Johannesburg Water SOC Ltd

Johannesburg Water

CONSTRUCTION OF 20ML

REINFORCED CONCRETE CARLSWALD RESERVOIR

VOLUME 2: APPENDICES

JW SPECIFICATIONS & GEOTECHNICAL REPORT

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JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

VOLUME 6 : CABLING

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6 CABLING

6.1 Scope

6.1.1 This specification covers the selection, installation, testing, marking and termination of electrical cables used for low voltage power and control installations as well as fibre-optic and copper cables for data transmission, used in process monitoring and control applications at Johannesburg Water wastewater sites.

6.2 Abbreviations

6.2.1 In this specification the following abbreviations will apply :-

SANS	:	South African National Standards
IEC	:	International Electrotechnical Commission
EN	:	Standards from the European Committee for Standardization
PLC	:	Programmable Logic Controller
UV	:	Ultra Violet
PVC	:	Poly Vinyl Chloride
OTDR	:	Optical Time Domain Reflectometer
OLTS	:	Optical Loss Test Set
SFP	:	Small Form Pluggable

MRM Ref. No. : The nominal mass in kg/m^2 multiplied by 100, used for steel wire mesh reinforcing.

6.3 Standards

6.3.1 All design standards for cabling shall be subject to the latest amendments and editions of the following standard specifications:-

SANS 10142-1	:	National Standards for the wiring of premises
SANS 1507	:	Electric Cables (300/500V to 900/3300V)
SANS 1574	:	Electric Cables Flexible cords and flexible cables
SANS 1411-1 to 7	:	Material of insulated electric cables and flexible cords
SANS 1507-1 to 3	:	Electric cables with extruded solid dielectric insulation for fixed installations (300/500V to 1900/3300V)
SANS 1803-1	:	Lugs and ferrules for insulated cables
SANS 60793	:	Optical fibres
SANS 1024:2006	:	Steel wire mesh
IEC 60793	:	Optical fibres
SANS 60794	:	Optical fibre cables
IEC 60794	:	Optical fibre cables

ISO/IEC 14763-3	:	Fibre optic testing
TIA/EIA 568-B.2-10	:	Copper data cable testing
EN 50288	:	Multi-element metallic cables used in analogue and digital communications and control
ISO/IEC SANS 11801:2002	:	Information Technology – Generic cabling for customer premises
IEC 60332-1	:	Flammability of a single vertical cable

6.4 General

6.4.1 All cables and wiring supplied must be supplied complete with fittings, accessories, etc.

6.4.2 The installation of all wires and cables must comply with SANS 10142-1:2003 and SANS 1507-1 to 3, all as amended.

6.4.3 The installation of flexible cords must comply with SANS 1574:2004 as amended.

6.4.4 All power, control and instrumentation cables (i.e. excluding fibre-optic cabling for data transmission) and wires must have untinned, annealed, multi-strand copper conductors and must comply with, SANS 1507-2 and SANS 1507-3: 2002 as amended.

6.4.5 All power, control and instrumentation cables (i.e. excluding fibre-optic cabling for data transmission) and wires must comply with the latest edition of SANS 1411-1 to 7 in terms of material of construction. The sheath of these cables must be an impermeable, halogen-free, reduced smoke emission, flame retardant, UV stabilised compound in accordance with the latest edition of SANS 1411.

6.4.6 All fibre-optic cables must comply with SANS 60793-1 for measurement and test methods, SANS 60793-2 for product specifications and SANS 60794 for generic, sectional and family specifications.

6.4.7 All blown fibre-optic installations must comply with the requirements of SANS 60794-5 which specifies the requirements of microduct optical fibre cables, microduct fibre units, microducts and protected microducts for installation by blowing for outdoor and/or indoor use.

6.4.8 All fibre-optic micro cables must comply with the requirements of SANS 60794-5-10 and all blown fibre-optic bundles must comply with the requirements of SANS 60794-5-20.

6.4.9 All blown fibre installations must be done by people who can provide proof of certified training by a recognized supplier/installer such as Lonspeare SA (Pty) Ltd. or equivalent.

6.4.10 Where fibre-optic data communication is employed, blown fibre installations will be the preferred method. Only where the use of fibre-optic cabling is unavoidable, will such cabling, instead of blown fibre assemblies be accepted.

6.4.11 All wires and cables must be from fresh stock, with the manufacturer’s original wrappings, labels and seals intact when delivered to site.

6.4.12 All cables must be inspected for visible defects or signs of damage before installation. A

checklist of cables checked for visible defects/damage must be available on request.

6.4.13 All cable ends must be sealed or capped immediately after cutting to prevent ingress of moisture, dirt, impurities, etc. This applies to cables to be installed as well as cable remaining on the drum.

6.4.14 Where cables or wires of different voltages run in the same trunking, cable trays, cable racks or cable supports, all insulation must be rated for the highest voltage being conducted.

6.4.15 For PLC panel wiring, this specification must be read in conjunction with the PLC Panels Specification (Volume 3 of the Automation And Control Standards).

6.4.16 All electrical and instrumentation cables must be tested, and the results recorded, for insulation resistance and conductivity in accordance with SANS 1507-3:2002 as amended, before installation and again before final termination. Rectification of faults in cables before final termination will be for the contractor's account.

6.4.17 For PLC I/O wiring, the minimum conductor size shall be 0.5mm^2 but contractors must ensure that all cables and wiring are capable of carrying the full system currents, inclusive of de-rating factors as specified in SANS 10142-1:2003 as amended.

6.4.18 All wiring for PLC panels, junction boxes, control panels, etc. shall be flexible, untinned, annealed, multi-strand copper wire of not less than:-

6.4.18.1 6mm² for 230V AC power between the main incoming circuit breaker of the PLC panel and the distribution AC circuit breakers.

6.4.18.2 4mm² for 24V DC power between the main DC circuit breaker of the PLC panel and the distribution DC circuit breakers.

6.4.18.3 1,5mm² for 230V AC or 110V AC power from below the distribution circuit breakers.

6.4.18.4 1,0mm² for 24V DC or AC power from below the distribution circuit breakers.

6.4.18.5 0,5mm² for all PLC I/O wiring between modules and marshalling terminals.

6.4.18.6 4,0mm² for earth drain.

6.4.19 Irrespective of the minimum wire sizes allowed in this specification, contractors must ensure that all cables and wiring are capable of carrying the full system currents, inclusive of de-rating factors as specified in SANS 10142-1:2003 as amended. If wiring of greater cross-sectional area than the sizes indicated in item 6.4.17 and 6.4.18 above are indicated on project design drawings, the larger wiring sizes will take precedence.

6.4.20 All wires and cable cores must be fitted with suitable lugs at the end of each wire or core. The fitting of lugs and ferrules must comply with SANS 1803-1:2002 as amended. No more than one wire may be crimped into a single lug. Where pin lugs are crimped onto the ends of wires, correctly sized pin lugs must be used, which fit into the terminals properly and such that the tightening of the terminal does not result in the loosening of the pin lug.

6.4.21 The use of lugs and ferrules must comply with SANS 1803-1:2002 as amended.

6.4.22 The outer sheath of all power cabling must be black and the outer sheath of all instrumentation and control cabling must be orange. The power supply to instruments

and transmitters are regarded as part of the instrumentation cabling and must therefore have an orange outer sheath. The outer sheaths of all blown fibre microduct assemblies must also be orange. Where blown fibre microduct assemblies have an outer sheath of a specific material (such as UV protection) which is not available in orange, the contractor can apply to the Engineer for a concession to use the assembly as is and only attach an orange heat-shrink (for identification purposes) at the ends where terminations are made.

6.4.23 The jacket or buffer tubes of fibre cores in fibre-optic cables must be colour coded and terminated in the following sequence:

Fibre/Tube	Colour
1	Blue
2	Orange
3	Green
4	Brown
5	Grey (Slate)
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Pink (Rose)
12	Aqua (Turquoise)

6.4.24 All fibre-optic cable will be CST (corrugated steel tape) or steel wire armoured, rodent-proof, UV protected, loose-tube, water blocking, suitable for use in direct burial and manufactured with an orange PVC sheath. The conductive steel armour of installed fibre cables shall be properly grounded to the protective earth at all termination points.

6.4.25 All blown fibre microduct assemblies installed in trenches must be suitable for direct burial in terms of strength and mechanical protection.

6.4.26 All blown fibre microduct assemblies installed on cable racks or supports above ground must have suitable mechanical protection. Suitable mechanical protection includes, blown fibre microduct assemblies on racks that are covered with metal covers, blown fibre microduct assemblies installed in metal tubing and blown fibre microduct assemblies with steel wire armouring or steel tape armouring.

6.4.27 Where blown fibre microduct assemblies are installed in buildings or in cable tunnels, such microduct assemblies must have an inner and outer sheath of fire retardant material. The outer sheath must also be low-smoke and halogen-free.

6.4.28 Where blown fibre microduct assemblies are exposed to direct sunlight, such microduct assemblies must have an outer sheath that is UV protected.

6.4.29 The contractor must take very careful note of the requirements for blown fibre microduct assemblies as outlined in items 6.4.25 to 6.4.28 above. These requirements imply that where the installation conditions change, suitable blown fibre microduct assemblies must be installed to suit the requirements of each section of the installation. The table below gives an example of the blown fibre microduct assembly requirements for various sections of an installation:

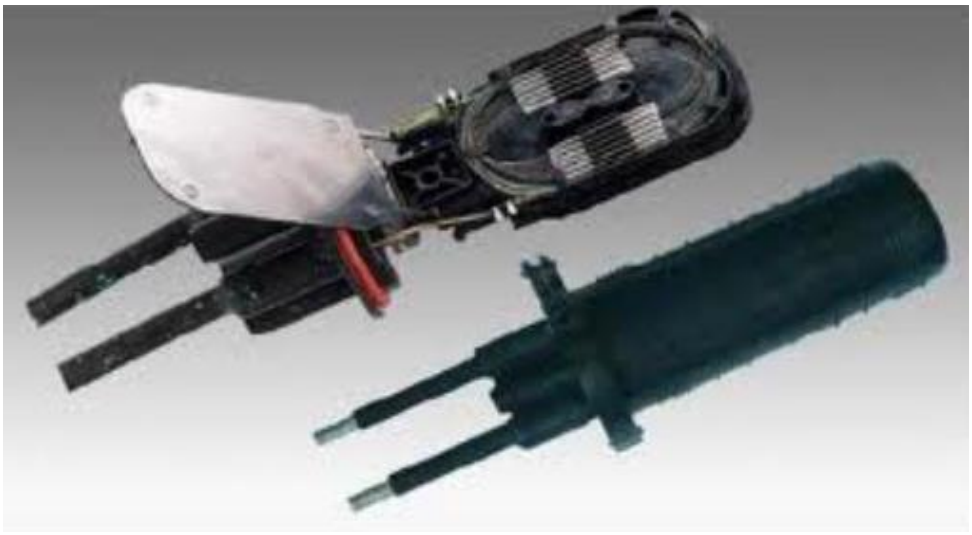
Installation Condition	Blown Fibre Microduct Assembly Requirem
In ceiling of a building	Rodent-proof, low-smoke, fire retardant, halogen
On a cable support against the side of the building	Steel wire or steel tape armoured, UV protected.
Buried in a trench	Suitable for direct burial.
On a rack in the open above ground	Mechanical protection, UV protection (if mechani protection is not steel covers or metal tubing).
On a rack inside a building	Mechanical protection, low-smoke, halogen-free, retardant.

6.4.30 All cables on racks, in trenches, in tunnels, in wire ways, on cable supports, etc. must be vermin-proof. I.e. such cables must be equipped with suitable armouring to prevent rodents or other vermin from chewing through core conductors or their insulation.

6.4.31 Bending of all cables and microduct assemblies for blown fibres must be limited to the safe criteria specified by the manufacturers.

6.4.32 Holes for cables or blown fibre microduct assemblies passing through walls, floors, partitions, ceilings, etc. must be done neatly and must be sealed off with plaster or filler as appropriate.

6.4.33 Splices in cables are prohibited, unless the route lengths exceed the maximum length of a drum or if the Engineer agrees to a splice. In such cases splices are to be made by using approved proprietary types of junction boxes, installed in an appropriate manner. For fibre-optic cables, dome splicing kits with a protection rating of at least IP68, installed in a manhole must be used. The dome splicing kit must be mounted vertically inside the manhole. The manhole must be big enough to create a 3m service loop in the each cable without exceeding the minimum bending radius of the cable and big enough to mount the enclosure appropriately in the manhole. Only fusion splices will be acceptable and ease of access to the splice must be ensured. Examples of such dome splicing kits are shown below. Alternatively the splice can be made in a junction box that complies with all the requirements of the specification “Field Junction Boxes And Panels” (Volume 19 of the Automation And Control Standards), mounted on a proper support, above ground level. Once a splice is completed, all the testing requirements of items 6.8.8 and 6.8 9 below must be complied with.



6.4.34 For blown fibre microduct assemblies, in-line splicing kits, installed in a manhole, can be used if a splice is approved by the Engineer. These kits must also have a protection rating of at least IP68. Only fusion splices will be acceptable and ease of access to the splice must be ensured. An example of such an in-line splicing kit is shown below. Alternatively the splice can be made in a junction box that complies with all the requirements of the specification “Field Junction Boxes And Panels” (Volume 19 of the Automation And Control Standards), mounted on a proper support, above ground level. Once a splice is completed, all the testing requirements of items 6.8.8 and 6.8 9 below must be complied with.

6.4.35 Splices in copper cables can be done with the aid of proprietary, resin-encapsulated splices that are completely water-proof (such as Scotch Cast or similar). Alternatively the splice can be made in a junction box that complies with all the requirements of the specification “Field Junction Boxes And Panels” (Volume 19 of the Automation And Control Standards), mounted on a proper support, above ground level.

6.4.36 Manholes used for splicing can be constructed using bricks or concrete. The manhole must allow for adequate drainage of water. All sleeves entering the manhole must be sealed with an appropriate sealer that will prevent moisture, dirt, rodents, etc. from getting into the sleeves, but the sealant must be of such material that it can easily be removed if required in future. The area around the sleeve where it enters the manhole must also be sealed to prevent moisture, mud, rodents, etc. from getting into the manhole. The manhole must not have any sharp edges that can damage cables or microduct assemblies.

6.4.37 Cables or conductors passing through holes must be fully protected against damage by

correctly fitted grommets, bushes, etc.

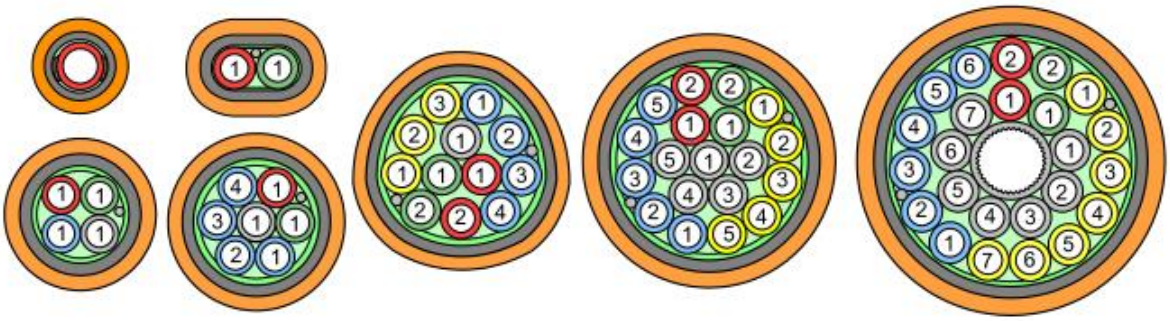
6.4.38 All cable routes, including trenches, cable racks, tunnels, cable supports, etc. must be clearly marked on drawings and submitted for approval by the Engineer. The project will not be regarded as complete until such cable route drawings have been submitted and approved.

6.4.39 The jacket or buffer tubes of fibre bundles used in blown fibre installations must be colour coded and terminated in the following sequence:

Fibre/Tube	Colour
1	Blue
2	Orange
3	Green
4	Brown
5	Grey (Slate)
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Pink (Rose)
12	Aqua (Turquoise)

6.4.40 The microducts (or inner tubes) of microduct assemblies used for blown fibre installations must be constructed from low-friction Poly Ethylene (PE). These microducts must be 5/3.5 in size (i.e. 5mm OD and 3.5mm ID). Surrounding the group of microducts, must be a layer of waterswell tape. Where steel wire armour or steel tape armour is not used, the microduct assembly must be metal-free.

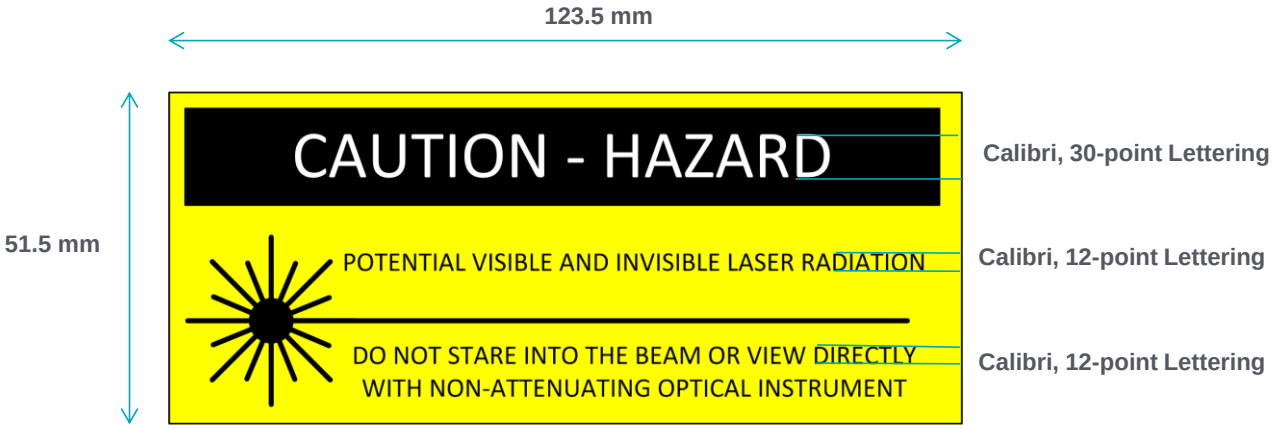
6.4.41 Microducts in microduct assemblies must be available in 1, 2, 4, 7, 12, 19 and 24 microduct assemblies and must be numbered and colour-coded as indicated in the sketch below.



6.4.42 The routes (i.e. source and destination) of microducts installed at each splice and/or termination must be noted down in detail during installation. This record must indicate for each fibre bundle that is blown into a microduct: Source – microduct colour – microduct number and Destination – microduct colour – microduct number. This detailed record must be submitted to the Engineer for approval before the blowing in of fibre bundles commences. Once it is approved, installation must be done according to this record. If a change is made, such a change must be recorded and a final “as-built” record of the installation must be produced for record purposes. The project will not be

regarded as complete until such microduct route records have been submitted and approved.

6.4.43 Wherever fibre-optic ends exist, such as at patch panels, splices, switches, transmitters, receivers, etc. and where it would be possible for a person to look into such fibre-optic ends, a danger warning as shown by the image below (or equivalent approved by the engineer), must be affixed to the panel, enclosure, etc. This label must comply with all the requirements stipulated in the JW Labelling Specification (Volume 25 of the Automation And Control Standards).



