier. Fuse carriers and bases shall be of the highest grade phenolic mouldings to BS 771 and shall be non-flammable and non-hygroscopic, with a hard gloss black finish.

15.1.4 Three spare fuses of each rating shall be provided and fixed into a suitable cubicle on the switchboard. The door of this cubicle shall be suitably identified.

15.1.5 Switches shall be interlocked to prevent the opening of the front covers unless the switches are in the "Off" position and the closing of the switches with the covers open.

The switches shall be lockable in the "Off" position. (For details on the Switch Mechanisms, refer to Section 10.3. of this specification).

15.1.6 Switches shall comply with the following provisions:

- Double break contact on each pole
- Arc barriers on each pole
- Silver plated copper contacts
- Neutral link where required
- Mechanically operated ON/OFF indicator
- Auxiliary switch facility
- Full interchange ability of equivalent rated units

15.2 **HRC Fuse Links**

15.2.1 HRC Fuse Links shall be of the high rupturing capacity type, compliant with SANS 60947-3. Fuse links shall incorporate a visual indication device to facilitate location of blown fuses and shall be designed to clip into the fuse carrier contacts without the use of fixing screws.

15.2.2 Breaking capacity of all fuse links shall be not less than Category of duty AC.50 at 415 Volts (SANS 60947-3). The Fusing factor of the fuses shall not exceed 1.5 (SANS 60947-3 Class Q1).

15.2.3 Fuse current ratings shall be indicated on engraved 20 x 12mm white-black-white trifoliate labels in 4mm letters. The labels are to be fitted at the fuse bases and shall not be obscured by wiring.

15.2.4 Fifty- percent spare fuses of each size shall be provided in suitable cubicle on the switchboard. The door of this cubicle shall be suitably identified.

15.3 **Air Circuit Breakers**

15.3.1 Air Circuit Breakers shall be used on the incoming supply side of the distribution board and shall comply with SANS 60947-2. Transnet Pipelines have standardised on withdrawable type Circuit Breakers for all Panels rated >= 400 A, and moulded case Circuit Breakers for Panels rated < 400 Amps.

15.3.2 Circuit Breakers shall have a continuous enclosed current rating as indicated on the relevant drawings, with a minimum fault capacity of 50 kA at 415 Volts for I sec, tested for category p.2, unless otherwise specified. All switchgear supplied shall be rated for Type 2 Co-ordination (SANS/IEC 60947-4-1) i.e. capable of renewed operation after testing at rated conditional short-circuit current.

15.3.3 Air Circuit Breakers shall be of the enclosed, ventilated, independent manual spring, draw out or permanently mounted type rated for 660 Volts and shall be suitably equipped for shunt tripping from a DC Battery supply (either 50 VDC or 110 VDC).

15.3.4 Shunt tripping facilities shall be provided; such that will cause the associated high voltage transformer circuit breaker to trip when the associated air circuit breaker is tripped (to protect against fault conditions) unless otherwise specified.

15.3.5 Adjustable inverse definite minimum time (IDMT) overcurrent release facilities are required in addition to the instantaneous fault trip for the air circuit breakers.

15.3.6 Mechanical interlocks shall be provided to prevent draw out type circuit breakers from being racked in or out when closed.

15.3.7 All circuit breakers shall be provided with mechanical position indicators for both the on and off positions.

15.4 **Moulded Case Circuit Breakers.**

15.4.1 Moulded Case Circuit Breakers (MCCB's) shall be of the fixed pattern, multi-pole, free handle, air-break, non adjustable type, housed in a moulded phenolic or glass polyester case and suitable for panel mounting, and shall comply with SANS 60947-2.

15.4.2 Circuit Breaker contacts shall be made of silver alloy, with arc chutes and blowouts provided.

15.4.3 Incoming terminals of miniature circuit breakers shall be suitable for connection to a common busbar. No looped wiring shall be permitted. Miniature Circuit Breakers shall be utilised for general-purpose applications, controlling of mixed circuits of lighting, heating and actuator motors. Ganged toggles shall not be permitted to be utilised.

