SPECIFICATION FOR EARTHING AND THE PROTECTION OF BUILDINGS AND STRUCTURES AGAINST LIGHTNING.

REVISIONS		
REV	DATE	APPROVED
01	MARCH 2017	S.Sewdayal

INDEX

1.0 SCOPE

1.1 This specification covers Transnet Group Capital requirements with respect to the protection of buildings and structures against lightning and the requirements for air terminal systems, down conductors and earthing of installation of this specification

1.2 This specification applies to assessing, testing and upgrading of existing lightning protection systems and earthing on existing buildings and structures.

2.0 STANDARDS, SPECIFICATIONS AND CODES OF PRACTICE

2.1 The following publications (latest editions and amendments) are referred to herein.

South African National Standards and International Electro-technical Commission Standards

2.2 In designing the lightning protection system (LPS), the design process as discussed in SANS 62305-3, section E.4 shall be followed. Furthermore, for the design or upgrade of LPS for the existing structures, the contractor/ designer must evaluate the need for protection and cost effectiveness of implementing the protection measures as per the procedure discussed in SANS 62305-2.

2.3 The requirements of the materials, design, layout, fabrication, assembly, erection, examination, inspection and testing of an earthing system on site shall be in accordance to the relevant sections of codes listed below:-

SANS 10313	-	The protection of structures against lightning.
SANS 10089-1	-	Electrical Code for Petroleum Industries
SANS 10121	-	Cathodic Protection of Buried and Submerged Structures
SANS 10142	-	Code of practice for the wiring of premises
SANS 10123	-	The Control of Undesirable Static Electricity
SANS 10198-12	-	Installation of Earthing System
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 Distribution Systems
SANS 1063	-	Earth Rods and Couplers
SANS IEC 61000-5	-	Electromagnetic Compatibility (EMC) Part 5: Installation and Mitigation Guidelines Section 2: Earthing and Cabling
SANS IEC 61312-1	-	Protection against Lightning Electromagnetic Impulse (LEMP) Part 1: General Principles
SANS IEC 61312-2	-	Protection against Lightning Electromagnetic Impulse (LEMP) Part 2: Shielding of Structures, Bonding inside Structures & Earthing

SANS IEC 61312-4		Protection against Lightning Electromagnetic Impulse (LEMP) Part 4: Protection of Equipment inn Existing Structures
SANS IEC 61024-1	-	Protection of Structures against Lightning Part 1: General Principles
SANS IEC 61024-1-1	-	Protection of Structures against Lightning Section 1: Guide A – Selection of Protection Levels for Lightning Protection Systems
SANS IEC 61024-1-2	-	Protection of Structures against Lightning Part 1-2: Guide A – General Principles Guide B – Design, Installation, Maintenance and Inspection of Lightning Protection Systems
SANS IEC 62305 -1	-	Protection against Lightning Part 1: General Principles
SANS IEC 62305 -2	-	Protection against Lightning Part 2: Risk Management
SANS IEC 62305 -3	-	Protection against Lightning Part 3: Physical Damage to Structures and Life Hazard
SANS IEC 62305 -4	-	Protection against Lightning Part 2: Electrical and Electronic Systems within Structure

OCCUPATIONAL HEALTH AND SAFETY ACT OF 1993 (ACT 85 OF 1993).

2.4 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.

3.0 SERVICE CONDITIONS

3.1 The cable shall be designed and rated for continuous operation under the following conditions :-

3.1.1 Ambient/Environment Conditions :

3.1.1.1	Altitude	:	Sea level.
3.1.1.2	Ambient temperature	:	-5° C to +45° C (daily average +35° C).
3.1.1.3	Relative humidity	:	As high as 96%

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3.1.1.4 Lightning conditions : Severe, with a maximum lightning ground flash density (Ng)
Refer to SANS 10313, Table C.1 for specific Ng values

3.1.1.5 Exposure conditions : Salt laden, industrial atmosphere as well as hazardous gases and dust atmosphere.

3.1.1.6 Electrolytic corrosion conditions prevail in all the areas owing to the proximity of direct current traction system and cathodic protection schemes.