6.5 Cabling On Racks And Supports

6.5.1 Cable ladders shall, unless otherwise specified, be heavy-duty cable ladder standard pattern.

6.5.2 Cable ladders used inside Elutriation Terrace pump stations or in areas within 10m or less of Ferric Chloride, Sodium Hypochlorite or Chlorine shall be manufactured from corrosion resistant GRP (Glass Reinforced Polyester). All GRP cable ladders shall consist of a 75 mm high side rail. The minimum thickness of the material that the cable rack is to be manufactured from, shall at least be 4mm. Cross rungs shall be spaced at maximum intervals of 300 mm (centre-to-centre). All screws, bolts and nuts shall be hexagonal to ISO Metric commercial standards. All bolts, nuts, spring washers, etc. shall be 316 grade stainless steel for all these corrosive applications, and all exposed metal shall be painted with a 2-component auto-motive or industrial paint (2K poly urethane paint). Racks for instrumentation and control cabling shall contain pigmentation to produce an electric orange rack. A sample of the rack material must be approved by the engineer before manufacturing commences. Sections of rack, bends, t-pieces etc. shall be joined together with the correct dowels and resins as specified by the supplier. Wherever racking is drilled or cut, the exposed areas of GRP must be sealed with the same resin and painted with 2K paint to ensure that the material does not fray. Channels or other sections used for securing of cable ladders should also be made from GRP. All cable glands must be totally encapsulated glands (envirogland type) as shown in the example below.

6.5.3 The GRP profile (cable rack or equipment support) shall consist of pultruded (i.e. a continuous process of pulling material, such as **glass fiber** and resin, through a shaped die for manufacturing of composite materials with constant cross-section), e-glass roving and e-glass multi-axial fabric strength mat, sandwiched between polyester synthetic veil or tissue of minimum 35 gram/ m^2, all of which is encased in an isophthalic vinyl-ester resin. The resin must contain UV stabiliser. It must also contain pigment to provide colour and additional environmental protection. The rack or support must be cleaned and de-greased before it is painted with a 2K automotive or industrial poly urethane paint.

6.5.4 Cable ladders used inside de-watering buildings shall be metal cable ladders, manufactured from corrosion resistant, powder coated, 3CR12 grade stainless steel. All cable ladders shall consist of at least 75 mm high side rail. The minimum sheet thickness of the material that the cable rack is to be manufactured from shall at least be 2mm. Cross rungs shall be spaced at maximum intervals of 300 mm (centre-to-centre). All screws, bolts and nuts shall be hexagonal to ISO Metric commercial standards. All bolts, nuts, spring washers, etc. shall be 316 grade stainless steel. Metal racks for instrumentation and control cabling shall be powder coated electric orange.

6.5.5 Cable ladders used for all applications other than those mentioned in items 6.5.2 to 6.5.4 above shall be heavy-duty metal cable ladders, manufactured from corrosion resistant hot-dipped galvanised, powder coated, mild steel. All metal cable ladders shall consist of at least 75 mm high side rail. The minimum sheet thickness of the material that the cable rack is to be manufactured from shall at least be 3mm. Cross rungs shall be spaced at maximum intervals of 300 mm (centre-to-centre). All screws, bolts and nuts shall be hexagonal to ISO Metric commercial standards. All bolts, nuts, spring washers, etc. shall be 316 grade stainless steel. Racks for instrumentation and control cabling shall be powder coated electric orange.

6.5.6 Power and control cabling must always be separated by no less than 500mm. Where it is unavoidable to cross power and control cabling, such cross-overs must be done at right angles.

6.5.7 Only single layers of cable will be allowed on a rack, to reduce de-rating and for ease of replacement and/or repairs.

6.5.8 Bends in cable racks and supports shall have radii which will ensure that cables are not bent more than the safe criteria specified by the cable manufacturers. For this reason all racking, whether horizontal or vertical must include 90 degree bends where there are 90 degree direction changes in cable runs. I.e. cabling cannot be run from one straight cable rack onto another straight cable rack at 90 degrees, without a 90 degree cable rack bend.

6.5.9 Angle iron cable supports may be used. All such angle iron supports must be hot-dipped galvanised, 3CR12 grade stainless steel, 304 grade stainless steel or 316 grade stainless steel and electric orange powder coated as for the cable racks. The material will depend on the application area as specified in items 6.5.2 to 6.5.5 above.

6.5.10 No more than two cables may be run on a single angle iron support.

6.5.11 The size of angle iron supports must be such that no part of a cable projects beyond the support.

6.5.12 The minimum size of angle iron cable supports is 25mm x 25mm x 5mm.

6.5.13 Wherever possible cable racks must be mounted in the vertical plane to avoid accumulation of dirt and debris.

6.5.14 UV stabilised PVC straps may be used for cables up to 4core x 25mm^2. For cables of larger diameter than this (i.e. 30mm diameter and larger), stainless steel strapping must be used.

6.5.15 Cables must be marked at both ends with stainless steel cable markers strapped to the cable with stainless steel or UV resistant straps in a position where this number is visible without the need to move cables or equipment to view the number. Cable numbering must comply with all the requirements of the Labelling Specification (Volume 25 of the Automation And Control Standards).

6.6 Electric Cable Terminations

6.6.1 All cable terminations must be made in a professional manner and cables shall be made off by using appropriate cable glands and UV treated shrouds. Glands similar or equal to the "Enviro" glands supplied by some manufacturers must be used. All cable glands must be:

- environmentally sealed to IP68 against the ingress of water from either end of the cable gland
- constructed from brass and black nylon plastic encapsulation
- supplied complete with brass locknut
- have a loose cone bush and cone ring
- suitable for use in an Ex e application and must therefore have an Ex identification band

6.6.2 Proprietary type wire strippers shall be used and no stranded conductor shall be terminated if one or more strands have been damaged.

6.6.3 Not more than one wire shall be connected to any terminal unless the terminal can accept pin lugs on either side of a screw or unless proper connecting material is used (see examples below).

Every wire shall be marked at both ends with a numbering system as specified in the Labelling Specification (Volume 25 of the Automation And Control Design Standards), or if approved by the Engineer, and all terminating wires shall also be suitably crimped to a terminal lug. Not more than one wire shall be crimped into a single lug. Bare wire terminations will not be accepted.

6.6.4 Where lugs are bolted onto studs, suitably sized lugs must be used. Enlarged holes in lugs will not be accepted.

6.6.5 Where pin lugs are crimped onto the ends of wires, correctly sized pin lugs must be used, which fit into the terminals properly and such that the tightening of the terminal

does not result in the loosening of the pin lug.

6.6.6 Where cable cores are terminated, sufficient slack must be allowed for wiring changes, re-terminations, etc.

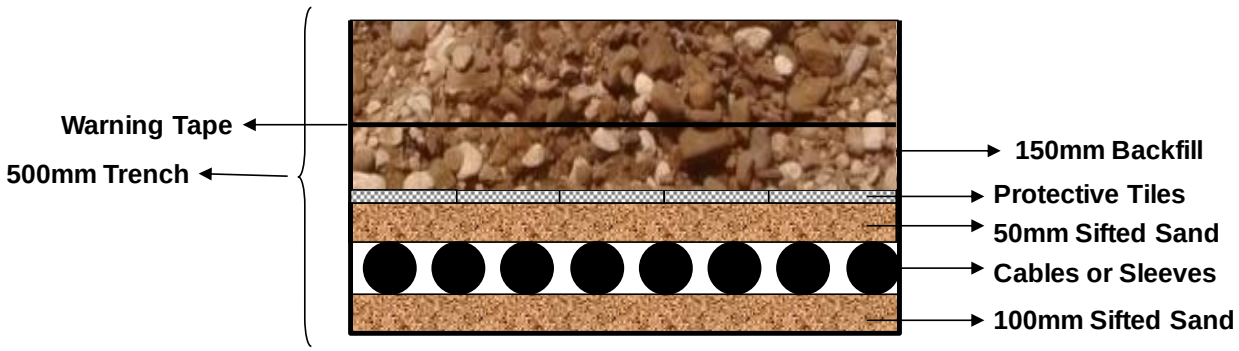
6.6.7 Where cable junction boxes, terminal boxes or terminations in instruments or any other panels in the field take place it must be ensured that such a junction box, termination box, instrument, etc. is not exposed to fire hazards from burning grass or other vegetation. If such a termination point is out in the open field (e.g. where grass grows below and/or around it), a clear area of at least 2.5m radius around this termination point must be provided. This must be a permanent clearing, such as a cement or concrete surface. A mere clearing of vegetation which can grow back again will not be accepted.

6.7 Cables, Sleeves Or Microduct Assemblies In Trenches

6.7.1 All cabling in trenches must be armoured cables to ensure sufficient mechanical protection.

6.7.2 Where cabling (electrical or fibre-optic) has to be done between points where cabling will not run along cable racks, in cable ducts or in cable tunnels, these cables or microduct assemblies for blown fibre must be run in trenches. Overhead cabling will not be acceptable. Blown fibre microduct assemblies buried in trenches must be suitable for direct burial.

6.7.3 Cable trenches must be at least 500 mm deep. There must be a 100mm layer of selective backfill (soft sifted sand), free of sharp and hard objects, at the bottom of the trench and another 50mm layer of selective backfill (soft sifted sand) directly above the cable, sleeves or microduct assemblies. Thereafter a single layer of protective pre-cast concrete tiles must be placed, without spaces between tiles, so that it forms one continuous protective layer. On top of the concrete tiles a layer of approximately150mm backfill must be placed before placing plastic cable warning tape. The warning tape must consist of a strip of polyethylene of thickness 0,04 mm and of nominal width 230 mm, completely impregnated with a pigment such that the colour of the tape is yellow, colour No B49 of SANS 1091, and having printed at intervals not exceeding 1 metre along its length, a black-triangle and an electric flash symbol and the words "Danger, Gevaar, Ingozi". Thereafter the trench must be filled with sand (see the sketch below).



6.7.4 Protective concrete tiles in trenches are there to provide protection against hand digging and warning of cables below. These tiles therefore can be paving blocks, precast wall slabs, etc. Requirements are that the tiles are not less than 38mm thick and will not break under their own weight (i.e. when the longest span of the tile or slab is supported on its ends) or when laid in the trenches by commonly accepted means.

The tiles must also not break when the soil is compacted. The tiles must cover the entire width and length of the trench. Before purchasing any protective tiles, the contractor must submit details of the proposed tiles to the engineer for approval.

6.7.5 Where trenches pass under roads, railway lines, buildings, structures, etc., the cable trench must be at least 800 mm deep and at least 110mm HDPE (High-density polyethylene) double wall, corrugated pipes must be used as sleeving.

6.7.6 Protective concrete tiles in trenches under roads must comply with all the requirements listed in item 6.7.4 above plus the concrete tiles must not break if subjected to the heavy vehicle traffic on that road. The requirements mentioned in items 6.7.5 and 6.7.6 must be extended for 2 meters beyond the edge of roads to ensure that cables and cable sleeves will suffer no damage from heavy vehicles driving beyond the edge of the road.

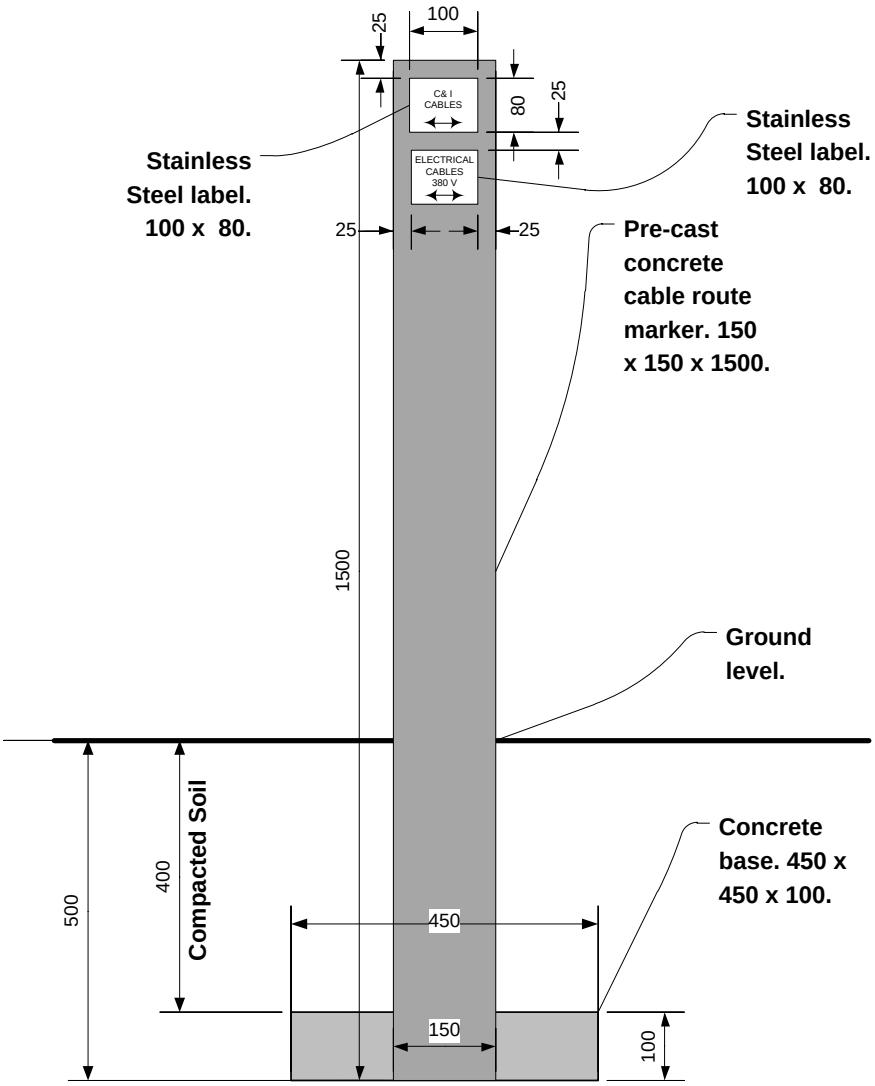
6.7.7 Cable route markers, in the form of concrete pre-cast posts, which stand 1.0m above ground level, secured in the ground, must be installed every 50m on straight runs and at every change in direction of the trench. Movable route markers will not be acceptable. The post must be equipped with a stainless steel plate engraved with “C&I CABLES” and/or “DATA CABLES” as applicable and the direction indicated in which the cables run. If there are electrical cables in the same trench, there must be a separate label engraved with “ELECTRICAL CABLES”, the voltage and the direction indicated in which the cables run. If there are data communication cables in the same trench, there must be a separate label engraved with “DATA CABLES” and the direction indicated in which the cables run. These labels must be cast into the concrete post so that they cannot be pried off.

6.7.8 At the bottom of the post a 450 x 450 x 100mm concrete base must be cast to ensure that the route marker can only be removed if it is deliberately dug out of the ground. Steel reinforcing mesh of MRM reference 156, in accordance with SANS 1024:2006 is required in the concrete and the concrete compressive strength of the base must not be less than 15 MPa. (Note: Reinforcing mesh to MRM 156 consists of 3.55mm diameter wire used to create 100 x 100 mm squares).

6.7.9 These route markers must be installed right next to the trench and not over the cables, so that the trench can be re-opened without affecting the route marker. The labels on the route marker must be on the trench side of the route marker.

6.7.10 All route markers for C&I and data cables must be painted with two coats synthetic polymer base emulsion paint for exterior use, complying with SANS 1586 Grade 1. The first coat may be thinned with no more than 10% water to aid penetration. Thereafter reflective yellow paint, suitable for use on concrete, must be applied.

6.7.11 The diagram below provides the required detail of these cable route markers.



6.7.12 Power and control cables must remain separated by at least 500mm as stated earlier. This means that power and control cables are not to be installed in the same cable sleeve.

6.7.13 Where sleeves are used for cables, an accessible manhole must be installed on every 50m straight run of sleeve and at every change of direction. This manhole can be built from bricks or concrete or it can be polyethylene Stakboxes as shown in the example below. Lids used on Stakboxes must not be made of material that is prone to theft for scrap metal (such as mild, steel, cast iron, etc.

6.7.14 The manhole must be large enough to allow proper access for cable installation. For example a manhole on a straight length of sleeving must in any event also not be smaller than 300mm x 300mm. Manholes installed at a change of direction must be large enough so that the bending radius of any cable running through it is not smaller that the manufacturer's recommended bending radius. The manhole must also not be smaller than 300mm x 300mm. If the manhole is required to make cable splices (fibre or copper) it must comply with all the requirements of item 6.4.36 above and there must be enough space so that cable loops can be comfortably left in the manhole without exceeding manufacturer's recommended minimum bending radii. Such a manhole must in any event also not be smaller than 600mm x 600mm.

6.7.15 The larger the number of cables running through the manhole, the larger the manhole must be to ensure ease of cable installation.

6.7.16 The depth below ground level at which the cables run through the manhole must not be less that the required cable burial depth as specified in item 6.7.3 above.

6.7.17 All sleeves entering the manhole must be sealed with an appropriate sealer that will prevent moisture, dirt, rodents, etc. from getting into the sleeves, but the sealant must be of such material that it can easily be removed if required in future. The area around the sleeve where it enters the manhole must also be sealed to prevent moisture, mud, rodents, etc. from getting into the manhole. The manhole must not have any sharp edges that can damage cables or microduct assemblies.

6.7.18 Where manholes are installed in roads, paving or paths where vehicles can travel, the lids and lid support structure must be strong enough so that heavy vehicle traffic from that area will have no detrimental effect on the lid or manhole. Such manhole covers must not be manufactured from material such as cast iron which is prone to theft. Metal covers filled with concrete will be acceptable.

6.7.19 The manhole covers shall either have a latch that requires a special tool to unlock and remove, or be heavy enough that lifting equipment is required to remove them (see the picture below).

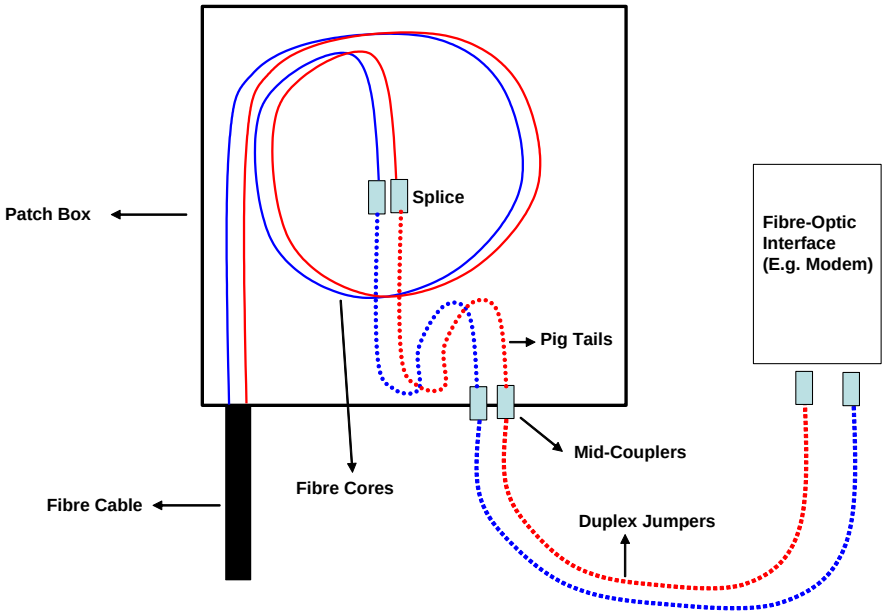
6.7.20 The base of the chamber must be made up of a dry mix of stone and cement so that it forms a hard but porous surface which is free draining for any water which enters the chamber.