15.4.4 Switch operating mechanisms shall be provided for CFS's, moulded case circuit breakers (on Panel Incomers only) and motor protection circuit breakers and shall comply with the following:

- Switch operating mechanisms shall be door mounted and the switches fixed mounted.
- Switch operating mechanisms shall positively engage with the switch shaft with the door fully closed and shall be interlocked with the door so that:

i) It shall not be possible to gain access via a cover or door to any live points unless the switch is in the open position.

ii) It shall not be possible to re-close the door or cover unless the switch is in the open position. Operation of the switch with the door open is permissible.

iii) Clear indication shall be given, both with the access cover/door open/closed, as to whether the switch is in the open or closed position. This indication shall be via internationally accepted symbols i.e. I (ON) and O (OFF). Colour indication alone will not be acceptable.

iv) Operating handles shall be pad lockable in the "off' position. The mechanisms shall accept not less than two padlocks each having a shackle diameter of 6mm.

15.4.5 Circuit Breakers shall have a continuous current rating, trip rating and rupturing capacity as defined on approved engineering drawings. Operating characteristics (curves) shall be selected to suit the particular application. All breakers shall have a minimum breaking capacity of Class SABS 5 kA. All switchgear supplied shall be rated for Type 2 Co-ordination (SANS/IEC 60947-4-1) i.e. capable of renewed operation after testing at rated conditional short-circuit current.

15.4.6 The full load current rating of the current limiting circuit breakers shall not exceed 100A where current limiting circuit breakers are used to protect 5 kA circuit breakers to SANS 60947-2.

15.5 Miniature circuit breakers

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

15.5.2 Provision shall be made for mcb's applied on multiple or single phase distribution sections or sub-sections to be operated from the front of the ASSEMBLY and this shall only be possible after opening the front door.

15.5.3 With regards to lockable isolating devices, a mechanical hinged pad lockable device shall be installed to disable operation of each of the mcb's individually.

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

15.5.5 Where cascading is required, the mcb's shall be certified by the OEM that the mcb's will be protected by the upstream switching device using proven cascading methods.

15.6 Residual current circuit breakers

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

15.7 Contactors

15.7.1 Contactors shall be that of triple-pole electro-mechanically operated air-break type, with a held in pattern unless otherwise specified. Contractors shall comply with the requirements of SANS 60947-4-1 and shall withstand the thermal and dynamic effects arising from the magnitude and duration of through fault currents as dictated by the characteristics of the associated protective devices.

15.7.2 Contractors shall be classified as utilisation category AC3 uninterrupted duty for motor starting and as utilisation category AC1 intermittent duty, Class 1, 60% for heater duty. All switchgear supplied shall be rated for Type 2 Co-ordination (SANS/IEC 60947-4-1) i.e. capable of renewed operation after testing at rated conditional short-circuit current.

15.7.3 Contactors shall be fitted with the required auxiliary contacts as indicated on the circuit diagrams. These shall be rated at not less than 10 A and shall be positively driven in both directions.

15.8 Anti Condensation Heaters

15.8.1 Anti Condensation Heaters shall be provided when called for in the project specification. A suitably rated circuit breaker shall be provided to control the heaters and protect the circuit.

15.8.2 Anti Condensation Heaters shall be powered from 230V AC. Wiring from the heater elements to terminals shall be of the high temperature, insulation covered variety.

15.9 Motor Starters

15.9.1 Motor starters shall comply with SANS 60947-4-1.

15.9.2 Motors starters supplying Ex "d' motors shall comply with SANS 60079-14, clause 11.2.

15.9.3 LV motors (typically operating at 400V) shall be controlled using Transnet Pipelines approved Type 2 coordinated motor starter combinations.

15.9.4 LV motor protective devices shall as a minimum cater for the following:

a. Rated short circuit protection
b. Thermal overload with single phasing protection (motors rated up to 55kW only).
c. Electronic motor protection (motors rated 75kW and above only).

15.9.5 Typical Transnet Pipelines LV motor starting philosophy is as follows:

a. LV motors ≤ 15kW DOL starting
b. LV motors > 15kW –VSD's / Soft Starter

16. INSTRUMENT SPECIFICATIONS

All instruments shall be of a matching, flush pattern of dial dimensions 96mm x 96mm, with calibrated scale lengths of 70 mm minimum.