4.0 EQUIPMENT AND MATERIALS

4.1 Equipment and materials to be used, shall be of high quality, and shall comply with all relevant specifications, codes as mentioned in this specification as well as the Occupational Health and Safety Act of 1993(Act 85 of 1993).

4.2 Where equipment and material does not comply with the relevant specifications it shall be submitted to Transnet Project's Engineer for approval.

4.3 All materials used for the lightning protection system shall withstand the electric and electromagnetic effects of lightning current and predictable stresses without being damaged.

4.4 Materials and sizes shall be chosen bearing in mind the possibility of corrosion of either the lightning protection system or the structure to be protected.

4.5 Components of the lightning protection system may be manufactured from the materials listed in SANS 10313, provided they have sufficient electrical conductivity and corrosion resistance

5.0 LIGHTNING PROTECTION REQUIREMENTS

5.1 The contractor shall carry out the installation in accordance with SANS 10313: Code of Practice for the protection of structures against lightning and the requirements of this specification.

5.2 Where the local supply authority requirements differ from those specified herein Transnet Group Capital's Electrical Engineer shall be approached for a decision.

5.3 All equipment and material shall comply with the relevant National or International standard specification. Where equipment does not comply it shall be submitted to the Transnet Group Capital Electrical Engineer for approval.

5.4 The system of protection will be finials/air terminals, down conductors and earth spike or roof conductors, down conductors and earth spike.

5.5 The earth resistance for separate earth electrodes if down conductors are not connected to a ring earth shall be not exceed the following;

Rt = 10 Ohm for category A structures
Rt = 15 Ohm for category B and C structures.

6.0 DESIGN OF LIGHTNING PROTECTION

The designer of lightning protection shall take into consideration the following principles and requirements during the design of the system.

6.1 GENERAL PRINCIPLES

6.1.1 **Basic Principles of Lightning Protection:** the requirements of the basic principles of lightning protection as detailed in SANS 10313 shall be taken into consideration to ensure proper protection of structures against lightning.

6.1.2 **Evaluation of Risk:** The risk of lightning stroke shall be evaluated as described in SANS: IEC 62305-2, and the lightning protection system shall be designed to ensure that the loss or injury to human and loss of service to public is below minimum allowable values specified in SANS: IEC 62305-2.

6.1.3 **Effective height of a structure (He):** The effective height of the highest point shall be determined by considering the average height of building, trees and structures and land profile of the surrounding area.

6.1.4 **Ground flash density (Ng):** The ground flash density (Ng) for general buildings, structures and installations shall be estimated from the average ground flash density given in table C.1 of SANS 10313 as a general guide. For important structures and installations the value of the ground flash density shall be determined on the basis of at least 5 lightning years, or from existing records

6.1.5 **Number of flashes to structure per 100 year (Nt):** The number of flashes to structures per 100 year shall be determined taking into consideration type and the height of the structure as described in SANS 10313.

6.2 HAZARD CATEGORY

6.2.1 Buildings and structures where lightning protection system will be installed shall be categorised prior to the installation. Hazard categories are based on the nature of the building, its content and occupancy.

6.2.2 The Hazard categories are classified for the protection of buildings structures against lightning. This classification is dependent on location of the structure to be protected, the classifications are categorised as below;

Category A: High Hazard

Category A1: Structures and areas containing explosives of Category Z.

Category A2: Structures and areas classified as
a) Division 0 areas in accordance with SANS 10089: Part II, or
b) Class I, Division 0 locations in accordance with SANS 10108-2.

Category A3: Strategic control and communications installations such as airport towers

Category A4: Thatched-roof structures of historic values or that contain irreplaceable works of art or like values.

Category B: Medium Hazard

Category B1: Structures and areas containing explosives of Category X or Y.

Category B2: Structures and areas classified as
a) Division 1 or 2 areas in accordance with SANS 10089, Part II, or
b) Class I, Division 1 or 2 locations, or Class II, Division 1 location in accordance with SANS 10108.

Category B3: All structures not included in Category A and to which the public normally has access or

which are of historic value.

Category B4: Large temporary structures used for exhibitions and entertainment.

Category B5: Thatched roof dwelling houses.