6.7.21 All installed sleeves must be equipped with draw wires (or equivalent, such as nylon rope) to allow pulling in of cables. These draw wires must be non-corrosive and must be strong enough to pull the cables intended for that sleeve.

6.8 Fibre-Optic Data Cable Terminations

6.8.1 All terminations must be done by fusion splicing cores of the fibre-optic cable onto pre-fabricated “pig tails”, inside a “patch box”. The optical fibres will be terminated in the sequence specified in item 6.4.23 and 6.4.39 above.

6.8.2 The “patch box” must be equipped with mid-couplers, to accept the “pig tails” from inside the “patch box”. The other end of these mid-couplers must accept the ends of the duplex jumpers fitted with LC connectors at both ends, which in turn are connected to the fibre-optic interface (modem, switch, hub, etc.). This arrangement is to ensure that disconnecting for testing or maintenance purposes does not involve working where the splices were made (see the sketch below).



6.8.3 The “patch box” must be hardened and robust, with a minimum environmental rating of IP65 and suitable for use in industrial applications.

6.8.4 All splices must be fusion splices, and not mechanical splices.

6.8.5 All fibre-optic cables must be at least 12-core cables to ensure sufficient spare cores in the event of faults and for future modifications, additions, etc.

6.8.6 All fibre-optic data communication cables must be single mode.

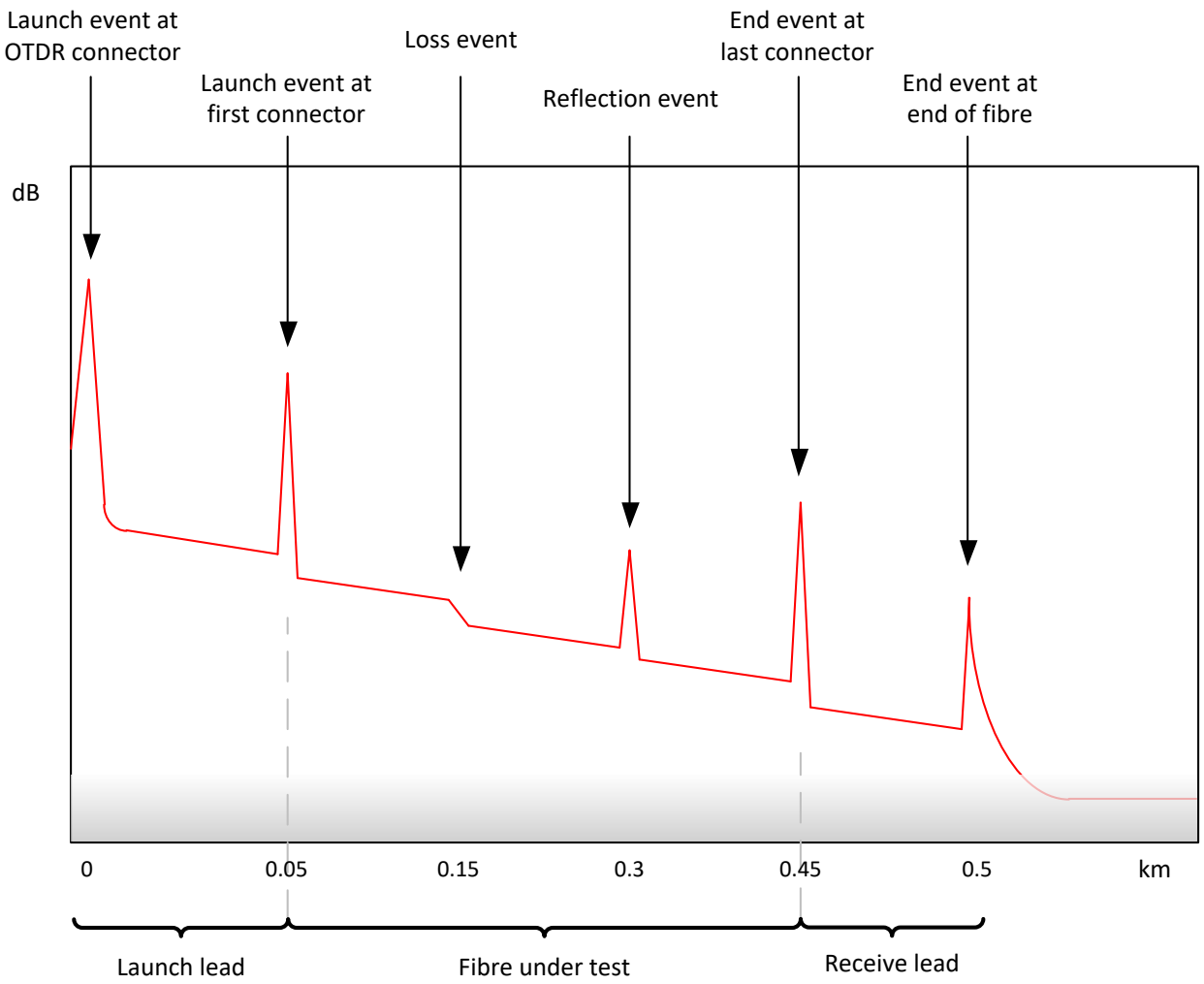
6.8.7 All fibre-optic cables supplied must comply with the relevant parts of SANS 60793/ IEC 60793 and SANS 60794/ IEC 60794 in terms of construction, installation and testing.

6.8.8 All the fibres and splices must be tested by an experienced fibre-optic network specialist and the results saved for analysis. The following tests have to be completed and test certificates have to be produced:

6.8.8.1 OTDR (optical time domain reflectometer) tests for all fibres at both 1310nm and 1550nm wavelengths, in both directions, must be completed when the cable is delivered to the site and again after the installation has been completed.

6.8.8.2 When performing OTDR tests, adequate launch and receiving leads must be used so that the splicing on both ends of the cable is clearly visible on the OTDR trace. The pulse width must be set to the minimum possible width for the distance under test and the time duration of the test must not be less than sixty (60) seconds. The scale of the trace should be set to 1.5x to 2x the length of the cable under test. The measured loss of each event must be captured in MS Excel and the original OTDR results must be saved in its native format. The results must be supplied to the engineer for approval. A typical OTDR trace is shown below.

Typical OTDR trace

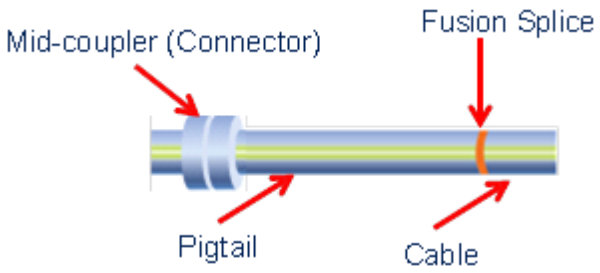


6.8.8.3 OLTS (optical loss test set) analysis with a power source and power meter must be done for all fibres after the installation has been completed. These tests must be done in both directions and the results have to be captured in MS Excel. A typical test report for one fibre is shown below. (P/Loss = Power Loss; ORL = Optical Reflection Loss).

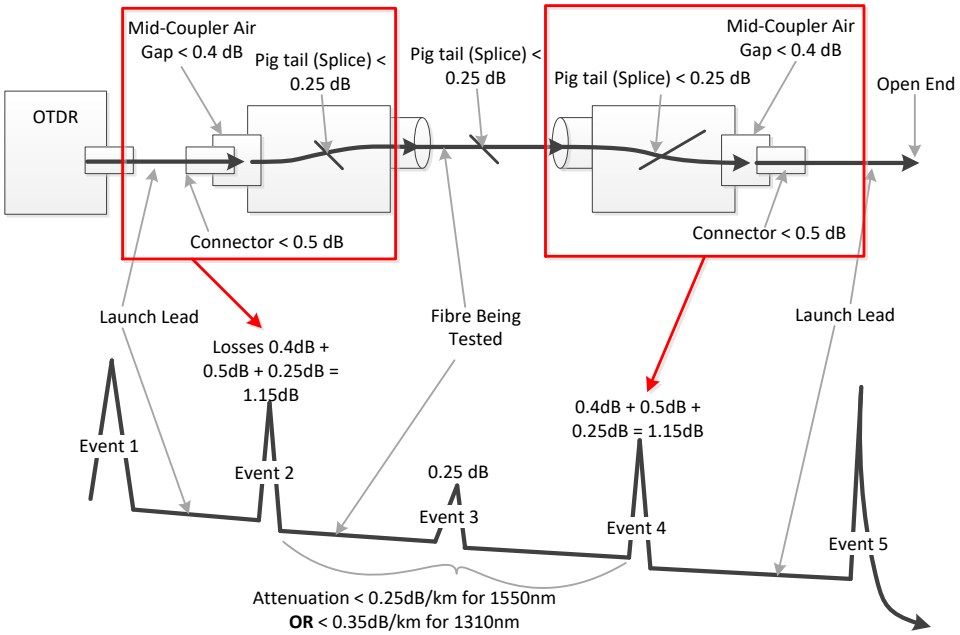
Fibre ID	Wavelength	P/Loss	P/Loss	Average	ORL A	ORL B	Length
		A->B	**B->A**				
	(nm)	(dB)	(dB)	(dB)	(dB)	(dB)	(km)

6.8.9 Losses in any fibre-optic core measured end-to-end at wavelengths of 1310nm and 1550nm, must not exceed **0.25dB per fusion splice**. The attenuation over the length of the fibre must not exceed 0.35dB/km at 1310nm and 0.25dB/km at 1550nm.

6.8.10 Losses over any connection (i.e. including mid-couplers) must not exceed 0.5dB.



6.8.11 The figure above shows a typical patch box situation (see item 6.8.2) where a pigtail is spliced onto the cable at one end and onto a connector (the mid-coupler) at the other end. These two events are too close together to be identified as separate events by an OTDR test. The overall maximum acceptable loss (at 1310 nm or 1550nm) for this combination will thus be **0.5 (connection) + 0.25 (fusion splice) = 0.75 dB**. This requirement is illustrated in the sketch below.



6.8.12 SFP's should be used so that the length of a fibre measured from one end to the other is greater than 5% of the rated maximum distance specified by the manufacturer of the SFP.

6.9 Copper Data Cables

6.9.1 All copper data cable shall be a high performance, 4-pair, Category 6, 23 AWG, unshielded, twisted pair (U/UTP) with solid copper conductors, polyolefin insulated PVC or low-flammability sheath and colour-coded pairs.

6.9.2 All copper data cable shall be tested after installation using an instrument with the capability of certifying the cable as Category 6 as specified in the TIA/EIA 568-B.2-10 industry standard.

6.10 Data Cabling General

6.10.1 All data cabling systems must be designed and installed in accordance with ISO/IEC SANS 11801:2002.

6.10.2 The cables must comply with EN 50288-5/6.

6.10.3 In terms of flammability, the cables or blown fibre microduct assemblies inside buildings (whether on racks, in ceilings, under floor panels, etc.) must comply with IEC 60332-1.

6.11 Cable Theft Prevention Measures

6.11.1 Cable theft prevention methods must be discussed with each site manager and implemented to suit the unique requirements in each area on each site.

6.11.2 Trenches in high risk areas (as defined by the relevant site manager) will have a 100mm thick layer of 20/20 concrete (i.e. 20MPA strength and 20mm aggregate size) supplied in the place of the concrete tiles.

6.11.3 Where inverted culverts with cable racking inside the culverts and concrete covers over the culverts are used the concrete covers must be constructed of reinforced concrete. The slabs must be sized to suit the width of the culvert. Each slab must weigh at least 100kg and must be provided with only two lifting holes.

6.11.4 Where cables are laid in trenches, the contractor must ensure that cable de-rating factors are strictly applied in accordance with SANS 10142-1:2003 to prevent cables from overheating. This clause is especially important to adhere to when existing inverted culverts with existing installed cables are to be filled with soil.

6.11.5 No bare copper conductors are to be used for earth conductors, earth strapping, earth bonding, etc. If possible a 5-core cable should be used to allow the 5^{th} core to be used as an earth conductor. If this is not a viable option, a 2-core PVC, SWA cable must be installed as an earth cable.

6.11.6 For short runs of earth cable (such as bonding of earth bars or earthing conductors of buildings), other cable (i.e. not copper), approved by the Engineer, must be used.

6.11.7 For high risk areas where cable racking is used, such cable racks must be covered with solid covers of the same material and complying with the same paint specification as the racking itself. Such covers must be bolted onto the rack in such a way that either special tools or a disk grinder would be required to remove these covers.

6.11.8 If any additional cable theft prevention methods are required, such requirements will be made clear to the contractor at the time of tender.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

VOLUME 5 : CLEAN POWER AND SURGE PROTECTION

Johannesburg Water (SOC) Ltd.
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Revision 14 August 2019

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Approved	Manager	T. Thabeng	09/09/2019	

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5 CLEAN POWER AND SURGE PROTECTION

5.1 Scope

5.1.1 This specification covers the selection, installation, testing, marking and termination of Uninterruptible Power Supplies and Surge Protection used for low voltage power and control installations at Johannesburg Water wastewater sites.

5.2 Abbreviations

5.2.1 In this specification the following abbreviations will apply :-

SANS	:	South African National Standards
IEC	:	International Electrotechnical Commission
PLC	:	Programmable Logic Controller
UPS	:	Uninterruptible Power Supply
CE	:	Official marking to indicate compliance with essential requirements of European Union directives
LGA	:	Local Government Association
GS	:	Geprüfte Sicherheit ("Tested Safety") is a voluntary certification mark
EMC	:	Electromagnetic Compatibility
EN	:	British Standard (BS EN)
PWM	:	Pulse Width Modulation
THD	:	Total Harmonic Distortion
Vpc	:	Volts per cell
Ah	:	Ampere hour
SPD	:	Surge Protection Device
LPZ	:	Lightning Protection Zone
ICASA	:	Independent Communication Authority of South Africa

5.3 Standards

5.3.1 All design standards for cabling shall be subject to the latest amendments and editions of the following standard specifications:-

SANS 10142-1	:	National Standards for the wiring of premises.
SANS 61643-1	:	Surge protection devices – performance requirements and testing methods
IEC 61643-1	:	Surge protection devices – performance requirements and testing methods
EN 50091-1, -2	:	General and safety requirements for UPS
EN 61000-3-2	:	Limits for harmonics

5.4 Uninterruptible Power Supply (UPS) General Requirements

5.4.1 The UPS must be a **TRUE** on-line, double conversion transformer-based unit (i.e. using a transformer which is an integral part of the UPS, on the **input** to the UPS). Hybrids, transformerless units or units with external, separate transformers will not be acceptable.

5.4.2 The UPS must employ PWM technology.

5.4.3 The UPS must have battery backup for at least 30 minutes at the **FULL RATED LOAD** of the UPS.

5.4.4 The output wave form shall be sinusoidal in form with the THD at full line load not exceeding 3%.

5.4.5 The output voltage variation must not exceed 2%.

5.4.6 Interference shall not exceed the limits laid down by ICASA.

5.4.7 The UPS must have a battery low voltage/DC cut-off which is not lower than 1,67 Vpc.

5.4.8 The UPS must be accompanied by the tenderer's proof of their ability to install, test, service, repair, etc. these devices in the field and that they have a suitable after-sales infrastructure.

5.4.9 The UPS must be equipped with an integral static bypass switch as well as an integral manual/maintenance bypass switch.

5.4.10 The UPS static bypass switch must be upgradable in order to be matched to the load inrush current.

5.4.11 The tenderer must be willing and able to provide a complete factory load test, which can be witnessed by the engineer and/or client.

5.4.12 If it is an imported UPS, the vendor must be the **ACTUAL** importer of the UPS. In other words, a middleman who cannot provide factory load tests or suitable after-sales service and backup will not be acceptable.

5.4.13 A voltage free contact rated for 230V AC at 2 amps shall be provided in all the UPS units. This general alarm relay shall be internally wired to energise when a collective signal from all alarms is healthy. Alternatively, this relay shall de-energise when a fault occurs, raw mains is interrupted or the battery power is low.

5.4.14 The UPS must be supplied complete with maintenance free batteries and with a capacity to run the system for 30 minutes at full load. If external battery packs are provided, the battery charger must be adequately rated to re-charge the additional batteries at the C/10 rate.

5.4.15 The UPS system shall be suitable for operation from a 230V AC single phase supply and must supply a nominal single phase 230 Volt, 50 Hz output.

5.4.16 Tenderers must satisfy themselves that the UPS rating is adequate to supply all the equipment which they are offering.

5.4.17 The units shall be able to sustain an overload of 125% for one minute or 150% for ten seconds whereupon it shall switch itself off. A full short circuit shall cause the unit to switch off without sustaining damage.

5.4.18 The UPS must be able to operate normally in an ambient service temperature of 0ºC to +35ºC and a relative humidity of 5 to 95% non-condensing at 1500 to 3000m above sea level.

5.4.19 The rated output voltage must be user selectable from 220/230/240V.

5.4.20 The output frequency must not vary by more than 3Hz.

5.4.21 All labelling must comply with the requirements as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

5.5 UPS Rating

5.5.1 The UPS should be able to supply a load with a power factor of 0.7 to unity. Tenderers must submit both the VA and Wattage rating of each UPS offered.

5.5.2 The UPS efficiency must be no less than 89% from zero to full load.

5.5.3 The UPS must be suitably rated to supply all the required equipment specified in this tender and any attached specifications and provide backup to this equipment for no less than 30 minutes at full load. Even if the equipment does not require it however, the UPS must not have a rating of less than 3kVA.