16.1 Ammeters

16.1.1 Combined maximum demand ammeters shall be used on major circuits only, all others being instantaneous current ammeters to suit load conditions.

16.1.2 Combined maximum demand type ammeters shall be of the moving iron type, showing instantaneous current, combined with an ambient corrected, manually reset, thermal maximum indicating ammeter, indicating the mean current reached during any 15 minute period. All three indications shall be given on concentric scales. Window cut-out scales are not acceptable. All maximum demand meters shall be fitted with a current transformer of 1 Amp secondary, unless otherwise specified. All maximum demand meters shall be fitted with a saturation transformer and marked with the appropriate phase colour to which it is connected.

16.1.3 Instantaneous current ammeters shall be of the moving iron type, showing instantaneous current. CT operated ammeters shall be 1 A full scale, calibrated to read actual primary circuit currents. The CT ratio shall be indicated on the face plate. A zero adjustment screw shall be provided. Full load or rated current shall be clearly indicated, preferably with a red line. Unless specified to the contrary, a 100% condensed over scale shall be provided for instantaneous reading instruments.

16.1.4 All ammeters shall incorporate an adjustable red pointer.

16.1.5 The intrinsic error, expressed in terms of the fiducial value on accordance with IEC 60051, shall be class 1,5 for the instantaneous readings and class 2,5 for the mean maxima.

16.2 Voltmeters

16.2.1 Voltmeters shall comprise of the moving iron, suppressed zero type, having a full scale deflection of not less than 480 Volts, unless otherwise specified. Voltmeters shall comply with IEC 60051 and BSS 89.

16.2.2 Where specified, a Selector Switch shall be provided enabling phase to phase, phase to neutral and off selection. The switch shall have a positive locating mechanism, and indicator plate included. The indicator plate shall have the positions "R-W", "W-B", "B-R" and "off" engraved on it.

16.3 Current Transformers

16.3.1 Current transformers shall be designed, constructed and tested in accordance with the requirements of SANS 61869-1; SANS 61869-2; IEC 60044-1, BS 3938 and BS 3941 respectively. Current transformers shall be on the low-impedance type and shall, where ratio, class and output requirements permit, preferably be of the ring-type bar-primary design.

16.3.2 Secondary windings of current transformers shall be earthed at one point only. Each group of current transformers (i.e. protection, metering, etc.) shall be earthed by means of bolted or insertion clamp, spring loaded terminal to the PE conductor.

16.3.3 Current transformers for ammeters and metering purposes shall be of 1A secondary unless otherwise specified. The rated output shall be selected according to the requirements of the driven circuit but shall not be less than 5 VA.

16.3.4 Current Transformers shall have accuracy's as detailed below, unless stated otherwise:

Indicating Instruments	(ammeters)	Class 5 or 3
KW Hour Meters	(commercial grade)	Class 1 or 0.55.
	(precision)	Class 0.5 or 0.2
Protection Relays		Class 10P5 or 10P10

16.3.5 Instrument transformer rating plates shall be duplicated on the main incomers of an ASSEMBLY. These duplicate plates shall be located on the sidewall of the relay compartment or adjacent to the cable termination (when the protection relay is remote from the ASSEMBLY) and shall identify the phase to which the current transformer is connected

16.4 Voltage Transformers

16.4.1 Voltage transformers shall comprise of the single-phase double wound type with an earth screen winding and shall be either air insulated or cast epoxy-resin encapsulated, in accordance with the requirements of SANS 61869-3; BS 3938 and BS 3941. Voltage adjustments over the range 95 – 105% of normal ratio shall be provided by off-circuit tappings.

16.4.2 Voltage Transformers shall be provided with isolating switches on the HV side and with protection on both the HV and LV sides.

16.4.3 Control transformers shall be rated as follows:
(Sealed-in burden of all contactors, relays, timers and lamps fed from the unit) + (Pickup burden of largest Contactor fed from the unit) + 10%.

The regulation on closing of the largest circuit with all the loads imposed on the transformer shall not exceed 5%.