Category B6: Communications towers, water towers and reservoirs.

Category B7: Caravans and Yachts.

Category B8: Buildings and areas used for livestock, fuel or flammable material.

Category C: Low Hazard

Category C1: Small buildings that are infrequently occupied.

Category C2: Dwelling houses other than thatched-roof houses.
Category C3: Farm buildings, other than those included in category B8.

6.3 ZONES PROTECTION AND SHIELDING ANGLES

6.3.1 The zone of protection shall be the area covered by either one of the following types of protection:

a) Single Vertical air terminal
b) Single horizontal air terminals
c) Area between two or more air terminals
d) Area between roof conductors.

6.3.2 The shielding angles Þ and ß are given in SABS 10313, Code of practice for the protection of buildings and structures against lightning.

6.3.3 The zone protection for Shielding Angles on Steep Slopes and High Ridges is not considered effective beyond a horizontal distance from the nearest air terminal of greater than 2He, where He is the effective height of the part of the air terminal above its immediate surroundings.

6.3.4 In roof areas away from the edges of tall structures (generally of He > 50m), shielding angles given in SANS 10313 can be used appropriate to hazard category of the roof area so protected and the effective height He of the air terminal above the roof area.

6.4 SELECTION OF AIR TERMINAL

6.4.1 Mast Protection: An air terminal consisting of one or more masts that cover the structure or area to be protected with the appropriate shielding angle will, with the possible exception of a few weak lightning strokes, successfully intercept lightning strokes.

6.4.2 Air Terminals as Part of the Structure: An air terminal as part of the structure may be one or more of the following:

a) A continuous metal roof.
b) A metal roof structure supporting a metal roof
c) The metal reinforcement in the roof of a reinforced concrete structure with peripheral conductors and finials where necessary.

d) Roof conductors and finials, where necessary, on a non-conducting roof.
e) Finials in chimney, gable ends, parapet walls, etc.

6.4.3 Air Terminal Systems For Category A Hazards: The protection is based on the principle that a primary air terminal system must be provided for the interception of major lightning strokes with, if necessary a secondary air terminal system for the interception of those weak lightning strokes that might penetrate the protection of the primary air terminal system. The secondary air terminal system shall not be intended to carry currents of major lightning strokes.

One of the following lightning protection systems shall be used as detailed in SANS 10313.

- Mast protection used as a primary air terminal
- Metal roof used as primary air terminal system
- Reinforced concrete structure used as primary air terminal system.

6.5 MASTS AND CATENARY CONDUCTORS OVER THE STRUCTURE TO BE PROTECTED

6.5.1 GENERAL

6.5.1.1 A lighting protection system consisting of free standing masts separate from the structure provides the highest degree of protection, subject to the correct positioning of the mast and to the correct choice of shielding angle.

6.5.1.2 The number and height of masts (and, where necessary, the provision of the catenary conductors between the masts) shall be based on cost, aesthetics, shielding angles and mechanical consideration

6.5.2 CLEARENCE FROM STRUCTURES

6.5.2.1 A safe clearance distance shall be kept between the mast and the catenary conductor strung between the masts and the structure to be protected by the mast or the catenary conductor. The clearance distance depends to various factors detailed in SANS 10313.

6.5.2.2 Where a common earth electrode is provided for mast and structures in close proximity, the following clearance distance “d” shall be maintained with a minimum of 100 m.

a) Between the mast and any point of structure: $d \geq 0{,}06.h$ m.
b) Between the catenary conductor and any part of the upper surface of the structure: $d \geq 0{,}1.(L/2)$ m for Category A hazard, and $d \geq 0{,}06.(L/2)$ m for Category B and C hazards.
c) Between a network of conductors and any part of the upper surface of the structure:
$d \geq 0{,}1.(D + (L – D)/N)$ m for Category A hazard, and
$d \geq 0{,}06.(D + (L – D) / n)$ m for Category B and C hazards.