5.6 UPS Backup Batteries

5.6.1 Tenderers must state the exact number of batteries that will be used.

5.6.2 Tenderers must state the type of batteries that will be used.

5.6.3 Tenderers must state the Ah rating of the batteries that will be used.

5.6.4 Tenderers must state the design life of batteries that will be used (3-5years, 10 years, etc.).

5.7 UPS Standards

5.7.1 All imported UPSs must have a CE rating.

5.7.2 The UPS must have CE, LGA/GS markings.

5.7.3 The UPS must comply with safety conformance to EN-50091-1.

5.7.4 The UPS must have EMC conformance to EN-50091-2 and EN-61000-3-2.

5.8 UPS Data Sheets

5.8.1 The tenderer must complete the data sheet below with his tender:

Technical Data Sheet: UPS

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model (E.g. true on-line, double conversion)	
Transformer-based unit (Y/N?)	
Technology employed (E.g. pulse width modulation)	
Output voltage variation	
Output frequency variation	
UPS rating (VA and Watts)	
UPS efficiency from zero to full load	
Maximum harmonic distortion at full load	
Overload handling capabilities (E.g. “x”% load for “y” minutes)	
Power backup period from batteries at full rated load	
Compliance with standards rating and markings (E.g. “Yes, full compliance” or “No”.	
Tenderer to provide complete factory load test that can be witnessed by the Engineer?	
Staff available for installation, testing and backup service?	
Number of batteries to be used	
Type of batteries to be used	
Ah rating of batteries	
Design life of batteries	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

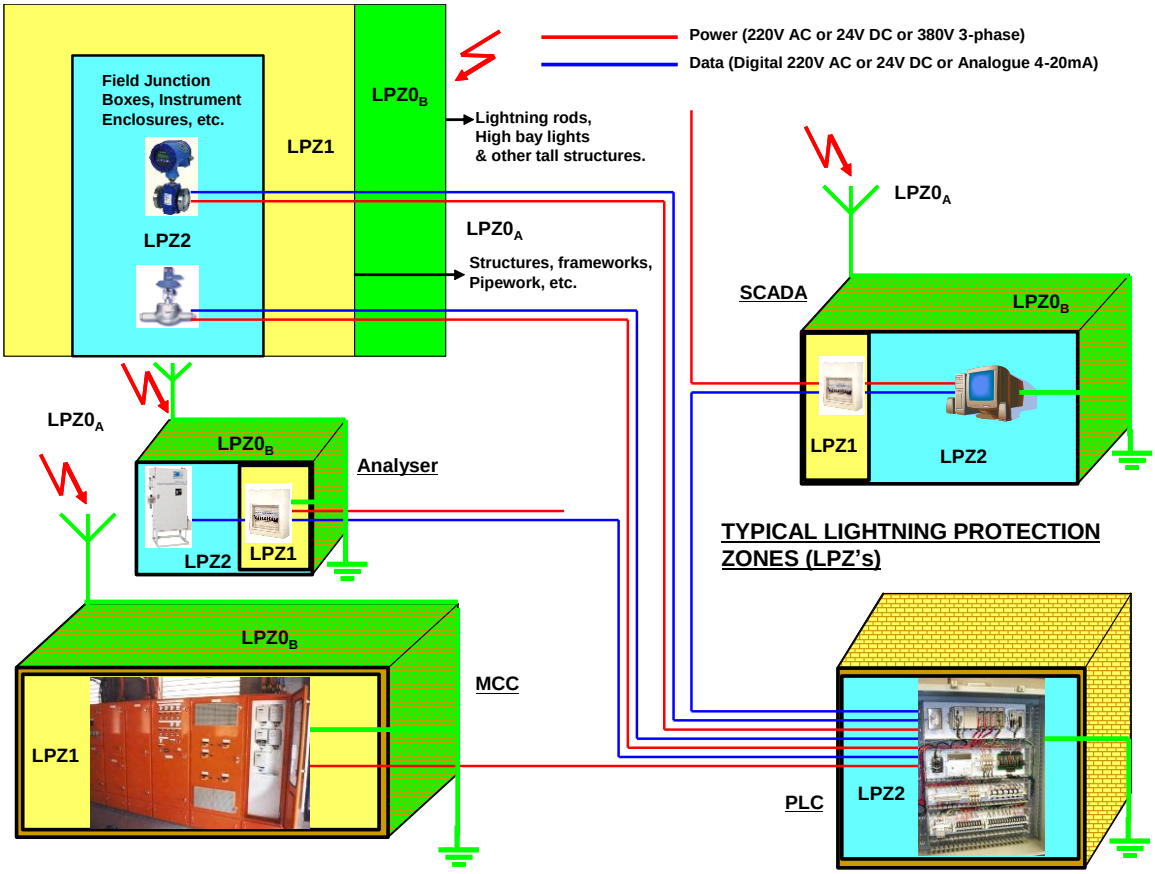
5.9 Surge Protection General

5.9.1 All labelling must comply with the requirements as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

5.9.2 The **Protection Level** required (i.e. Level I, Level II or Level III-IV in accordance with Table L.2 in SANS 10142-1:2003 Annex L) needs to be established for every installation where there is doubt about these requirements. This requirement looks at the consequential loss resulting from potential lightning hazards. Generally for all JHB Water wastewater sites in the Gauteng area, Level III-IV will suffice. In other words, a lighting impulse level of 100kA (10/350µs) needs to be considered when designing protection systems.

5.9.3 The function of the Surge Protection Device (SPD) is to prevent damage from occurring to the electrical and electronic devices due to destructive currents and voltages arising from extraneous events such as lightning discharges, switching surges etc. All lightning and surge protection must comply with SANS 10142-1:2003 Annex L, SANS 61643-1/IEC 61643-1 and any other specifications referred to in SANS 10142-1:300 Annex L.

5.9.4 The definition of lightning protection zones (LPZs), as specified in SANS 61643-1/IEC 61643-1, must be used to determine the **Class** of SPD to be used (i.e. Class I, Class II or Class III in accordance with SANS 61643-1/IEC 61643-1). These classes (also referred to as IEC Classes or IEC Category Classes or Types) define the surge handling ability which SPDs must have for use in each Class.



5.9.5 Notwithstanding the requirements of SANS 10142-1:2003 Annex L, the surge handling ability of the SPDs installed in the various LPZs for JHB Water applications must be as follows:

At the Interface Between:	IEC Class SPD Required	Min. Required SPD Rating
LPZ 0_A and LPZ 1	Class I	For Single Units: I_{imp} = 50kA (10/350 µs) for SPDs between PHASE and NEUTRAL I_{imp} = 100kA (10/350 µs) for SPDs between NEUTRAL and PE and For Combination Units: I_{imp} = 25kA (10/350 µs) per channel
LPZ 0_B and LPZ 1	Class II	I_{sn} = 20kA (8/20 µs) for SPDs between PHASE and NEUTRAL I_{sn} = 12kA (10/350 µs) for SPDs between NEUTRAL and PE
LPZ 1 and LPZ 2	Class III	I_{sn} = 5kA (8/20 µs)

Where: I_{imp} = The standard impulse current curve with a 10/350 µs waveform
I_{sn} = The nominal discharge current or peak value of the current flowing through the SPD. It has an 8/20 µs impulse current waveform.

5.9.6 All SPDs used must limit the voltage to less than two times the nominal operating voltage for systems below 60V (AC or DC) and for systems above 60V it must limit the voltage to the values given in Table L.1 in SANS 10142-1:2003 Annex L.

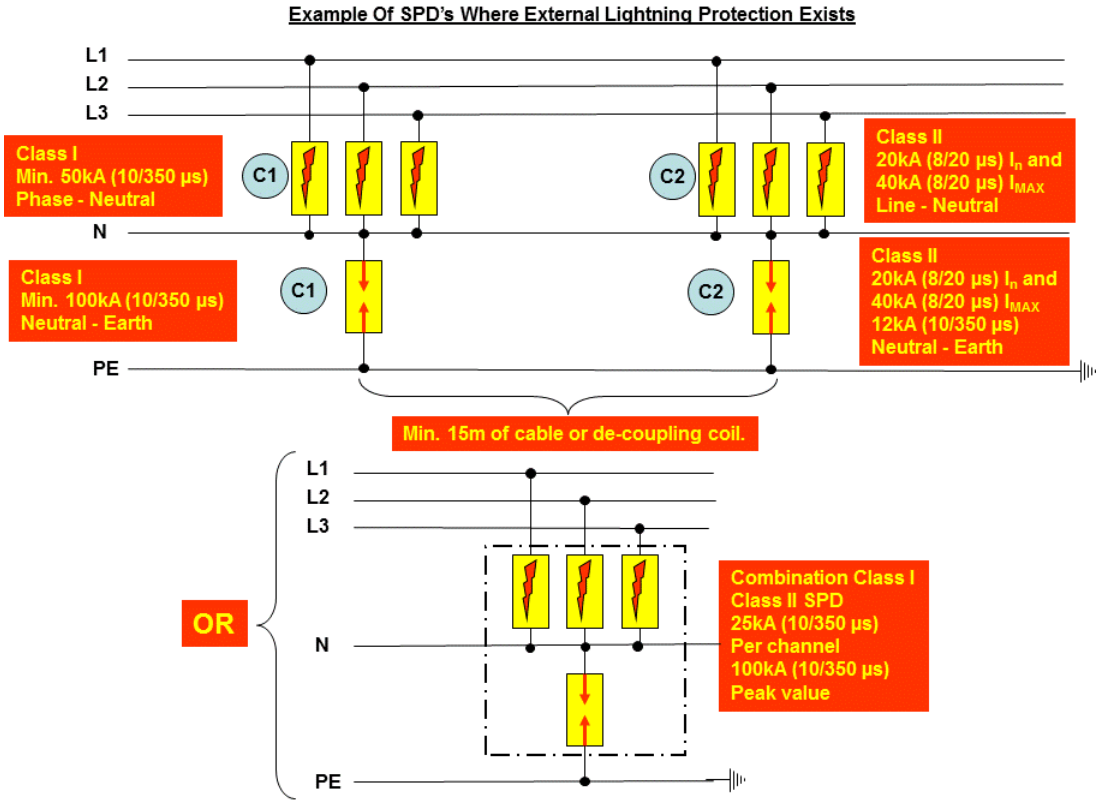
5.9.7 In order to ensure that individual protective devices are selectively effective, i.e. each protection stage only takes on the amount of interference energy which it is designed for, if one protection stage is faced with the threat of an energy overload, the upstream, more powerful arrester must “respond” and thus take over the discharge of the interference energy.

5.9.8 Even though surge arresters (i.e. Class II and Class III devices), by definition, are only tested to pulse waveforms of 8/20 µs, it is imperative to determine the ability of the device to carry an impulse current of the partial lightning currents with the waveform 10/350 µs for the co-ordination between surge arrester (i.e. Class II and Class III devices) and lightning current arrester (i.e. Class I devices), and also for the SPD.

5.9.9 All SPDs must be DIN rail mounted.

5.9.10 Should the building (where the PLC, distribution board, etc. and surge protection is installed) have external lightning protection, then a combination of Class I lightning current arresters (min. rating of 50kA (10/350 µs) each phase to neutral) plus one Spark Gap (min. rating of 100kA (10/350 µs) neutral to earth) and Class II nominal discharge current I_n = 20kA (8/20 µs) and maximum discharge current I_{MAX} = 40kA (8/20 µs), non-linear surge arresters from each phase to neutral and one Spark Gap, nominal discharge current I_n = 20kA (8/20 µs) and maximum discharge current I_{MAX} = 40kA (8/20 µs) surge arresters must be installed as per SANS 10142-1:2003 Annex L (see the diagram below). In all other cases a minimum of Class II SPDs are required.

5.9.11 These surge arresters (Class I and II or combination Class I/Class II above) must be installed from each Phase to Neutral and from Neutral to Earth. It must be borne in mind that if Class I **and** Class II SPDs are used, a minimum of 15m of cabling is required between these two systems for de-coupling. Another alternative is to use the correct coils available on the market to simulate the 15m difference. Preference will however be given to **combination** Class I and Class II units with pluggable modules because this eliminates coils and long cables and it allows replacement/inspection without the need to disconnect cables.



5.9.12 For Class I lightning arresters the minimum conductor size is 16mm^2 and pre-fusing of 315 Amps is required if the upstream protection is greater than 250 Amps. Fuses must be connected in series with the SPDs and must have the same fault current level or higher than that of the panel or board where they are installed.

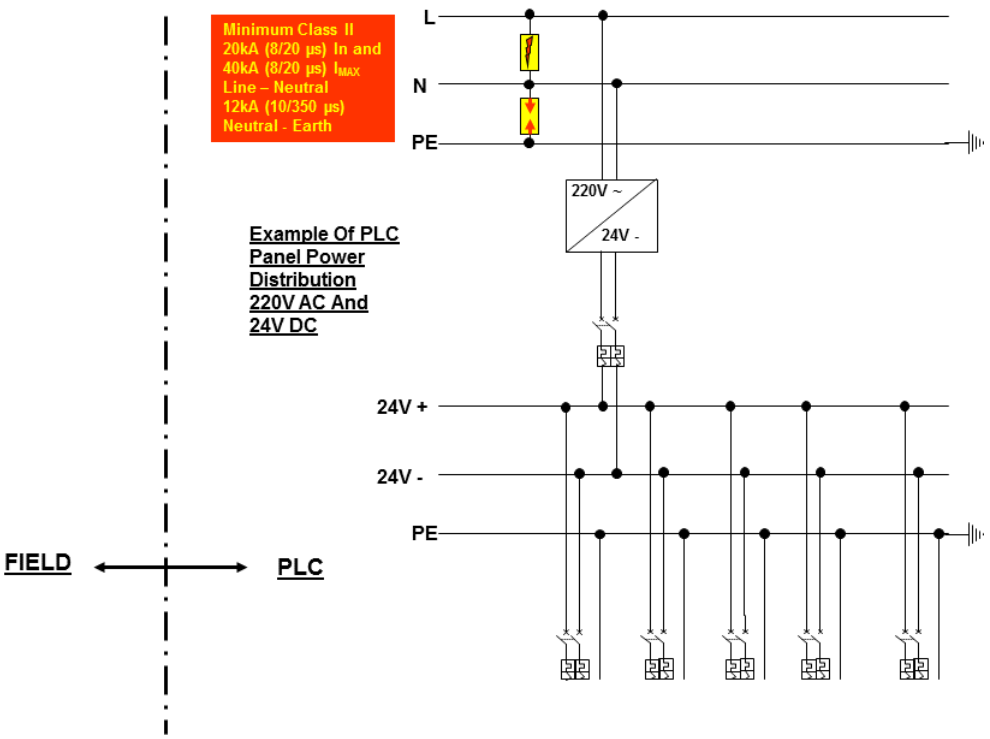
5.9.13 For Class II the minimum conductor size is 6mm^2 and pre-fusing of 125 Amps is required if the upstream protection is greater than 250 Amps. Fuses must be connected in series with the SPDs and must have the same fault current level or higher than that of the panel or board where they are installed.

5.10 Surge Protection On Mains Power

5.10.1 If there is no external lightning protection on the building, the protection units on the mains supply of the PLC panel must consist of at least IEC Category Class II, nominal discharge current I_n = 20kA (8/20 µs) and maximum discharge current I_{MAX} = 40kA (8/20 µs), non-linear surge arresters from each phase to neutral and one Spark Gap, nominal discharge current I_n = 20kA (8/20 µs) and maximum discharge current I_{MAX} = 40kA (8/20 µs), surge arrester from neutral to earth (same arrangement as the example shown above).

5.10.2 All the surge arresters must be DIN rail mounted and must comply with IEC 61643-1 (other designations, SANS 61643-1 and SANS IEC 61643-1) and there must be visual indication if the unit is over stressed (i.e. it has failed).

5.10.3 The spark gap must be able to withstand surges of 12kA (10/350 µs) and must specifically bond between neutral and earth.



5.11 Surge Protection On Field I/O

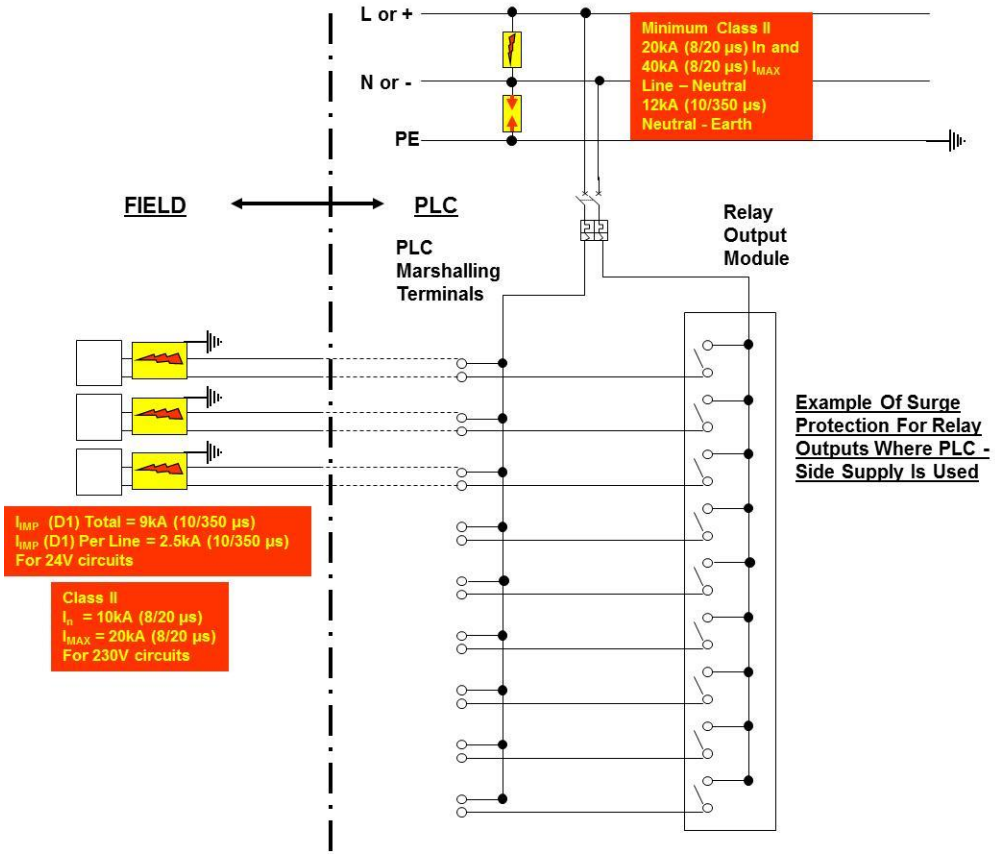
5.11.1 SPDs used for data protection (i.e. of digital and analogue I/O connected to devices outside the PLC building where induced voltages and currents are possible) must be designed to repeatedly withstand direct lightning currents I_{imp} of 2.5kA (10/350 µs) per line and nominal (i.e. peak) surges I_{sn} of 20kA (8/20 µs) for 4-20mA control loops, 24V DC digital and analogue systems and 24V AC systems. SPDs used for 230V AC digital I/O connected to devices outside the PLC building where induced voltages and currents are possible, must be designed to repeatedly withstand nominal discharge currents I_n of 10kA (8/20 µs) and maximum discharge currents I_{max} of 20kA (8/20 µs). These 230V AC SPDs must be rated at least Class II according to IEC 61643-1 or Type 2 according to IEC 61643-11.

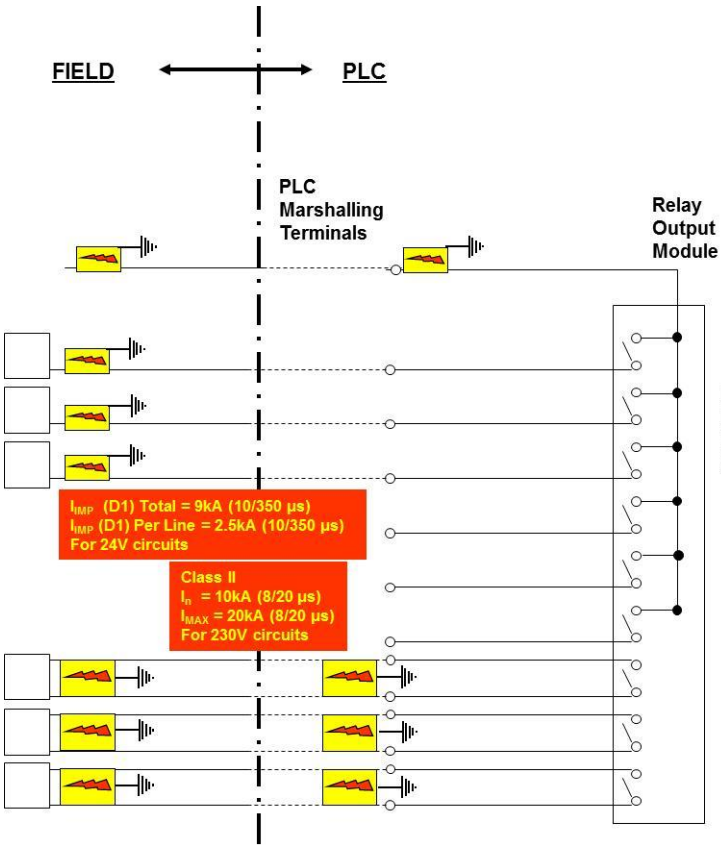
5.11.2 SPDs must be installed at both ends of each cable (i.e. at the PLC and at the field instrument, MCC, control panel, junction box, etc).