One side of the transformer secondary winding or the star point shall be connected to earth via a removable bolted link.

16.4.4 Conductors that connect VT's to the busbars shall be protected by suitable fuses installed close to the busbars. The fuses used shall be accessible without the use of tools to open covers.

16.5 Aux Relays, Pushbuttons, Indicator Lamps

16.5.1 Auxiliary relays for control purposes shall be of the multiple pole type with the following features:

a. Positive-acting mechanical retaining clips. Contact friction alone, as a retaining method is unacceptable.
b. A keyed member on plug and socket sides to prevent incorrect insertion.
c. Clear and indelible markings on both the relay and base indicating the circuit reference in conformity with the associated circuit and connection diagram.

16.5.2 Pushbutton and selector switches shall comprise of the one-hole fixing, oil tight pattern and shall be keyed to prevent rotation of the assembly in the panel. Contacts shall be adequately rated for the circuit duty but shall not be less than 10 A, 230V AC or 120V DC rating.

16.5.3 Pushbutton operators shall be coloured to indicate their function as follows:

Green	To indicate action e.g. “start”, “forward”, “reverse”, “up”, “down”, “close” or to close a circuit.
Red	To stop a function e.g. “stop”, “open”, * or to open a circuit.
Black	Test functions only

In addition the operator shall carry an internationally acceptable symbol indicating its function and shall have mounted immediately above it a clear legend of its function or action.

16.5.4 Indicating lamps shall be continuously rated for a voltage of 10% in excess of the rated voltage. The LED indicator and lens assembly shall be replaceable from the exterior of the panel and shall be possible to execute this operation without the use of any special tools.

16.5.5 Indicating lamp tools shall follow the following standard:

Red	Circuit off i.e. open*, motor stopped, etc.
Green	Circuit in operation, i.e. closed*, motor running, etc.
Amber	Alarm condition, trip indication.

Indicating lamps shall render good visibility under conditions of an ambient illumination level of 400 Lux.

17. INSTALLATION

17.1 General

17.1.1 All Assemblies, including Motor Control Centres shall comply with the requirements of SANS 60439-1 Low-voltage Switchgear and Controlgear Assemblies.

17.1.2 The internal separation of circuits shall be either Form 3b or Form 4 to SANS 60439-1 (refer paragraph 7.7) All internal separation of circuits shall have an enclosure rating of IP4X or better to SABS 1222.

17.1.3 Small power Distribution Boards shall have an internal degree of separation of form 2B as detailed in SANS 60439-1.

17.1.4 All Assemblies inclusive of motor control centres but excluding Valve Distribution panels, shall in addition to the specified cubicles, make provision for at least 10 % spare unequipped cubicles complete with busbars, partitioning into compartments etc for future extensions.

17.1.5 Valve Distribution Assemblies shall be sized to cater for the following requirements:

- Provision for an additional 25 % spare valve MCB's, of which 10% shall be installed and labelled as spare.

17.1.6 The maximum height of all MCC boards shall be 2 200 mm unless otherwise approved by the Engineer. No equipment other than busbars and/or inter panel control wiring shall be installed higher than 1 800 mm above finished floor height, neither shall any equipment, other than cable glands and inter panel control wiring be installed lower than 300mm above finished floor level.
Where a base frame is utilised for cabling purposes, cables may be glanded at the panel base.

18. LABELLING

18.1 Internal Labels:

18.1.1 All components shall be labelled according to the schematic diagram, with their complete "-" Component Identification designation, in accordance with the Transnet Pipelines Label Designation Standard attached to this Specification (Ref: 631-001_LVLabelSpec, 711-001_PLCLabelSpec).

18.1.2 Where possible, labels are to be attached on the panel next to the device, but where this is not practical, then, and only then, may the label be placed directly onto the device.

18.1.3 Labels shall comprise of the Traffolyte engraved type, and fixed to the board by means of stainless steel screws or epoxy glue.

18.1.4 Finish shall comprise of black letters against a white background, except in the case of cautionary labels where letters shall appear white on a red background.

18.1.5 Labels shall be affixed in such a way that they are easily legible and not obstructed by the wiring or by other components.