Where L = *length of path measured from the base of one mast along the catenary conductor to the base of the other mast between which the catenary conductor is suspended, m.*
D = *spacing between the mesh of the network measured along the catenary conductor, m*
h = *height of structure, m*
n = *number of cross bonds between two catenary conductors.*

6.5.2.3 Where the earth electrode of a mast is separate from the metal water main, other services or the earth electrode of a structure, the following clearance distance “d” shall be maintained with a minimum of 1.00 m:

a) Between the mast and any point of the structure: d ≥ 0,06.h + 0,1. Rs m.
b) Between a horizontal catenary conductor and any part of the roof of the structure: d ≥ 0,06.)L/2) + 0,1. Rs m.

Where Rs = numerical value of the earth electrode resistance of the mast or, where masts are connected together by a catenary conductor, of the mast thus connected together, measured in ohms.

6.5.2.4 The minimum clearance distance "d" where the structure has no earth electrode and has limited water or electricity supply, shall be maintained within the following minimum clearance distances:

a) d ≥ 1, 00 m between the mast or catenary conductor and any part of the structure.
b) D ≥ 0,1 Rs m between the mast and any water pipe or electric cable, whether buried or above ground unless the mast electrode is bonded to the metal pipe of the underground water main. If Rs is not known, the clearance distance D must be at least 3m.

6.5.3 MAST PROTECTION IN THATCHED ROOFS

6.5.3.1 Thatched roofs shall be protected by one or more free-standing masts only. The zone of protection of the masts must include gable ends, chimneys, antennas, vent pipes and any other metal objects.

6.5.3.2 Telephone wires, overhead services connections to the electricity supply, or other overhead metal wires or pipes, shall not enter the structure through or close to the thatch.

6.5.3.3 On remote chimneys or gable ends close to imaginary surface of the protection zone, install a finial and down conductor well away from the thatch.

6.5.3.4 Metal wires and metal-coated insulating sheets used in the construction of the thatched roof shall be bonded together and to the earthed metal water main or electrode of the structure.

6.5.3.4 Where metals used in the construction of the roof are not bonded and earthed, a minimum clearance distance c of 1m between metals of the roof and water pipes, vent pipes, tanks, gas pipes, antennas, telephone and bell wires, bugler alarms and electrical wiring and conduits shall be maintained.

7.0 INSTALLATION

7.1 AIR TERMINALS ON THE STRUCTURE TO BE PROTECTED.

7.1.1 The purpose of an air terminal on a structure to be protected shall be to intercept lightning strokes at preferential points of an air terminal, thereby:

a) Minimizing penetration of a lightning discharge current which could have followed a random path in the roof structure with possibility of a resultant fire.
b) Preventing the loosening of masonry or the cracking of precast panels or reinforced concrete.

7.1.2 The selection of the air terminal system and the position of down conductors shall be so selected such that at any likely point of incidence of lightning stroke, there are at least two parallel paths for the current to flow to earth.

7.1.3 Parallel routes shall not be necessary in the following cases.

a) An air terminal on a small structure having only one prominent point of incident.
b) Dead-ended conductors, i.e. those conductors of the air terminal for which it is not feasible to provide a connection to a down conductor.

7.1.4 Where a peripheral roof conductor is required for the protection of the outer side edge of a structure, the conductor shall be installed as close to the edge as is practicable (preferable not more than 100mm from the outer edge)

7.1.5 Where buttresses or parapet walls are not already equipped with an air terminal in the form of continuous metal cladding or similar metalwork and peripheral conductors are to be provided at an effective height He of 15 m or more, finials shall be added on all exposed outer corners and at intervals not exceeding 30 m between outer corners. The finials shall be placed as close as possible to the outer edge, and so position the down conductors such that their connection to the peripheral conductor is close to the finial.

7.1.6 Concrete masonry chimneys or gables ends that are not protected with the appropriate shielding angle of another structure shall be protected by means of a finial or metal cap. Where the chimney or gable end is of masonry, a peripheral conductor along the gable or around the chimney shall be used instead.

7.1.7 Where it is not feasible to provide a down conductor at one end of an air terminal or a connection to another part of the lightning protection system, a dead ended conductor shall be used provided it is not longer than 10 m an generally flows a horizontal or downward course from the free end to end connected to the remaining part of the lightning protection system.