5.11.3 The LPZ in which the instrument, instrument distribution board or instrument junction box is, must be used to determine the ratings of the SPD. The ratings on digital and analogue I/O protection must just never be lower than the ratings mentioned in item 5.11.1 above.

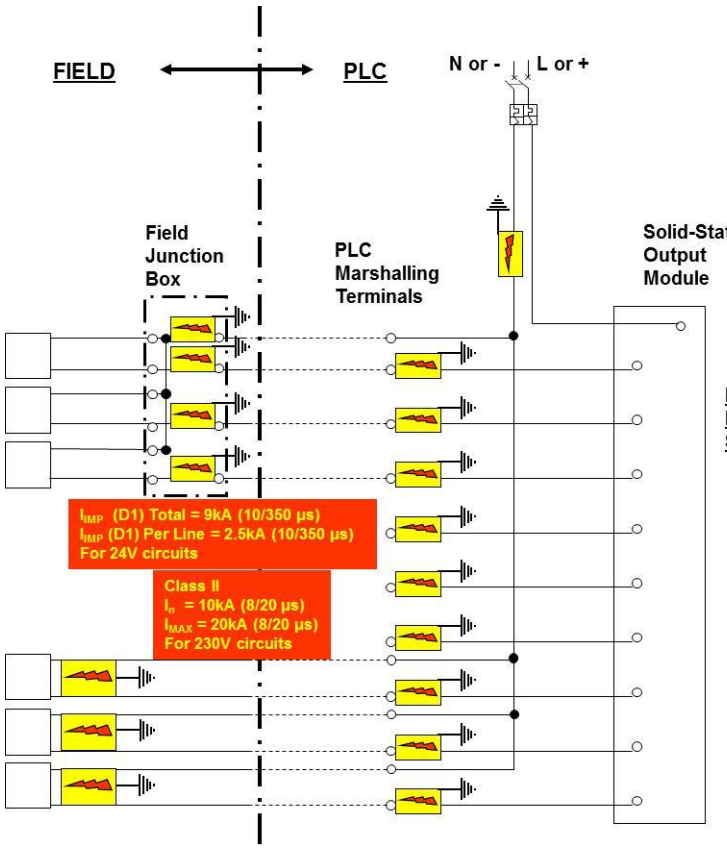
5.11.4 The rated operating current for SPDs used for protection of I/O systems must not be less than 0.75Amp.

5.11.5 All SPDs must consist of a base and a pluggable top which can be disconnected without interrupting the signals.

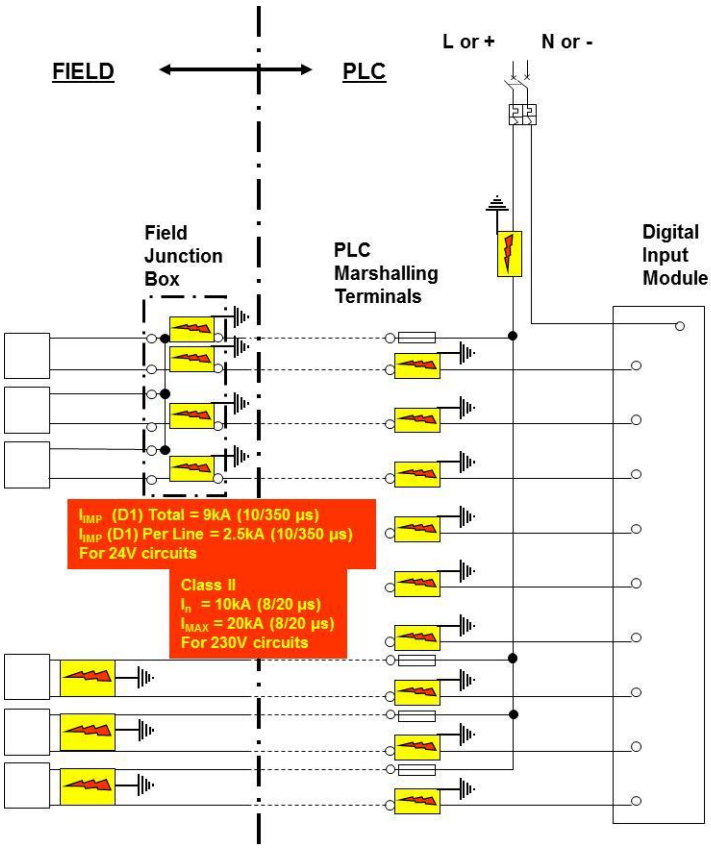

L or +
N or -
PE
Minimum Class II
20kA (8/20 µs) In and
40kA (8/20 µs) IMAX
Line – Neutral
12kA (10/350 µs)
Neutral - Earth
FIELD
PLC
PLC
Marshalling
Terminals
Relay
Output
Module
IIMP (D1) Total = 9kA (10/350 µs)
IIMP (D1) Per Line = 2.5kA (10/350 µs)
For 24V circuits
Class II
In = 10kA (8/20 µs)
IMAX = 20kA (8/20 µs)
For 230V circuits
Example Of Surge
Protection For Relay
Outputs Where PLC -
Side Supply Is Used



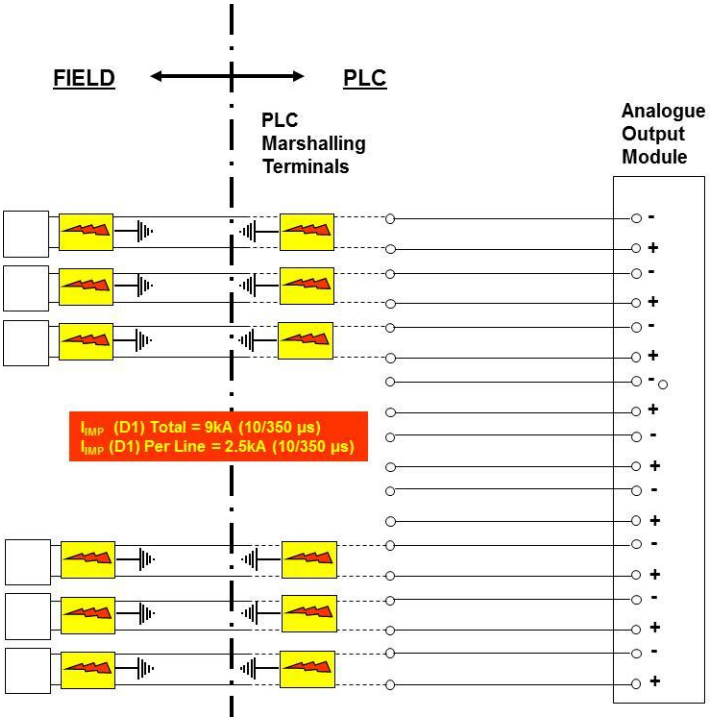
Example Of Surge Protection For Relay Outputs Where External Supply Is Used



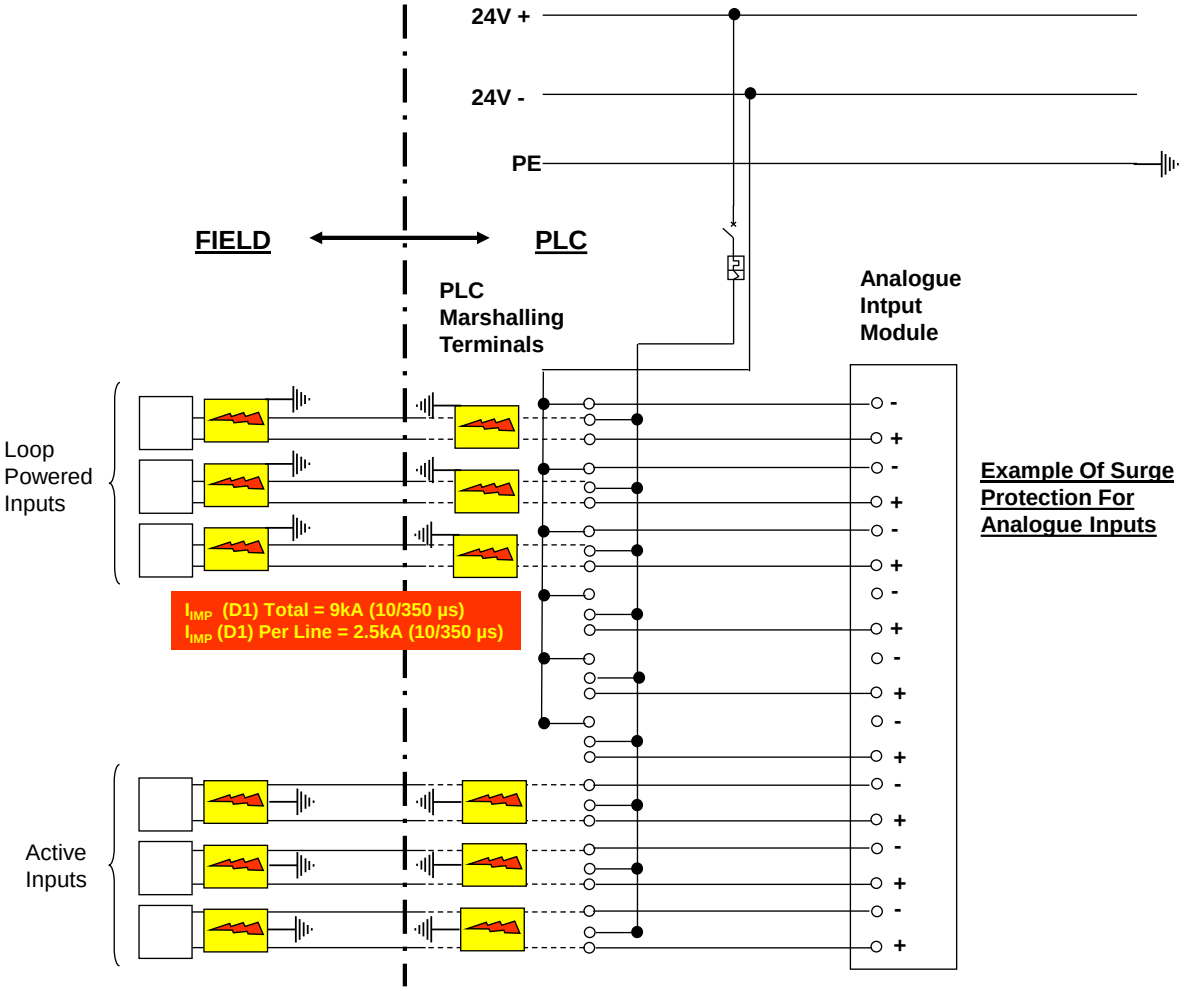
Example Of Surge Protection For Solid State Outputs



Example Of Surge Protection For Digital Inputs



Example Of Surge Protection For Analogue Outputs


24V +
24V -
PE
FIELD
PLC
PLC
Marshalling
Terminals
Analogue
Intput
Module
Loop
Powered
Inputs
Active
Inputs
I_IMP (D1) Total = 9kA (10/350 µs)
I_IMP (D1) Per Line = 2.5kA (10/350 µs)
Example Of Surge
Protection For
Analogue Inputs

5.12 Surge Protection Data Sheets

5.12.1 The tenderer must complete the relevant data sheets below with his tender:

Technical Data Sheet: Mains Surge Protection

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Order No./Part No./Reference No.	
Class (E.g. Class I, Class II, combined Class I/Class II, etc.)	
Surge current rating at the relevant waveform (E.g. 20kA, 10/350µs, phase-to-neutral)	
Rated operating voltage	
Rated operating current	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

Technical Data Sheet: Surge Protection 230V Digital I/O

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Order No./Part No./Reference No.	
Class (E.g. Class I, Class II, combined Class I/Class II, etc.)	
Discharge current rating at the relevant waveform (E.g. 20kA, 10/350µs, phase-to-neutral)	
Rated operating voltage	
Rated operating current	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

Technical Data Sheet: Surge Protection 24V DC Digital I/O

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Order No./Part No./Reference No.	
Lightning Impulse Current and pulse form (E.g. 9kA - 10/350µs – total, 2.5kA - 10/350µs – per line, etc.)	
Rated operating voltage	
Rated operating current	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

Technical Data Sheet: Surge Protection Analogue I/O

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Order No./Part No./Reference No.	
Lightning Impulse Current and pulse form (E.g. 9kA - 10/350µs – total, 2.5kA - 10/350µs – per line, etc.)	
Rated operating voltage	
Rated operating current	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

VOLUME 19 : FIELD JUNCTION BOXES AND PANELS

Johannesburg Water (SOC) Ltd.
PO Box 61542
Marshalltown
2107

Revision 19 August 2019

DOCUMENT CONTROL SHEET

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DOCUMENT APPROVAL

ACTION	FUNCTION	NAME	DATE	SIGNATURE
Prepared	HOD	C. Du Toit	2019-08-26	
Reviewed	Engineer	L. Gobinca	2019-08-26	
Approved	Manager	T. Thabeng	09/09/2019	

RECORD OF REVISIONS

Date	Revision	Author	Comments
2019-08-26	19	C. Du Toit	Cover page updated
2019-08-14	18	C. Du Toit	Use of materials in corrosive areas updated (GRP)
2019-06-25	17	C. Du Toit	Stopper plugs used updated.
2019-06-15	16	C. Du Toit	Cable terminations plus wiring and terminations updated to correspond with that in PLC Panels and
2019-01-28	15	C. Du Toit	Included Cydna requirement for no direct sunlight on display units.
2018-11-30	14	C. Du Toit	Updated reference to Labelling specification, IJBs should not cause obstruction, clearing to be created
2014-04-17	13	C. Du Toit	Updated FJB stands and labelling
2013-10-07	12	C. Du Toit	Updated footer and racking on IJB stands
2012-07-27	11	C. Du Toit	Updated headers & footers.
2012-03-08	10	C. Du Toit	Added Polycarbonate boxes and updated labelling requirements.

2012-03-08	9	C. Du Toit	Changed required paint thickness for IJBs, added requirements for supports/brackets and changed (Pty)
2011-07-11	8	C. Du Toit	Removed 2010 logo.
2010-07-27	7	C. Du Toit	Altered minimum panel powder coating thickness & hinges material.
2010-03-12	6	C. Du Toit	Altered submission time of FJB panel drawings.
2009-08-18	5	C. Du Toit	New logos and data display viewing requirements
2009-03-25	4	C. Du Toit	JW Wastewater Partnership deleted & logos altered as per client's requirements.
2008-10-08	3	C. Du Toit	"Joburg" & "JW" Logos added to top & partnership logos removed.
2007-06-05	2	C. Du Toit	Revision block updated and "Joburg" logo added
2007-03-28	1	C. Du Toit	Final copy issued for approval and sign-off

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19 FIELD JUNCTION BOXES AND PANELS

19.1 Scope

19.1.1 This specification covers the manufacturing, supply and installation of Field Junction Boxes, Field Equipment Panels and any other panels used for housing terminals, surge protection devices, instruments, control switchgear (such as pushbuttons, selector switches, indicating lamps, potentiometers, etc.) for process monitoring and control applications at Johannesburg Water wastewater sites.

19.2 Abbreviations

19.2.1 In this specification the following abbreviations will apply :-

BS	:	British Standards
PLC	:	Programmable Logic Controller
I/O	:	Input/Output
MCB	:	Miniature Circuit Breaker
LPZ	:	Lightning Protection Zone
SPD	:	Surge Protection Device

19.3 Standards

19.3.1 All design standards for cabling shall be subject to the latest amendments and editions of the following standard specifications:-

SANS 10142-1	:	National Standards for the wiring of premises.
SANS 1091:2004	:	National Colour Standard.
SANS 1274-2005	:	Coatings applied by the powder-coating process.
BS 381C:1980	:	Paint colour chart.

19.4 General Requirements

19.4.1 The Field Panel will typically house the following items:-

19.4.1.1 Terminals, fuses, MCB's, trunking, surge protection, relays, etc.

19.4.1.2 Pushbuttons, selector switches, potentiometers, indicating lamps, etc.

19.4.1.3 Power supplies, indicating instruments, etc.

19.4.1.4 Instruments such as transmitters.

19.4.2 The supply and installation shall in general comply with the relevant clauses in all specifications attached to the tender documentation.

19.4.3 The panels shall be free standing units with bottom cable entry (via a glanding plate) and have front door access (hinged and lockable).

19.4.4 For areas other than those mentioned in item 19.4.12 below, the panel should be manufactured from at least 3CR12 grade stainless steel typically not less than 1,5 mm thick. All hinges, locking devices, bolts, nuts and washers must also be at least 3CR12 stainless steel. The panel will have a door on the front which opens to the full width and height of the panel. The panel shall be free standing and the top edge of the panel shall not be more than 1,8m above floor level and it should be sized to accommodate all the associated equipment comfortably.

19.4.5 Once the door is open there should be no obstruction to prevent full access to every point inside the panel.

19.4.6 The panel shall be epoxy powder coated electric orange (Shade B26) finish. Interior chassis mounting plates will be finished in appliance white.