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

18.2 Internal Labels: Terminal Rails

18.2.1 All Terminal Rails shall be labelled with their complete "-" Component Identification designation, in accordance with the Transnet Pipelines Label Designation Standard attached to this Specification. (Ref: 631-001_LVLabelSpec, 711-001_PLCLabelSpec).

18.2.2 Note that two types of Terminal Rail Labels have been defined as follows:

a. Field Marshalling – label identifies the Cable ID terminated into the terminals
b. PLC I/O Marshalling – label identifies the PLC ID:Rack No:Slot No of the associated I/O Card

18.2.3 Labels are to be attached to Terminal Rail Label Holders located at the top of the terminal rail.

18.3 Internal Labels: Equipment

18.3.1 Each device shall be labelled with its complete Functional Identification designation, in accordance with the Transnet Pipelines Label Designation Standard attached to this Specification. (Ref: 631-001_LVLabelSpec, 711-001_PLCLabelSpec). The labels shall be readable/visible after the wiring has been done. Where possible, labels are to be attached on the panel above the device.

18.3.2 MCB's shall be clearly labelled as to their functionality (what equipment is supplied) and supply voltage by means of a laminated legend plate located on the inside door panel of the cubicle housing the respective MCB's. In addition, all MCB's shall be individually labelled with the respective MCB No's on the front top of the breaker so as to enable rapid visual identification.

18.3.3 MCB's feeding valve actuators shall be individually labelled with the respective Valve Ops Code Identifiers on the front top of the breakers so as to enable rapid visual identification.

Refer to Section 18 for details on Label Specifications.

18.4 External Labels

18.4.1 Labels shall be provided in compliance with the OSH Act and SANS 10142-1, and as required to facilitate the operation of the equipment with no prior working knowledge of the Equipment.

18.4.2 Labels shall comprise of the Traffolyte engraved type, and fixed to the board by means of stainless steels screws. Finish shall comprise of black letters against a white background, except in the case of cautionary labels where letters shall appear white on a red background.

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

18.5 External Labels: Equipment Designation

18.5.1 Each Panel/Cubicle door shall be labelled with its complete "=/+" Identification designation, in accordance with the Transnet Pipelines Label Designation Standard attached to this Specification. (Ref: 631-001_LVLabelSpec, 711-001_PLCLabelSpec). Labels are to be attached on the panel door top right corner where possible.

18.5.2 RATING PLATE

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

- Name of the ASSEMBLY
- Plant coding
- Manufacturer
- Manufacturer's address and contact telephone number
- Standard to which it was manufactured and type-tested
- Main Busbar current rating
- Rated operating voltage
- Control voltage
- Rated impulse withstand voltage
- IP rating
- Short-circuit rating in kA and duration in seconds
- Form of separation of respective sections

18.5.3 INCOMER CUBICLES

- Incomer Equipment Designation (by Function "=" and Location "+")
- Manufacturers name or Trademark
- Rated Voltage and Current
- Short Circuit Rating and Duration I_{SC}
- Rated Insulation Voltage
- IP rating
- Type of Earthing System
- Indication of where the board is fed from

18.5.4 EQUIPMENT CUBICLES

- Equipment Designation (by Function "=" and Location "+")
- Equipment Description
- Equipment Rating

18.5.5 SMALL POWER & DISTRIBUTION CUBICLES (Fault Level < 10kA)

- DB Board Designation (by Function "=" and Location "+")
- Rated Voltage and Current
- Short Circuit Rating and Duration I_{SC}
- Indication of where the board is fed from

18.6 **EXTERNAL LABELS: WARNING**

18.6.1 The following warning & equipment labels shall be supplied as a minimum on applicable cubicle doors:

18.6.2 INCOMER CUBICLES

- Incomer Equipment Designation (e.g. F31), as well as indication of function "MAIN SWITCH". Black text on white background.
- Danger Notice giving instructions that the switch disconnector be switched off in the event of inadvertent contact or leakage.
- Where series-connected (cascaded) systems have been installed, the warning notice as detailed in SANS 10142-1:2012 Section 6.7.4 (d) shall be installed. White Text on red background.