7.1.8 Where a dead-ended conductor partly flows an upwards course, the dead-ended conductor shall be not longer than 7.5 m. If the top of the protected part is considerably lower than the ridge conductor to which the dead-ended conductor is connected, a finial shall not be used at the free end, unless it is required for the enhancement of the protection of the surrounding area, in which case an additional down conductor at the free end is recommended.

7.1.9 Metal gutters shall be bonded along the outside perimeter of the roof to the nearest down conductor, or to the metal of the roof, where applicable.

7.2 METAL ROOFS AND NON-METAL ROOFS SUPPORTED BY METAL ROOF STRUCTURES

7.2.1 Structures having roofs covered with electrically continuous metal sheets do not require air terminals, but shall be earthed by down conductors.

7.2.2 Sheet metal separated from each other by insulating strips or by epoxy or plastic coating s, may be regarded as providing continuous metal roof. However where sparking between such roofing is considered undesirable because of magnetic interference, all sheets adjacent to the ridge conductor or peripheral conductor shall be bonded.

7.2.3 A non-metal roof consisting of non-combustible roofing material held by metal fasteners to a roof supporting structure of metal construction may be considered to be a metal if the metal structure is earthed by down conductors, or supported by earthed metal columns, and spacing between roof beams does not exceed 15m for Category B and C hazards.

7.3 REINFORCED CONCRETE STRUCTURES

7.3.1 Reinforced steel shall not be used as parallel paths to enable lightning discharge current to flow safely to general mass of the earth.

7.3.2 Air terminals or finials and where necessary peripheral conductors shall be installed, taking into consideration the likely points of incidence of lightning and the path of the current through internal down conductors.

7.3.3 Where the outer support columns of the structure may be regarded as continuous from roof to basement, the peripheral and air terminal conductors shall be bonded to the internal or external down conductors.

7.3.4 Peripheral conductors and finials shall be used for medium height structures with reinforced concrete. Where the peripheral conductor is on a parapet wall that surrounds a metal roof or the air terminals of other structures, the other air terminal shall be connected to the peripheral conductor, preferably close to a down conductor. The peripheral conductor and other air terminal shall be connected to internal or external down conductor.

7.3.5 If the upper edge of the structure with chimneys and cooling towers and of medium height is not metal clad, horizontal conductors around the upper circumference of the structure, equipped with finials at intervals of not more than 15 m, with a minimum of two shall be installed.

7.3.6 On tall reinforced concrete structures, one of the following shall be installed in order to increase the protective efficiency, depending on the risk and the degree of protection required, height and slenderness of the structure:

a) At intervals of not more than 10 m, install oblique finials along the upper perimeter, pointing upwards and outwards such that the tip of each finial points outwards at an angle of 30° to the vertical through the outer edge of the structure, and is at least 400mm above the structure, each finial being connected to a peripheral conductor.
b) A horizontal conductor that follows the contour of the structure and that is so raised on oblique struts of length at least 500 mm that the conductor is displaced outwards at an angle of 30° to the vertical through the outer edge of the structure.
c) Oblique finials spaced as in (a) above, positioned on a horizontal conductor arranged as in (b) above and in line with the oblique struts, each finial pointing upwards and outwards at an angle of 30 to the vertical through the outer edge of the structure, and of length such that the tip of the finial is at least 800 mm above the outer edge of the structure.

Where the structure is slender, an air terminal as in (b) or (c) above is to be preferred to that in (a)

The air terminal shall be bonded to the internal down conductor at intervals not exceeding 10m , or where the circumference exceeds 60 m, at appropriate intervals not exceeding 30m with a minimum of six bonds.

7.4 FINIALS AND ROOF CONDUCTORS

7.4.1 Roof conductors and finials shall be installed along the ridges of the roof and on other projections, in accordance to SANS10313 – code of practice for the protection of structures against lightning.

7.4.2 Protruding metal objects shall be bonded in a horizontal or in a downwards direction to the nearest roof or down conductor where the distance between the metal object and the conductor is less than 7.5m otherwise provide a separate down conductor. In all cases where the pitch of the roof is less than 30°, metal gutters and roof conductors shall be bonded or eaves conductors shall be provided.