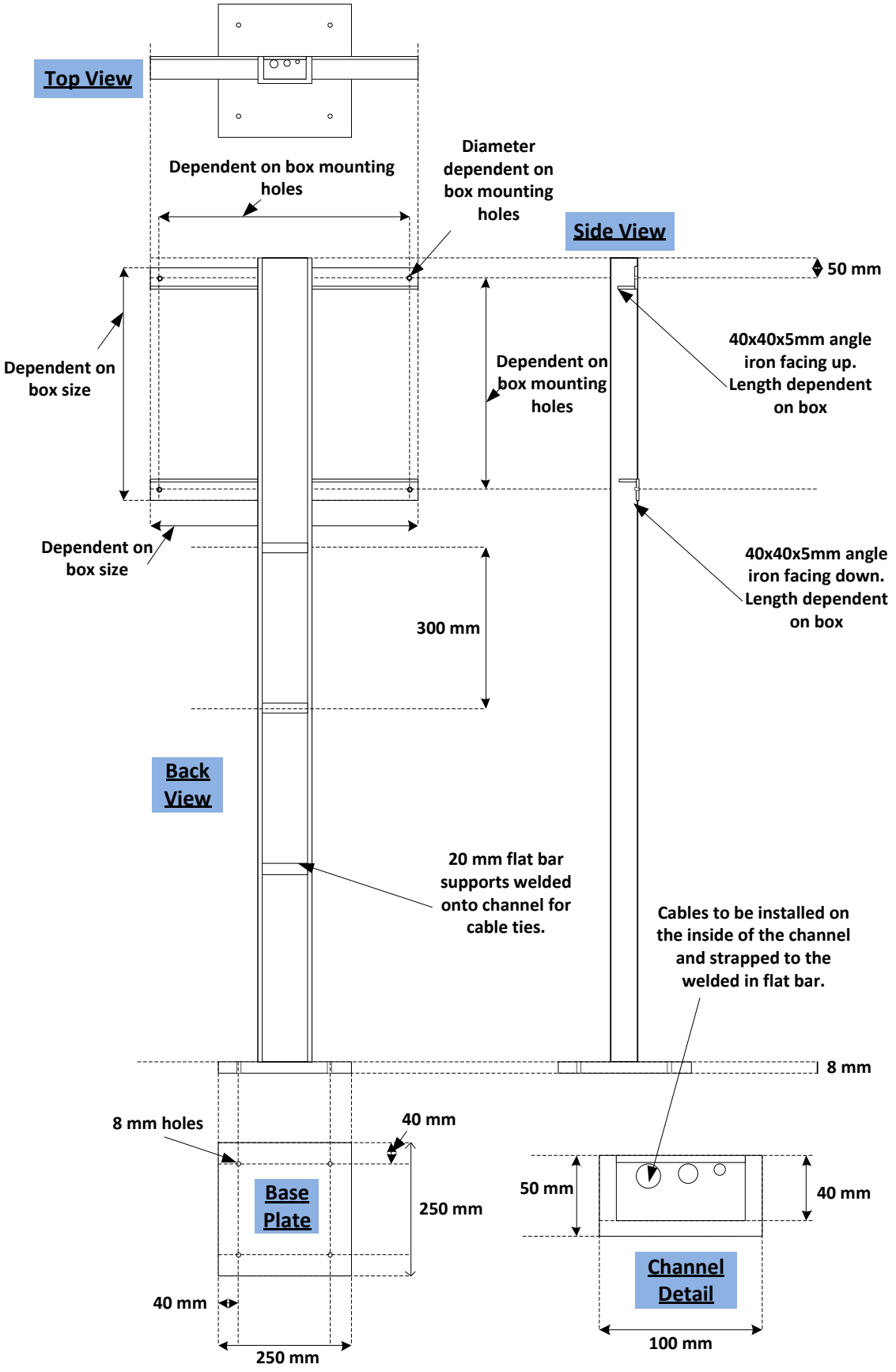
19.4.7 All IJBs should be clearly labelled with labels as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

19.4.8 The panel must be vermin-proof and must have a protection rating of no less than IP 65.

19.4.9 Where equipment such as pushbuttons, selector switches, potentiometers, etc. are required on the panel exterior, a double door system must be used. The equipment must be mounted on a hinged door, which in turn is located inside a second hinged door fitted with a transparent panel so that all relevant equipment can be viewed without the need to open this external door. This external door with the glass panel must ensure that the IP 65 protection rating is not compromised by the fitting of equipment such as pushbuttons, switches, etc.

19.4.10 Where outer doors are equipped with transparent panels, such a panel must consist of a material that will not deteriorate significantly due to its exposure to the elements such as ultra-violet radiation, heat, wind, rain, etc. Glass panels will be preferred.

19.4.11 Where there are no existing structures against which the panel can be mounted, a sturdy stand (see the picture below), or mounting bracket must be manufactured of the same material as the panel (i.e. at least 3CR12 grade stainless steel), painted to the same specification and in the same colour as the panel. A ladder type cable rack of suitable width to accommodate all the cabling, plus at least 10% spare space must be fitted to the stand or structure to enable proper securing of the cables, if the cables cannot comfortably be run inside the channel used for the stand or if there is no stand (i.e. where brackets or wall-mounting is used). The cable racking must comply with all the requirements in the Cabling Specification (Volume 6 of the Automation And Control Standards).


Top View
Dependent on box mounting holes
Diameter dependent on box mounting holes
Side View
50 mm
Dependent on box size
Dependent on box mounting holes
40x40x5mm angle iron facing up. Length dependent on box
Dependent on box size
300 mm
40x40x5mm angle iron facing down. Length dependent on box
Back View
20 mm flat bar supports welded onto channel for cable ties.
Cables to be installed on the inside of the channel and strapped to the welded in flat bar.
8 mm
8 mm holes
40 mm
Base Plate
250 mm
50 mm
40 mm
Channel Detail
40 mm
250 mm
100 mm

19.4.12 Field junction boxes used inside Elutriation Terrace pump stations or in areas within 10m or less of Ferric Chloride, Sodium Hypochlorite or Chlorine shall be manufactured from Polycarbonate. All bolts, nuts, spring washers, etc. shall be 316 grade stainless steel, painted with 2K poly urethane paint, for all these applications. A sample of the panel must be approved by the engineer before manufacturing or purchasing commences. Channels or other sections used for securing of these junction boxes should be made from GRP (Glass Reinforced Polyester). Where transparent covers are used, they must be high visibility Polycarbonate with UV filtration. Since these Polycarbonate panels are used in highly corrosive atmospheres, they must contain as little metal as possible. Hinges, locking devices, etc. wherever possible, should also be Polycarbonate. All cable glands must be totally encapsulated glands (envirogland type) as shown in the example below.

19.4.13 The GRP profile (cable rack or equipment support) shall consist of pultruded (i.e. a continuous process of pulling material, such as **glass fiber** and resin, through a shaped die for manufacturing of composite materials with constant cross-section), e-glass roving and e-glass multi-axial fabric strength mat, sandwiched between polyester synthetic veil or tissue of minimum 35 gram/ m^2, all of which is encased in an isophthalic vinyl-ester resin. The resin must contain UV stabiliser. It must also contain pigment to provide colour and additional environmental protection. The rack or support must be cleaned and de-greased before it is painted with a 2K automotive or industrial poly urethane paint.

19.4.14 IJB's shall not be installed such that they obstruct passageways or are close to the road where moving objects such as vehicles, forklifts etc. can damage the IJB.

19.4.15 Where cable junction boxes, terminal boxes or terminations in instruments or any other panels in the field take place it must be ensured that such a junction box, termination box, instrument, etc. is not exposed to fire hazards from burning grass or other vegetation. If such a termination point is out in the open field (e.g. where grass grows below and/or around it), a clear area of at least 2.5m radius around this termination point must be provided. This must be a permanent clearing, such as a cement or concrete surface. A mere clearing of vegetation which can grow back again will not be accepted.

19.5 Standard Features

19.5.1 Each panel shall have the following features as standard:-

19.5.1.1 No ventilation fans shall be mounted in the panel and thereby compromise the protection rating.

19.5.1.2 No holes may be drilled for tapping, riveting, bolts & nuts, etc. in any section of the panel where it will compromise the protection rating of the panel. I.e. only in the first (i.e. inner) door of a 2-door panel, in the backing plate or in the glanding plate may holes be drilled. Where drilling is unavoidable, e.g. to affix labels, the holes must be sealed so that the protection rating of the

panel is not compromised.

19.5.1.3 Bolts with nuts shall not be used to attach equipment to any mounting plate at any point. On mounting plates only bolts in tapped holes will be acceptable. Bolts with nuts will be allowed on enclosure doors however, where the bolts and nuts are easily accessible.

19.5.1.4 Where bolts are used on the door or any outside panels of the enclosure, a sealing method (e.g. rubber washers) must be used to ensure that the IP protection rating of the enclosure is not compromised.

19.5.1.5 Wherever bolts are used, the bolts must be as short as practically possible so that there are no long protrusions that can injure people or snag clothing, wiring, other equipment, etc. If bolts are cut to the correct length, the ends of the bolts must be neatly de-burred and smoothed so that there are no sharp edges that can cause injuries and so that the nuts can be easily screwed on and off. No more than four threads of the bolt end must be visible beyond the nut. It is however preferred that the correct length of bolts are used so that shortening is not required.

19.5.1.6 A copper earth bar running the width of the panel at the bottom with solid electrical connection to the panel doors and to the steel of the panel at two or more places and provided with terminals for connection of equipment and screen earth wires.

19.5.1.7 Terminals and equipment of the same voltage must be grouped together, while terminals and equipment of different voltages must be clearly marked and separated by at least 50mm or by suitable insulated barriers to ensure that inadvertent contact or accidental terminations in the wrong place are avoided. Where such barriers are used between terminals of different voltages, these barriers must be larger than the terminals (i.e. standard terminal end barriers will not be acceptable) to ensure that there is a clear separation and to avoid accidental incorrect terminations.

19.5.1.8 Where the panel will be installed out in the open (i.e. not in an area where it is in the shade), the panel must be equipped with a cover which will provide shade for the panel while allowing air flow between the panel and the cover. Such panels should as far as practically possible be installed to face South and the cover should ensure that all transmitters, analysers, pushbuttons, lamps, etc. are protected from direct sunlight. It must be ensured that transmitter LED/LCD displays are **never** exposed to direct sunlight.

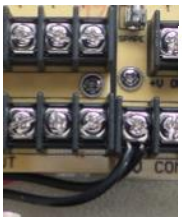
19.5.1.9 Where stopper plugs are used to seal holes that are not used, no plastic stopper plugs will be acceptable. All stopper plugs must be threaded, non-corrodible, metal plugs with rubber washers on both sides of the panel to ensure at least an IP65 seal (see examples below).

19.6 Wiring and Terminals

19.6.1 All terminals shall be screw type terminals and shall be mounted on raised DIN terminal rail, secured to the chassis plate at the back of the panel.

19.6.2 Proprietary type wire strippers shall be used and no stranded conductor shall be terminated if one or more strands have been damaged.

19.6.3 Not more than one wire shall be connected to any terminal unless the terminal can accept pin lugs on either side of a screw or unless proper connecting material is used (see examples below).



Every wire shall be marked at both ends with a numbering system as specified in the Labelling Specification (Volume 25 of the Automation And Control Design Standards), or if approved by the Engineer, and all terminating wires shall also be suitably crimped to a terminal lug. Not more than one wire shall be crimped into a single lug. Bare wire terminations will not be accepted.

19.6.4 All wiring shall be flexible, tinned, annealed, multi-strand copper wire not less than:-

19.6.4.1 1,5mm² for 230V AC or 110V AC power

19.6.4.2 1,0mm² for 24V DC or AC power

19.6.4.3 0,5mm² for all PLC I/O wiring between modules and marshalling terminals

19.6.4.4 4,0mm² for earth drain

19.6.5 Irrespective of the minimum wire sizes allowed in this specification, contractors must ensure that all cables and wiring are capable of carrying the full system currents, inclusive of de-rating factors as specified in SANS 10142-1:2003 as amended.

19.6.6 All wire terminations must be done by using suitable lugs. Where pin lugs are crimped onto the ends of wires, correctly sized pin lugs must be used, which fit into the terminals properly and such that the tightening of the terminal does not result in the loosening of the pin lug.

19.6.7 All panel wiring shall run in suitable sized slotted trunking for as much of their course as possible, thereafter in spiral band or similar conduit to its destination if the exposed run would exceed 100mm.

19.6.8 The distance between the terminals and the trunking or between equipment (such as relays, surge protection, circuit breakers, etc.) and trunking shall not be less than 50mm.

19.6.9 Control wiring should not run with power wiring and all cross-overs shall be at ninety degrees.

19.6.10 Each analogue and digital input and output to and from the PLC shall have surge protection units as specified in the Clean Power And Surge Protection Specification

(Volume 5 of the Automation And Control Standards).

19.6.11 Internal wiring shall be colour coded as follows:-

19.6.11.1 230V AC Power

Live	Brown
Neutral	Blue
Earth	Green and Yellow

19.6.11.2 24V DC Power

Positive	Red
Negative	Black

19.6.11.3 Digital Inputs

230V AC	Yellow
24V DC	Red

19.6.11.4 Digital Outputs

230V AC	Grey
24V DC	Red

19.6.11.5 Relay Outputs

230V AC	Grey
24V DC	Red

19.6.11.6 Analogue Signals

Positive	Orange
Negative	Purple

19.6.12 A terminal section for AC and DC power distribution shall be included in the panel where both voltages are used for equipment power supplies. The terminal groups shall be clearly identified to indicate the various voltages.

19.6.13 All wiring must be continuous from one termination (in a terminal strip or device such as a relay, contactor, surge arrester, etc.) to the next. No spliced wiring will be accepted.

19.7 Existing Panels

19.7.1 All modifications and wiring changes to existing panels must comply with the specifications as laid down for new panels.

19.8 Factory Acceptance

19.8.1 Before delivery of the panels, a comprehensive system factory acceptance test must take place. The Engineer must be notified one week in advance of the proposed test.

19.8.2 The test shall comprise of at least, but not be limited to:

19.8.2.1 Checking the panel manufacturing and assembly for compliance with this specification.

19.8.2.2 Layout, numbering and labelling of equipment.

19.8.2.3 Wiring – sizes, numbering, colours, termination, etc.

19.8.2.4 Wiring as per drawings, I/O schedules, etc. (i.e. loop checks).

19.9 Over-Voltage/Lightning Protection

19.9.1 The function of the over-voltage/lightning protection units is to prevent damage from occurring to the electrical and electronic devices due to destructive voltages, by resistive coupling, capacitive coupling or inductive coupling, arising from extraneous events such as lightning discharges, switching surges etc. All lightning and surge protection must be in accordance with the requirements in the Clean Power And Surge Protection specification (Volume 5 of the Automation And Control Design Standards).

19.9.2 The SPD's on all incoming power supplies to the panel shall be in accordance with the LPZ in which the panel is and must comply with the requirements of SANS 10142-1:2003 Annex L. Even if the LPZ dictates that class III surge protection is required, at least class II surge protection must be installed.

19.9.3 All analogue and digital input and output circuits shall be in accordance with the LPZ in which the panel is and must comply with the requirements of SANS 10142-1:2003 Annex L. and even if the LPZ dictates that class III surge protection is required, at least class II surge protection must be installed. for protection of these circuits.

19.10 Spares

19.10.1 The tenderer will be required to provide at least 10% spare fuses and other consumable items which may be required during commissioning. In addition to commissioning spares, a recommended spare list for three years maintenance, should be submitted. This item must be completed so that spares may be ordered as part of the capital contract. Tenderers ignoring this condition may be disqualified.

19.11 Painting (Powder Coating Method)

19.11.1 **General**

Switchboards and panels shall be epoxy powder coated in accordance with Type 1 coatings to SANS 1274-2005.
Unless specified otherwise, a high gloss finish in the following colour shall be provided:
Colour - Light Orange, Colour No. B26, Munsell Ref. 2,5 YR C/14 to SANS 1091 : 2004 and Colour No. 381C-557 to BS 381C : 1980.
Paintwork must be guaranteed against blistering, peeling, cracking and general deterioration which can lead to rusting, corrosion, etc. for a period of no less than three years. If the tenderer cannot comply with this requirement, it must be clearly stated as such in the tender.

19.11.2 **Specifications**

The following specifications in accordance with SANS 1274-2005 shall be provided:-

Property	Requirement	Test Method
Thickness, minimum	50 micron	6,7
Marking Resistance (400g)	No marking	6.20
Impact Resistance, J, minimum	6,78	6.10
Water Resistance, h, minimum	720	6.13

Humidity resistance, h, minimum	1000	6.14
Resistance to salt fog, h, minimum	1000	6.16

19.11.3 **Surface Preparation**

Surface preparation of sheet steel components shall be carried out by means of the multi-bath zinc phosphate/chromate passivation treatment.
All fabricated sheet steel components are to be degreased and de-rusted ready for treatment.
A steel surface is considered ready for treatment when all dirt, grease, rust, mill scale, moisture or other contaminants have been removed in an alkaline degreaser to give a dry, clean, bright, metallic surface.
Steel plate less than 4mm thick - black steel sheet shall be pickled to white metal condition while pre-pickled, bright, cold rolled sheet steel shall be solvent cleaned. These surfaces shall be treated within eight hours in all cases while still uncontaminated and rust-free.
The prepared steel surface shall be treated by means of immersion in a heated zinc phosphate solution bath, rinsing and thereafter chromate passivated by means of immersion in the final treatment bath.

19.11.4 **Powder Coating**

A thermosetting powder consisting of epoxy/polyester resin shall be applied by means of an electrostatic spray gun to give a uniform coating thickness of 50 to 60 micron. Less than 50 micron will not be acceptable.

The powder coating shall be baked at a metal temperature of 185ºC so as to melt the powders to form a continuous film over the metal substrate.

19.12 Drawings And Diagrams

19.12.1 The tenderer must submit layout drawings, showing the panel size, cable entry, location of equipment, details of equipment (such as trunking size, circuit breakers, fuses, terminals, etc.), panel colour, material of construction (e.g. 2mm 3CR12 SS), etc. for approval by the Engineer before any manufacturing commences.

19.12.2 The drawings must be accompanied with data lists of the proposed equipment. These data sheets must show the type, supplier, make, model, size, etc. of equipment where applicable. For example:

Treminals - Phoenix SK12, 4mm, white.
MCB's - Merlin Gerin, 5A, 10kA, single-pole.
Etc.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

VOLUME 8 : FLOW MEASUREMENT

Johannesburg Water (SOC) Ltd.
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Reviewed	Engineer	L. Gobinca	2019-08-26	
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8 FLOW MEASUREMENT

8.1 Scope

8.1.1 This specification covers the supply and installation of Flow meters, complete with sensors, transmitters, indicators, panels, etc. used for process monitoring and control applications at Johannesburg Water wastewater sites.

8.2 Abbreviations

8.2.1 In this specification the following abbreviations will apply :-

BS	:	British Standards
PLC	:	Programmable Logic Controller
I/O	:	Input/Output
CPU	:	Central Processing Unit
UPS	:	Uninterruptible Power Supply
MCC	:	Motor Control Centre
MCB	:	Miniature Circuit Breaker
SPD	:	Surge Protection Device
FJB	:	Field Junction Box
SSO	:	Switched Socket Outlet
SPDT	:	Single Pole Double Throw (refers to relay or switch contact arrangements).
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
PTFE	:	Polytetrafluoroethylene
O&M	:	Operating And Maintenance

NPT	:	National Pipe Thread
DP	:	Differential Pressure
LP	:	Low Pressure
HP	:	High Pressure
RH	:	Relative Humidity
IS	:	Intrinsically Safe

8.3 Standards

8.3.1 The supply and installation of all Flow meters and associated cabling, panels and any other equipment shall be subject to the latest amendments and editions of the following standard specifications:-

SANS 10142-1	:	National Standards for the wiring of premises.
SANS 1091:2004	:	National Colour Standard.
SANS 1274-2005	:	Coatings applied by the powder-coating process.
BS 381C:1980	:	Paint colour chart.
BS 3680	:	Measurement of liquid flow in open channels.
SANS10108:2005	:	The classification of hazardous locations and the selection of apparatus for use in such locations.
SANS60079-10:2005	:	Electrical apparatus for explosive gas atmospheres. Part 10: Classification of hazardous areas.
SANS60079-11:2005	:	Electrical apparatus for explosive gas atmospheres. Part 10: Intrinsic safety “i”.
SANS10086-1	:	The installation, inspection and maintenance of equipment used in explosive atmospheres Part 1: Installations including surface installations on mines

8.4 General Requirements

8.4.1 This specification must be read in conjunction with the following specifications:-

8.4.1.1 PLC Panels Specification (Volume 3 of the Automation And Control Standards).

8.4.1.2 Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

8.4.1.3 Cabling Specification (Volume 6 of the Automation And Control Standards).

8.4.1.4 Field Junction Boxes And Panels (Volume 19 of the Automation And Control Standards).

8.4.1.5 Labelling (Volume 25 of the Automation And Control Standards).

8.4.2 Where cables are exposed to physical damage (including damage from rodents) armoured cables must be used or un-armoured cables must be run in steel conduit.