18.6.3 EQUIPMENT CUBICLES

- Where cubicles are fed from two or more different sources, a warning label shall be installed identifying the sources
  E.g. Feed from Generator ("Emergency Supply"), UPS ("UPS Supply") or both ("Emergency & UPS Supply") White text on red background

18.6.4 All identification shall comply with As Built drawings and single line diagrams, in accordance with the Transnet Pipelines Label Designation Standard attached to this Specification. (Ref: 631-001_LVLabelSpec, 711-001_PLCLabelSpec).

18.7 **External Labels: Small Power & Distribution**

18.7.1 All Plug Sockets, Light Switches etc. shall be labelled with their complete Functional Designation, in accordance with the Transnet Pipelines Label Designation Standard attached to this Specification. (Ref: 631-001_LVLabelSpec). Labels are to be attached on the equipment front cover top right corner where possible.
In this regard, designators shall identify the MCB from which the equipment is fed e.g. = 38 DB01.Q10.

19. FACTORY ACCEPTANCE TEST PROCEDURES

19.1 Unless otherwise specified, work and acceptance tests shall be conducted on all equipment at the place of manufacture. Contractors shall be responsible for the compilation of an Acceptance Test Schedule to be used for acceptance testing of the system. The test schedule shall be comprehensive and must cover all aspects of the system to be tested and will be subject to the approval of Transnet Pipelines, prior to commencement of Pre-acceptance Testing.

19.2 The successful Tenderer will be responsible for providing all test equipment and facilities required for the period of the acceptance tests such as the Engineer may deem necessary, and to produce a report of the tests concerned.

19.3 Transnet Pipelines reserves the right to add or delete any item or test from the test result of hardware failure, re-scheduling of the test will be at the discretion of the Engineer. Transnet Pipelines reserves the right to repeat or incorporate any additional test into the test schedule.

19.4 Inspection by the TPL representative shall be performed at the following pre-defined stages of manufacture:

a. Prior to commencement of wiring
b. Prior to Functional Testing

19.5 The following tests shall be required to be performed as part of a Factory Acceptance Test Procedure:

a. A physical check of all equipment shall be made against drawings and shall include a check for tightness of connections, correct core idents etc.
b. A terminal to terminal routing check of all panel wiring shall be made against drawings and the drawings red-lined accordingly
c. Trip element ratings of all supply and distribution breakers shall be made
d. Earth leakage tripping shall be made on all circuits
e. Effectiveness of earthing system shall be checked
f. Powering up of panel shall be conducted and equipment run for a period of three hours. During this time a check for abnormal operating conditions shall be made eg. temperature and current.
g. Simulation of all discrete and analog signals from the respective field terminals into the respective PLC I/O modules

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

19.7 The following Continuity/Insulation Tests in accordance with SANS 60439-1 shall be performed by manufacturer. NB: All electronic components will require to be isolated before commencement of these insulation tests.

a. Insulation tests
b. Torque tests of all bolted Busbar connectors
c. Point to point wiring checks. (wire buzzer checks)

20. APPENDIX 1

PREFERRED EQUIPMENT LIST			
ITEM	**DESCRIPTION**	**MANUFACTURER**	**TYPE NUMBER**
1	Incoming Circuit Breakers >400A Draw Out	Schneider Electric	Masterpact
2	Incoming Circuit Breakers <400A Fixed Pattern	Siemens; Schneider	3VF; Masterpact
3	Distribution Circuit Breakers	Siemens; Schneider	3VF/3RV
4	Miniature Circuit Breakers	Siemens; Schneider	5SX2
5	Motor Protection Circuit Breakers	Siemens; ABB	3VU/3RV
6	Contactors	Siemens	3TF/3RT
7	Overloads	Siemens	3UA5/3RU1
8	Push Buttons	Siemens	3SB1
9	PLC Interface Relays	Siemens	3TX7
10	Change Over Switches	Krauss & Naimer	
11	Terminals	Klippon	SAK/RSF1
12	Fuses and Bases	Siemens	3NW3
13	Over Voltage Protection	Strike Technologies; Dehn	ZORC
14			
15			
16			
17			
18			
19			
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