7.4.3 In the case of large roofs of non-conducting material, additional conductors shall be installed across the surface of the roof, perpendicular to the long side of the roof and at extremely equal spaces not exceeding 15m. If the width of the roof exceeds 15m install conductors to form a grid at approximately equal spacing not exceeding 15m in either direction.

7.4.4 Roof conductors, finials and roof conductor grids shall be connected to the closest down conductor.

7.5.5 All roof conductors shall be manufactured from SABS approved single-core bare aluminium conductor with a minimum cross sectional area of 25mm^2.

7.5 DOWN CONDUCTORS

7.5.1 Down conductors shall be installed close to the point of the air terminal that are most likely to be struck by lightning and preferably run them vertically along the most direct route to the earth electrode.

7.5.2 At least two down conductors shall be provided in a building, such that in plan view no point of a structure is more than 15m from the nearest down conductor , except for masts and small structures having only one prominent point of incident, such as rondavels, these need only one down conductor.

7.5.3 Each down conductor shall be supplies with a separate earth electrode. This will reduce the current flow per down conductor, resulting in a lower voltage drop across the down conductor caused by the surge impedance of the conductor.

7.5.4 Down conductors shall not be placed close to doorways or entrances to buildings. Maintain a minimum clearance distance of the order of 1 m from the door and window frames, balustrades and other large metal objects.

7.5.5 Where down conductors deviate from a vertical route due to sharp bends and loops required to carry a conductor over eaves and parapet walls, shall be permitted, provided that all requirements stated in SANS 10313, are met.

7.5.6 Steel columns and internal metal storm water drain-pipes shall be used as down conductors only if they are joined by screwing, bolting or welding.

7.5.7 External metal stair cases, fire escapes or other large frames shall be used as down conductors if they are electrically continuous over their full height. If not electrically continuous they shall be bonded to the lightning protection system at the top or at the bottom of the framework.

7.5.8 In the case of structures of Hazard Category A, Test joints shall be installed in down conductors at convenient heights above finished ground level.

7.5.9 Internal reinforcing steel of vertical concrete column, particularly those on the outer corners can be used as down conductors, provided that the reinforcement is electrically continuous.

7.5.10 Vertically discontinuous reinforcement shall be bonded between the reinforcement of each section to provide a continuous path to ground or an external down conductor shall be installed.

7.5.11 Large external metal frames, balconies and metal cladding on the top floors of tail structures (typically 30 floors or more) that may be exposed to direct lightning strokes must be bonded to the reinforcement of the structure or to a down conductor that is connected to the reinforcement of the roof.

8.0 STATUTORY REQUIREMENTS

8.1 The Contractor shall ensure that the installation satisfies the requirements of all relevant South African Statutory Regulations

8.2 Where applicable, equipment items shall carry the SABS mark to demonstrate compliance with the regulations.

9.0 RESPONSIBILITY FOR WORK

9.1 The tenderer shall be responsible for the complete installation of the lightning protection system including testing, earthing conductors, surge protection devices, spikes etc. as required for various buildings and structures. These installations shall include the review and the upgrading of the existing lightning protection systems. Due considerations shall be taken of the effects of lightning covered herein below in clause 8, in providing the lightning protection system.

9.2 The tenderer shall undertake to repair all faults due to bad workmanship and/or the use of faulty materials and to replace all defective materials within six months after the installation date.

9.3 The tenderer shall rectify all the defects to the satisfaction of Transnet Group Capital that may become apparent during the guarantee period.

9.4 The tenderer may be required to carry out builders work such as cutting of concrete columns and coring of holes for testing of the continuity of the existing steelwork or cabling. Good contact between reinforcing bars should be ensured.

10 APPLICABLE INFORMATION

10.1 **Electrical effect** – The current discharged through the earth electrode resistance produces a resistive volt drop which may raise the potential of the system to a high value relative to true earth.

10.2 **Side-flashing** – The point of strike may be raised to a high potential, and there is a risk of flashover from the protection system to any metal or in the structure.

10.3 **Thermal effect** – The thermal effect of a lightning discharge is confined to the temperature rise of the conductor through which the current passes.