8.4.3 All power supply cables to instruments must have a black outer sheath, while all control cables (such as digital and analogue signals to PLC's) must have an orange outer sheath as specified in the Cabling Specification (Volume 6 of the Automation And Control Standards).

8.4.4 FJB's and as far as practically possible all instrument sensors and transmitters, must be mounted such that all equipment, wiring, numbers, terminations, etc. are readily accessible and can be viewed clearly. No equipment may be mounted such that it becomes a hazard or dangerous to view or gain access to such equipment.

8.4.5 Where sensors and/or transmitters cannot be mounted where they are readily accessible, the installation must be done in such a way that the sensor or transmitter can easily be moved to a safe and convenient position for testing, maintenance, replacement, etc. (e.g. by using hinged brackets, telescopic brackets, etc.).

8.4.6 Where transmitters can be exposed to the elements (wind, rain, ultra violet, etc.) such transmitters must be installed inside the FJB. LCD displays must always be protected from direct sunlight, either by facing them away from the sun or by installing it inside the FJB, in the shade of the FJB canopy. Where transmitters are protected from the elements (i.e. inside buildings) but they are exposed to potentially harmful conditions like moisture from splashing or equipment being hosed down, or the sensor is in such a position that the transmitter display is not clearly visible from floor level, without the need to climb onto ladders or structures to access it, the transmitter must also be installed inside the FJB. Only where transmitters are not exposed to the elements or any other harsh or potentially harmful conditions and where the displays on such transmitters are clearly legible by an average person standing on the ground or the normal walking surface (e.g. grating above ground level), can the transmitter be mounted outside the FJB.

8.4.7 FJB's must be mounted against a wall or structure or on a sturdy pedestal such that the top of the FJB enclosure is no higher than 1.8 m from the floor and easily accessible from the front.

8.4.8 All instrument installations must be done in accordance with the manufacturer's requirements and recommendations for proper operation. It is the tenderer's responsibility to ensure that he/she is familiar with both the requirements of the manufacturer as well as the installation requirements, in terms of location, site conditions, materials, equipment or substances to be measured (e.g. hot liquids, acids, abrasive material, etc.) and to ensure that if there are potential problems, they can be pointed out and rectified before orders for equipment are placed.

8.4.9 Costs incurred for alterations required to ensure proper operation of instruments, after orders have been placed, will be for the tenderer's account. For example, if instruments have been ordered and it is found there is insufficient space to install the instrument, or the instrument is not flooded with liquid all the time as it is required for proper operation, or the instrument transmitter is sometimes flooded in its installed position, or the sensing head is sometimes outside the medium it is supposed to measure, or the instrument linings are damaged by abrasive liquids, or the sensor is does not have a suitable range of measurement, etc. alterations or

replacements required to rectify such problems will be for the tenderer's account if the Engineer finds that the tenderer was negligent in his/her assessment of the installation.

8.4.10 Each instrument must be equipped with a circuit breaker connected to the power supply of the instrument, to enable local isolation in case of repairs or replacement.

8.4.11 The supplier of the instrument must be present for the installation, testing and commissioning of the instrument on site. Due allowance must be made for this in the tender sum.

8.4.12 The tenderer must supply a complete and detailed set of documentation for the installation, connections, terminations, power supply, technical details, setting up, calibration (if applicable), testing, etc. of the instrument for inclusion in a final O&M manual.

8.4.13 If a flow meter (for any application) is offered, which has the facility to store calibration and set-up data electronically, so that it can be downloaded when an instrument is replaced, the contractor must include the supply of all the necessary equipment (special cables, memory cards, etc.) to enable the use of this facility.

8.4.14 Completed data sheets are required as part of the returnable documents of each tender. Failure to complete these data sheets, supplied at the end of this specification, will lead to disqualification of the tender.

8.5 Surge Protection

8.5.1 Each instrument and its associated equipment must be suitably protected against surges from induced voltages, switching of equipment, lightning strikes, etc. as detailed in the Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

8.5.2 The power supply to the instrument must be equipped with suitable surge protection, both at the instrument and at the source of the power supply (i.e. at the distribution board, MCC, PLC panel, etc.), as detailed in the Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

8.5.3 Both the digital and analogue signals between the instrument and other remote devices (such as the PLC), must be equipped with suitable surge protection, both at the instrument and at the remote device as detailed in the Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

8.6 Open Channel Flow Measurement – Controller/Transmitter

8.6.1 Flow calculations for all open channel flow measurement must be done in accordance with BS 3680.

8.6.2 All flow measurements in open channels must be done by using ultra-sonic distance measurement, which is converted into a flow value at weirs or venturi flumes. Where there are no weirs or venturi flumes, area/velocity flow meters must be used (see requirements later in this specification).

8.6.3 All instrument transmitter enclosures must have at least an IP 65 or higher rating.

8.6.4 The instrument must be equipped with an isolated, active, 4 – 20mA output which will be connected to a maximum 500 ohm load. This output must be user-programmable.

8.6.5 The instrument must be equipped with at least one SPDT relay, rated for at least 230V AC, 500mA, for totalised flow pulses. This output must be user-programmable for the units-per-pulse.

8.6.6 The transmitter must be suitable for use with a 230V AC, 50/60 Hz power supply.

8.6.7 The transmitter must have an accuracy of at least 0.25% or 6mm, whichever is greater.

8.6.8 The transmitter must have a resolution of at least 0.1% or 2mm, whichever is greater.

8.6.9 The transmitter must have an LCD or LED display showing instantaneous flow and totalised flow.

8.7 Open Channel Flow Measurement – Sensor/Transducer

8.7.1 The range of the sensor must be suitable for the application (see items 8.4.8 and 8.4.9 of this specification).

8.7.2 The sensor must be suitable for an operating temperature range of -10ºC to +50ºC.

8.7.3 The sensor must be equipped with automatic temperature compensation.

8.7.4 The sensor must have a protection rating of at least IP 67 or higher.

8.7.5 Brackets used for the mounting of ultra-sonic sensor heads and velocity sensor heads (if external velocity sensors are used) must be made of at least 3CR12 grade stainless steel.

8.8 Full Pipeline Flow Measurement – Controller/Transmitter

8.8.1 All flow measurements in full pipelines must be done by using electro-magnetic flow (mag-flow) measurement, which is converted into a flow value where accuracy of measurement is required for dosing and/or custody transfer of flow. Where measurement for flow distribution or flow diversion is required or for pump protection (i.e. where high accuracy is not essential), non-intrusive flow measurement using external sensors can be applied. These systems must incorporate either ultrasonic time of flight or Doppler principles. Ultrasonic time of flight systems can be used on clean water with low contents of air bubbles or other entrained gasses and suspended solids of less than 10,000 milligrams/litre. Doppler systems can be used on liquids with entrained particles or gasses of 100 microns or larger and suspended solids in excess of 75 milligrams/litre.

8.8.2 All instrument transmitter enclosures must have at least an IP 65 or higher rating.

8.8.3 The instrument must be equipped with an isolated, active, 4 – 20mA output which will be connected to a maximum 500 ohm load. This output must be user-programmable.

8.8.4 The instrument must be equipped with at least one SPDT relay, or an output that can be used to drive a relay, for totalised flow pulses. This output must be user-programmable for the units-per-pulse.

8.8.5 The transmitter must be suitable for use with a 230V AC, 50/60 Hz power supply.

8.8.6 The transmitter for electro-magnetic flow meters must have an accuracy of at least 0.5%, or better, of the measured value for flow velocities which are greater than 0.5 meters/second. Transmitters of flow meters for flow distribution/diversion can have an accuracy of less than 0.5% but they must not be less accurate than ±2% of the full scale for Doppler meters and not less than ±2% of the measured value for time of flight meters. For both Doppler and time of flight meters these accuracy requirements apply to flow velocities of 0.5 meters/second or greater. Repeatability must not be less than 1% of the measured value.

8.8.7 The transmitter must have an LCD or LED display showing instantaneous flow and totalised flow.

8.9 Full Pipeline Flow Measurement – Sensor/Transducer

8.9.1 The range of the sensor must be suitable for the application (see items 8.4.8 and 8.4.9 of this specification).

8.9.2 The sensor lining for electro-magnetic flow meters used in sludge or non-corrosive liquids must be Neoprene or Rubber, suitable for operating in temperatures ranging from -10ºC to +80ºC.

8.9.3 The sensor lining for electro-magnetic flow meters used in corrosive or heated liquids must be PTFE, suitable for operating in temperatures ranging from -20ºC to +150ºC.

8.9.4 The sensor must have a protection rating of at least IP 68 or higher.

8.9.5 The sensor tube material for electro-magnetic flow meters must be at least 304, 316 or 3CR12 grade stainless steel.

8.9.6 The sensor electrode material for electromagnetic flow meters must be at least 304, 316 or Hastelloy C grade stainless steel.

8.9.7 The sensor for electromagnetic flow meters must have either a grounding electrode or earth rings fitted.

8.9.8 Where process flow in the pipeline cannot be stopped or isolated by any other means, isolation hand valves must be fitted on either side of electro-magnetic flow meters for removal/replacement of the flow meter.

8.9.9 The sensor material for flow meters used for flow distribution/diversion must be stainless steel.

8.9.10 Magnetic flow meters must be equipped with an “Empty Pipe” detection which is configurable to stop the 4-20mA flow indication and/or operate a potential free contact, or an output that can be used to drive a relay, for PLC interfacing.

8.9.11 Electro-magnetic flow meters must not be a wafer-type. I.e. the sensor tube or wafer must be housed in a flanged stainless steel spool piece which can readily be bolted onto flanges in the pipe where it must be installed.

8.10 Partially Filled Pipeline Or Channel Flow Measurement – Controller/Transmitter

8.10.1 Where electro-magnetic flow meters (e.g. for full pipes) or conventional ultrasonic flow meters (e.g. at weirs or venturi flumes) cannot be used, such as in partially filled pipes or open channels without a weir or venturi, area-velocity flow meters must be used. A liquid velocity measurement as well as a liquid depth measurement, together with the dimension of the pipe or channel which is programmed into the controller/transmitter, must then be used to produce a proportional flow measurement.

8.10.2 The flow measurement must be done by using ultrasonic, microwave or radar signals to measure both velocity and depth of liquid.

8.10.3 The controller/transmitter must have at least an IP66 rating or higher.

8.10.4 The controller/transmitter must have a backlit LCD display to display flow rate and total flow.

8.10.5 The error of the level measurement must not be more than 0.25% of the range and the error of the velocity must not exceed 2% of the velocity reading.

8.10.6 The repeatability and linearity must be 0.1% or better.

8.10.7 The unit must be suitable for use with a 230V AC supply.

8.10.8 The unit must have 3 x 4-20mA outputs, one for flow, one for level and one for velocity.

8.10.9 The unit must have at least 2 x SPDT relays, rated at no less than 2A at 230V AC. One of the relays must be programmable for flow pulses and the other must be programmable for flow and/or level alarm.

8.10.10 The unit must have at least 3 x 4-20mA outputs, one for velocity, one for level/depth and one for flow. These outputs will be connected to a maximum 500 ohm load.

8.10.11 The unit must suitable for operating in temperatures ranging from minus 15ºC to +60ºC.

8.11 Partially Filled Pipeline Flow Measurement – Sensors/Transducers For Velocity Measurement

8.11.1 If the velocity sensor is installed below the water, the velocity sensor must be shaped and installed in such a manner that the cabling to it is protected from any debris that might flow in that pipe or channel.

8.11.2 The velocity sensor must be able to measure in a range of 0.03 to 6.2 m/sec and reverse flow of -1.5m/sec if a submerged sensor is used. If an non-submerged sensor is used, it must be able to measure in a range of 0.2 to 6 m/sec.

8.11.3 The velocity sensor must be suitable for operating in temperatures ranging from minus 15ºC to +65ºC.

8.11.4 The velocity sensor must be equipped with continuous, automatic temperature compensation.

8.12 Partially Filled Pipeline Flow Measurement – Sensors/Transducers For Level Measurement

8.12.1 The level sensor must have a low profile, in order to provide the maximum measuring distance in enclosed pipes.

8.12.2 The level sensor must have a measuring range of at least 3.66m and a minimum range (deadband) of not more than 203.2mm.

8.12.3 The level sensor must be suitable for operating in temperatures ranging from minus 15ºC to +65ºC.

8.12.4 The level sensor must be equipped with continuous, automatic temperature compensation.

8.13 Partially Filled Pipeline Flow Measurement – General

8.13.1 The submerged velocity sensor must not be installed in locations where sediment builds up.

8.13.2 The sensors must not be installed in locations where there is high water turbulence (the lower the turbulence, the higher the accuracy).

8.13.3 The sensors must be installed in locations where the velocity and level are equally distributed across the channel or pipe.

8.13.4 The channel or pipe where the sensors are installed must not have drops or direction changes immediately upstream of the sensors.

8.13.5 The slope of the pipe or channel where the sensors are installed must not exceed 3%.

8.13.6 Under no circumstances must sensors be installed in a manner or in a location which makes it impossible for site maintenance staff to access it for repairs or replacement later.

8.14 Gas Flow

8.14.1 The flow measurement must be done by using thermal dispersion technology, with a guaranteed drift-free operation and a turn down ratio up to 100:1 to measure volumetric gas flow. With thermal dispersion, two temperature probes are used. The first probe generates a temperature and the second one measures the dispersed temperature. Thermal dispersion measurement must be unaffected by changes in gas pressure or gas temperature. The sensor must also maintain a minimum accuracy of 2% of the reading ± 0.2% of full scale for changes in gas composition as high as ±2.5% of CH_4.

8.14.2 The instrument must be equipped with a remote transmitter which can be mounted in an IJB located in an easily accessible location in a non-hazardous area for viewing, maintenance and repairs. The transmitter shall have a 10-digit LED display for indication of flow rate and totalised flow. Where compensating leads for Pt100s are used, the contractor must ensure that the cable between the sensor

and transmitter is installed as supplied by the supplier. I.e. cables must not be cut. Excess cable must be coiled up neatly at the IJB.

8.14.3 The instrument must be equipped with integrated compensation for humidity. The average biogas composition which will be used must be 60% Methane and 40% Carbon Dioxide.

8.14.4 All instrument transmitter enclosures must have at least an IP 67 or higher rating.

8.14.5 The instrument must be equipped with a 4 – 20mA output which will be connected to a maximum 500 ohm load, for instantaneous volumetric flow in m^3/hr. It must also be equipped with a pulsed output for flow totalization.

8.14.6 The instrument must be suitable for use with a 24V DC power supply and it must have an EEx [i, e or d] rating, suitable for use in a Zone 1 area with Methane gas.

8.14.7 The sensor shall be of the insertion type with full stainless steel design. The housing shall be a compression-proof, dual compartment, stainless steel housing of material type DIN 1.4571 (316Ti). All sealing on the housing shall be done with Viton “O” rings.

8.14.8 The sensor must be equipped with a hot tapping unit for ease of insertion removal during normal digester operation. The compression fitting on the hot tapping unit must be with a metal-Viton elastomer design, resistant to pipe vibration and with a robust, threaded process connection for frequent mounting/dismounting of the sensor for inspection.

8.14.9 The sensor must be installed strictly in accordance with the supplier’s recommendations and requirements. The sensor must be equipped with locating pins to ensure that the sensor cannot be replaced incorrectly after removal.

8.14.10 The range of the instrument must be suitable for the application (see items 8.4.8 and 8.4.9 of this specification)

8.14.11 The instrument must be suitable for an ambient operating temperature range of minus 20ºC to +70ºC and a process temperature operating range of minus20ºC to +120ºC.

8.14.12 The instrument must be suitable for operating in a humidity range of 0 to 100% RH.

8.15 Spares

8.15.1 The tenderer will be required to provide a recommended spares list for three years maintenance. This item must be completed so that spares may be ordered as part of the capital contract. Tenderers ignoring this condition may be disqualified.

8.16 Hazardous Areas

8.16.1 If the flow meter is going to be used for any combustible gas flow measurement, the tenderer must ensure that there is a hazardous area classification for the area in which the instrument will be installed.

8.16.2 If no hazardous area classification exists, the tenderer must allow a suitable cost for the classification of all relevant areas and must clearly indicate this cost in either the Bill Of Quantities or in a covering letter.

8.16.3 The flow meter and associated equipment supplied must all be suitable for use in the hazardous area concerned.

8.17 Intrinsically Safe Installations

8.17.1 Where intrinsically safe (IS) installations are required the tenderer must allow a cost to have the IS design from the Engineer certified as safe and compliant with the relevant legal requirements. This certification can only be done by a suitably accredited organization or company.

8.17.2 Once the certified IS design has been installed, the installation must be certified as correct and in accordance with the certified design. The tenderer must allow a cost for the certification. This certification can only be done by a suitably accredited organization or company.

8.17.3 All instruments supplied for use in a hazardous area must have the hazardous area rating and classification (E.g. Ex ia IIC T5) and suitable marking as specified in SANS 10108, ARP 0108:2007, Annex B, indicated on the instrument and the instrument must be certified by an approved testing/certification body as listed in SANS 0108, ARP 0108:2007.