10.4 **Mechanical effect** – When a high current is discharged along parallel conductors in close proximity or along a single conductor with sharp bends, a different mechanical effect is exerted by a lightning flash. This is due to a sudden rise of 30 000K in air temperature and the resulting explosive expansion of the adjacent air in the channel along which the charge is propagated.

11.0 PROTECTION AGAINST CORROSION

11.1 The tenderer shall ensure that atmospheric, chemical and or electrolytic corrosion of copper and other metals is prevented from occurring when used for the lightning protection system.

11.2 The contact surfaces of dissimilar metals shall be kept completely dry and protected against ingress of moisture to prevent the acceleration of electrolytic corrosion.

11.3 Although copper is highly resistant to many types of chemical attack, lead coating shall be recommended wherever subjected to severe corrosion due to presence of sulphur compounds.

11.4 Stainless steel material of similar grading shall not be used unless prior approval is obtained.

12.0 TECHNICAL REQUIREMENTS

12.2.1 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: (SANS 10086-1:2001)

The embedded conductor has a cross-sectional area equal to those of the live and neutral conductors.

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. (SANS 10089-2:2002)

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 SANS 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 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 SANS 10089 Part II 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 back nut, 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 back nut, 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 SANS 10142 1&2 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 SANS 10313) 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).

12.2.2 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 cad welded 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 SANS 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.

12.3 Switchgear Room Building and Equipment

12.3.1 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 coloured, PVC insulated, stranded copper conductor, to facilitate testing of the Earth System.
- **Transformers**. By means of 70mm^2, 600-volt class, green coloured, PVC insulated, stranded copper conductor
- **MV/LV Panels**. By means of dual 70mm^2, 600-volt class, green coloured, PVC insulated, stranded copper conductors
- **Generator**. By means of 70mm^2, 600-volt class, green coloured, PVC insulated, stranded copper conductor
- **Instrument Earth**. By means of dual 70mm^2, 600-volt class, green coloured, PVC insulated, stranded copper conductors
- **Manifold Earth**. By means of dual 70mm^2, 600-volt class, green coloured, 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).

12.3.2 All secondary earthing within the substation shall be attached to this station earth bar at appropriate demarcated points.

12.4 Control Room Building and Equipment

12.4.1 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 coloured, 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.

12.4.2 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 coloured, 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.

12.4.3 Instrument and Electrical Earth systems shall be clearly labelled.

12.5 Manifold Area and Equipment

12.5.1 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 coloured, 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.

12.4.2 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 back nut, to ensure good earth contact.

12.6 Earth System Identification Standards

12.6.1 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 equal or similar approved to 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.

12.6.2 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:

- Equal or similar approved to 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

12.7 Testing

12.7.1 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 SANS.10199.

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.

12.7.2 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

13.0 INSPECTION AND GUARANTEE

13.1 Transnet Group Capital reserves the right to inspect the installation and the equipment to be used.

13.2 All lightning protection systems shall be inspected and certified by an accredited person after completion of the installation, to verify conformance as required by Code of Practice, SANS 10313.

13.3 All components of the lightning protection system shall be inspected to ensure that they are in good condition and are capable of performing their designed functions.

13.4 The tenderer shall ensure that all elements of the electrical installation have been incorporated into the protected space by bonding or extensions to the lightning protection system.

13.5 The mechanical condition of all conductors, bonds, joints and earth electrodes shall be checked and the observations noted. .

13.6 The tenderer shall undertake to repair and replace all faults and faulty materials due to bad workmanship during a period of six months.

13.8 The tenderer shall be required to guarantee the installation for a period of twelve (12) months.

END

SIGNATURE OF TENDERER: ----------

DATE: ----------

TRANSNET GROUP CAPITAL
DESIGN SERVICES

ANNEXURE 1

STATEMENT OF COMPLIANCE
(TO BE COMPLETED BY TENDERER)

This tender complies with specification TPD: 004-EARTHINGSPEC in all respects.

SIGNATURE : _____ DATE : _____

This tender complies generally with specification TPD: 004-EARTHINGSPEC, but differs from it on the following points.

_____

_____

_____

_____

_____

_____

SIGNATURE : _____ DATE : _____

Transnet Group Capital