8.18 Data Sheets

8.18.1 All data sheets in the attached Appendix 1 must be completed.

APPENDIX 1

DATA SHEET – OPEN CHANNEL FLOW METER

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Power Supply (Voltage)	
Analogue Output Type & Programmable (Y/N)?	
Digital Output Type & Rating (E.g. SPDT, 230V AC, 5A) & Programmable (Y/N)?	
Controller/Transmitter Enclosure Rating	
Accuracy	
Resolution	
Programmable Totaliser (Y/N)?	
Display Data & Type (E.g. instantaneous & total LCD)	
Transducer/Sensor range	
Transducer/Sensor temperature operating range	
Transducer/Sensor temperature compensation (Y/N)?	
Transducer/Sensor enclosure rating	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

DATA SHEET – FULL PIPELINE FLOW METER (MAGNETIC)

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Power Supply (Voltage)	
Analogue Output Type & Programmable (Y/N)?	
Digital Output Type & Rating (E.g. SPDT, 230V AC, 5A or 24V DC output) & Programmable (Y/N)?	
Controller/Transmitter Enclosure Rating	
Accuracy	
Repeatability	
Programmable Totaliser (Y/N)?	
Display Data & Type (E.g. instantaneous & total LCD)	
Transducer/Sensor range	
Transducer/Sensor wafer-type or flange-type?	
Transducer/Sensor temperature operating range	
Transducer/Sensor temperature compensation (Y/N)?	
Transducer/Sensor enclosure rating	
Transducer/Sensor lining material	
Transducer/Sensor tube material	
Transducer/Sensor grounding details	
Transducer/Sensor equipped with “Empty Pipe” detection as specified (Y/N)?	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

DATA SHEET – FULL PIPELINE FLOW METER FOR DISTRIBUTION/DIVERSION

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Power Supply (Voltage)	
Analogue Output Type & Programmable (Y/N)?	
Digital Output Type & Rating (E.g. SPDT, 230V AC, 5A) & Programmable (Y/N)?	
Controller/Transmitter Enclosure Rating	
Accuracy	
Repeatability	
Programmable Totaliser (Y/N)?	
Display Data & Type (E.g. instantaneous & total LCD)	
Transducer/Sensor range	
Transducer/Sensor temperature operating range	
Transducer/Sensor material	
Transducer/Sensor rating	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

DATA SHEET – GAS FLOW METER

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Power Supply (Voltage)	
Analogue Output	
Hazardous area rating (E.G. Ex ia IIC T5)	
Hazardous classification certification body (E.G. CSA, CESI, DEMKO, DMT, LCIE, etc.) as approved by SANS 10108, ARP 0108:2007.	
Controller/Transmitter Enclosure Rating	
Accuracy	
Range	
Display Data & Type (E.g. instantaneous m^3/hr LCD)	
Ambient temperature operating range	
Process temperature operating range	
Humidity range	
Sensor material	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

DATA SHEET – AREA-VELOCITY FLOW METER

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Power Supply (Voltage)	
Analogue Output Type & Programmable (Y/N)?	
No. Of Analogue Outputs	
Digital Output Type & Rating (E.g. SPDT, 230V AC, 2A) & Programmable (Y/N)?	
No. Of Relay Outputs	
Controller/Transmitter Enclosure Rating	
Velocity Accuracy	
Level Accuracy	
Repeatability & Linearity	
Programmable Totaliser (Y/N)?	
Display Data & Type (E.g. instantaneous & total LCD)	
Velocity Transducer/Sensor range	
Level Transducer/Sensor range	
Velocity Transducer/Sensor temperature operating range	
Level Transducer/Sensor temperature operating range	
Velocity Transducer/Sensor temperature compensation (Y/N)?	
Velocity Transducer/Sensor temperature compensation (Y/N)?	
Local agent (Y/N)?	
Local agent contact details	
Guarantee period	

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

VOLUME 9 : LEVEL MEASUREMENT

Johannesburg Water (SOC) Ltd.
PO Box 61542
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Revision 14 August 2019

DOCUMENT CONTROL SHEET

Document Title: **Particular Specification – VOLUME 9 : Level Measurement**

JW Reference: **BWW523C**

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2018-11-30	12	C. Du Toit	Added reference to Labelling specification.
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2013-10-07	10	C. Du Toit	Updated footer
2012-07-27	9	C. Du Toit	Updated headers & footers.
2012-03-08	8	C. Du Toit	Changed (Pty) to (SOC).
2011-07-11	7	C. Du Toit	Removed 2010 logo.
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2009-08-18	5	C. Du Toit	New logos and transmitter position requirements added.
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2007-06-05	2	C. Du Toit	Revision block updated and ”Joburg” logo added
2007-03-28	1	C. Du Toit	Final copy issued for approval and sign-off

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9 LEVEL MEASUREMENT

9.1 Scope

9.1.1 This specification covers the supply and installation of Level meters, complete with sensors, transmitters, indicators, panels, etc. used for process monitoring and control applications at Johannesburg Water wastewater sites.

9.2 Abbreviations

9.2.1 In this specification the following abbreviations will apply :-

BS	:	British Standards
PLC	:	Programmable Logic Controller
I/O	:	Input/Output
CPU	:	Central Processing Unit
UPS	:	Uninterruptible Power Supply
MCC	:	Motor Control Centre
MCB	:	Miniature Circuit Breaker
SPD	:	Surge Protection Device
FJB	:	Field Junction Box
SSO	:	Switched Socket Outlet
SPDT	:	Single Pole Double Throw (refers to relay or switch contact arrangements).
LCD	:	Liquid Crystal Display
LED	:	Light Emitting Diode
O&M	:	Operating And Maintenance

9.3 Standards

9.3.1 The supply and installation of all Level meters and associated cabling, panels and any other equipment shall be subject to the latest amendments and editions of the following standard specifications:-

SANS 10142-1	:	National Standards for the wiring of premises.
SANS 1091:2004	:	National Colour Standard.
SANS 1274-2005	:	Coatings applied by the powder-coating process.
BS 381C:1980	:	Paint colour chart.

9.4 General Requirements

9.4.1 This specification must be read in conjunction with the following specifications:-

9.4.1.1 PLC Panels Specification (Volume 3 of the Automation And Control Standards).

9.4.1.2 Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

9.4.1.3 Cabling Specification (Volume 6 of the Automation And Control Standards).

9.4.1.4 Load Cells And Their Installation

9.4.1.5 Labelling (Volume 25 of the Automation And Control Standards).

9.4.2 Where cables are exposed to physical damage (including damage from rodents) armoured cables must be used or un-armoured cables must be run in steel conduit.

9.4.3 All power supply cables to instruments must have a black outer sheath, while all control cables (such as digital and analogue signals to PLC's) must have an orange outer sheath as specified in the Cabling Specification (Volume 6 of the Automation And Control Standards).

9.4.4 FJB's and as far as practically possible all instrument sensors and transmitters, must be mounted such that all equipment, wiring, numbers, terminations, etc. are readily accessible and can be viewed clearly. No equipment may be mounted such that it becomes a hazard or dangerous to view or gain access to such equipment.

9.4.5 Where sensors and/or transmitters cannot be mounted where they are readily accessible, the installation must be done in such a way that the sensor or transmitter can easily be moved to a safe and convenient position for testing, maintenance, replacement, etc. (e.g. by using hinged brackets, telescopic brackets, etc.).

9.4.6 Where transmitters can be exposed to the elements (wind, rain, ultra violet, etc.) such transmitters must be installed inside the FJB. Where transmitters are protected from the elements (i.e. inside buildings) but they are exposed to potentially harmful conditions like moisture from splashing or equipment being hosed down, or the sensor is in such a position that the transmitter display is not clearly visible from floor level, without the need to climb onto ladders or structures to access it, the transmitter must also be installed inside the FJB. Only where transmitters are not exposed to the elements or any other harsh or potentially harmful conditions and where the displays on such transmitters are clearly legible by an average person standing on the ground or the normal walking surface (e.g. grating above ground level), can the transmitter be mounted outside the FJB.

9.4.7 FJB's must be mounted against a wall or structure or on a sturdy pedestal such that the top of the FJB enclosure is no higher than 1.8 m from the floor and easily accessible from the front.

9.4.8 All instrument installations must be done in accordance with the manufacturer's requirements and recommendations for proper operation. It is the tenderer's responsibility to ensure that he/she is familiar with both the requirements of the manufacturer as well as the installation requirements, in terms of location, site conditions, materials, equipment or substances to be measured (e.g. hot liquids, acids, abrasive material, etc.) and to ensure that if there are potential problems, they can be pointed out and rectified before orders for equipment are placed.

9.4.9 Costs incurred for alterations required to ensure proper operation of instruments, after orders have been placed, will be for the tenderer's account. For example, if

instruments have been ordered and it is found there is insufficient space to install the instrument, or the instrument is not flooded with liquid all the time as it is required for proper operation, or the instrument transmitter is sometimes flooded in its installed position, or the sensing head is sometimes outside the medium it is supposed to measure, or the instrument linings are damaged by abrasive liquids, or the sensor is does not have a suitable range of measurement, etc. alterations or replacements required to rectify such problems will be for the tenderer's account if the Engineer finds that the tenderer was negligent in his/her assessment of the installation.

9.4.10 Each instrument must be equipped with a circuit breaker connected to the power supply of the instrument, to enable local isolation in case of repairs or replacement.

9.4.11 The supplier of the instrument must be present for the installation, testing and commissioning of the instrument on site. Due allowance must be made for this in the tender sum.

9.4.12 The tenderer must supply a complete and detailed set of documentation for the installation, connections, terminations, power supply, technical details, setting up, calibration (if applicable), testing, etc. of the instrument for inclusion in a final O&M manual.

9.4.13 Completed data sheets are required as part of the returnable documents of each tender. Failure to complete these data sheets, supplied at the end of this specification, will lead to disqualification of the tender.

9.5 Surge Protection

9.5.1 Each instrument and its associated equipment must be suitably protected against surges from induced voltages, switching of equipment, lightning strikes, etc. as detailed in the Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

9.5.2 The power supply to the instrument must be equipped with suitable surge protection, both at the instrument and at the source of the power supply (i.e. at the distribution board, MCC, PLC panel, etc.), as detailed in the Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

9.5.3 Both the digital and analogue signals between the instrument and other remote devices (such as the PLC), must be equipped with suitable surge protection, both at the instrument and at the remote device as detailed in the Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

9.6 Level Measurement – Controller/Transmitter

9.6.1 All level measurements must be done by using ultra-sonic distance measurement, which is converted into a level value.

9.6.2 All instrument transmitter enclosures must have at least an IP 65 or higher rating.

9.6.3 The instrument must be equipped with an isolated, active, 4 – 20mA output which will be connected to a maximum 500 ohm load. This output must be user-programmable.

9.6.4 The instrument must be equipped with at least three to five SPDT relays, rated for at least 230V AC, 2A, for preset level outputs. These outputs must be user-programmable for various levels.

9.6.5 The transmitter must be suitable for use with a 230V AC, 50/60 Hz power supply.

9.6.6 The transmitter must have an accuracy of at least 0.25% or 6mm, whichever is greater.

9.6.7 The transmitter must have a resolution of at least 0.1% or 2mm, whichever is greater.

9.6.8 The transmitter must have an LCD or LED display showing instantaneous level and relay status.

9.7 Level Measurement – Sensor/Transducer

9.7.1 The range of the sensor must be suitable for the application (see items 9.4.8 and 9.4.9 of this specification).

9.7.2 The sensor must be suitable for an operating temperature range of -10ºC to +50ºC.

9.7.3 The sensor must be equipped with automatic temperature compensation.

9.7.4 The sensor must have a protection rating of at least IP 67 or higher.

9.7.5 Brackets used for the mounting of ultra-sonic sensor heads must be made of at least 3CR12 grade stainless steel.

9.8 Spares

9.8.1 The tenderer will be required to provide a recommended spares list for three years maintenance. This item must be completed so that spares may be ordered as part of the capital contract. Tenderers ignoring this condition may be disqualified.

9.9 Labelling

9.9.1 All labelling must comply with the requirements as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

9.10 Data Sheets

9.10.1 All data sheets in the attached Appendix 1 must be completed.

APPENDIX 1

DATA SHEET – LEVEL METER

DESCRIPTION	DATA
Make/Manufacturer	
Type/Model	
Power Supply (Voltage)	
Analogue Output Type & Programmable (Y/N)?	
Digital Output Quantity, Type & Rating (E.g. 5 x SPDT, 230V AC, 5A) & Programmable (Y/N)?	
Controller/Transmitter Enclosure Rating	
Accuracy	
Resolution	
Display Data & Type (E.g. instantaneous level & relay status LCD)	
Transducer/Sensor range	
Transducer/Sensor temperature operating range	
Transducer/Sensor temperature compensation (Y/N)?	
Transducer/Sensor enclosure rating	
Local agent (Y/N)?	
Local agent contact details.	
Guarantee period	

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

VOLUME 7 : NETWORKING

Johannesburg Water (SOC) Ltd.
PO Box 61542
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2012-03-08	9	C. Du Toit	Changed (Pty) to (SOC), updated core switch port requirements, core switch power supply requirements,
2011-07-11	8	C. Du Toit	Removed 2010 logo.
2010-07-27	7	C. Du Toit	Area and core switch requirements clarified, data irrelevant to tenderers deleted and data sheets
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2007-06-05	2	C. Du Toit	Revision block updated and "Joburg" logo added
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7 NETWORKING

7.1 Scope

7.1.1 This specification covers the supply and installation of equipment, the network topologies, the communication methods and the security for data communication systems, typically between Programmable Logic Controllers and Supervisory systems, used in process monitoring and control applications at Johannesburg Water wastewater sites.

7.2 Abbreviations

7.2.1 In this specification the following abbreviations will apply :-

CD	:	Compact Disk
CLI	:	Command Line Interface
DiffServ	:	Differentiated Services
EMC	:	Electro-Magnetic Compatibility
GARP	:	Generic Attribute Registration Protocol
GMRP	:	GARP Multicast Registration Protocol
GUI	:	Graphical User Interface
GVRP	:	GARP VLAN Registration Protocol
HTTPS	:	Hyper Text Transfer Protocol Secure switches
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronic Engineers
IGMP	:	Internet Group Management Protocol
LACP	:	Link Aggregation Control Protocol
LAN	:	Local Area Network
LED	:	Light Emitting Diode
MAC	:	Media Access Control
Mbit	:	Mega bits
Mbps	:	Mega bits per second
MDI/MDI-X	:	Medium Dependent Interface/ Medium Dependent Interface (crossed)
OS	:	Operating system
PC	:	Personal Computer
PLC	:	Programmable Logic Controller
QoS	:	Quality Of Service
RD	:	Read
RSTP	:	Rapid Spanning Tree Protocol
SANS	:	South African National Standards
SCADA	:	Supervisory Control And Data Acquisition

SNMP	:	Simple Network Management Protocol
SSH	:	Secure Shell
SSL	:	Secure Sockets Layer
TCP/IP	:	Transmission Collision Protocol/Internet Protocol
TOS	:	Type Of Service
TX	:	Transmit
USB	:	Universal Serial Bus
VLAN	:	Virtual Local Area Network

7.3 Standards

7.3.1 All design standards shall be subject to the latest amendments and editions of the following standard specifications:-

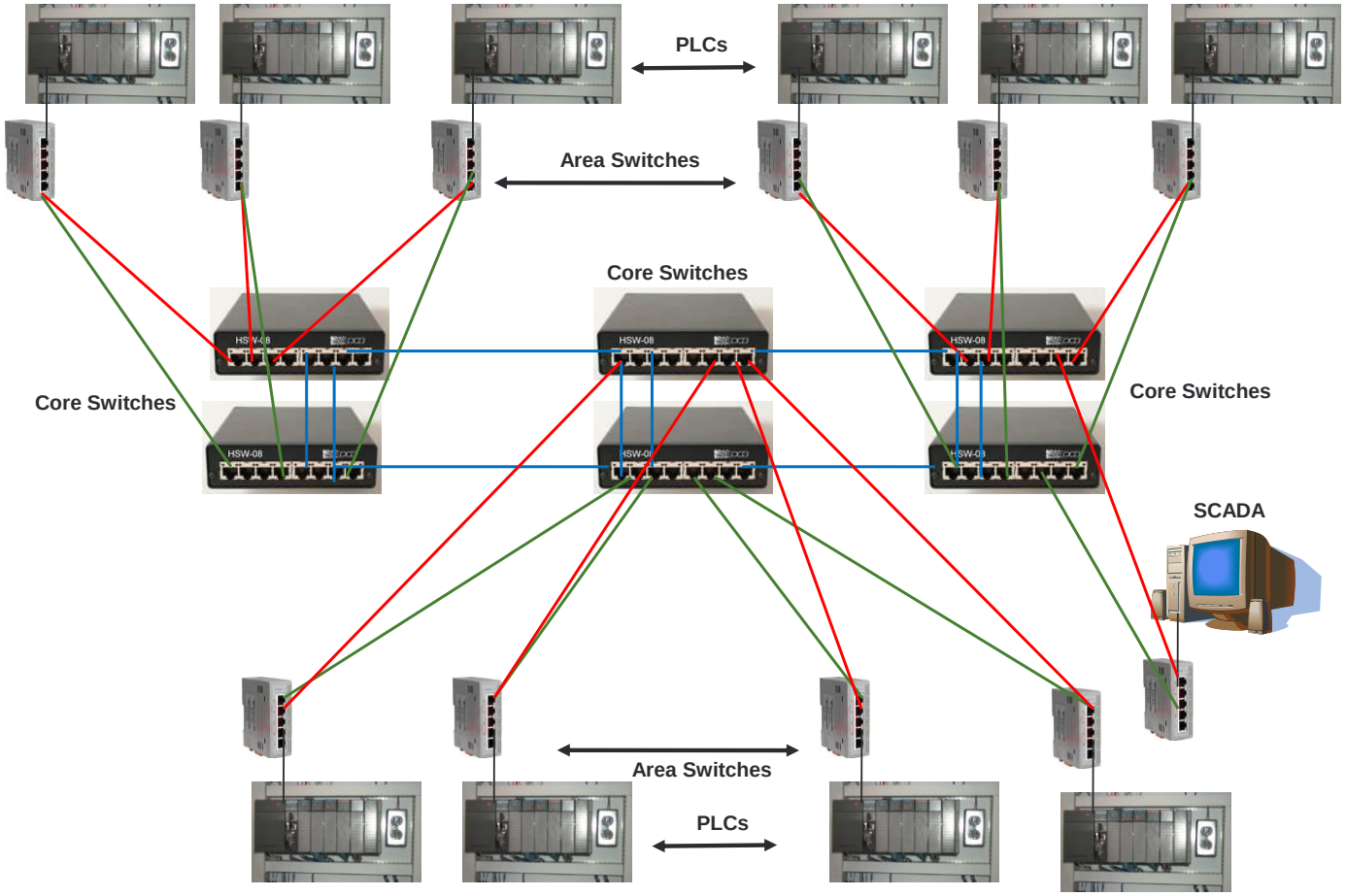
SANS 10142-1	:	National Standards for the wiring of premises
IEEE 802.3-2005	:	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications
IEEE 802.3ad (Now IEEE 802.1AX)	:	Link Aggregation
IEEE 802.1d	:	MAC Bridges
IEEE 802.1p	:	Quality of service
IEEE 802.1Q	:	VLAN Tagging
IEEE 802.1w	:	Rapid Spanning Tree Protocol
IEEE 802.1X	:	Port Based Network Access Control
IEC 60068-2-6	:	Environmental Testing - Vibration
IEC 60068-2-27	:	Environmental Testing – Test Ea and guidance: Shock
SANS 61000-4/IEC 61000-4	:	Electromagnetic compatibility – testing and measurement techniques

7.4 Communication Protocol

7.4.1 The preferred method of communication between PLC’s or between PLC’s and SCADA systems is Ethernet TCP/IP.

7.4.2 Systems must be designed and equipment selected with the view of communicating via TCP/IP over Ethernet.

7.5 Network Topology



7.5.1 The preferred topology is an Ethernet star/mesh topology as indicated in the diagram above.

7.5.2 Where existing installations make the use of a star/mesh topology impractical, contractors must link into the existing system in such a way that future conversion to a star/mesh topology will not be hampered by the current installation.

7.5.3 All systems must be designed and equipment selected with the view of converting to a star/mesh topology when possible.

7.5.4 Network redundancy must be such that if one core switch fails, there must be a second one that can maintain communication (as shown in the diagram above).

7.5.5 Data communication between core switches and from core switches to the area switch patch panels must be done via 9/125µm, single mode, PVC, CST (Corrugated Steel Tape) cable or single mode blown fibre microduct assemblies (see the Cabling Specification (Volume 6 of the Automation And Control Standards)). The number of cores must be as specified in the project scope of work and the tender bill of quantities.

7.5.6 Each core switch pair (i.e. the two core switches which form a dual redundant system at a particular location) must be equipped with two UPSs (Uninterruptable Power Supplies) as specified in the “Automation And Control Design Standards, Volume 5, Clean Power And Surge Protection”. The two power supplies must be connected to both switches (i.e. each UPS supplies both core switches) to provide redundancy. These supplies must also be equipped with proper surge protection as detailed in the same specification - “Automation And Control Design Standards, Volume 5, Clean Power And Surge Protection”.

7.6 Switches

7.6.1 Minimum Requirements For Area Switches

7.6.1.1 Only industrial type switches will be accepted. No standard “commercial” or “Office” switches will be accepted. These switches must have at least an IP 20 rating, must have a rugged high-strength metal case and must have DIN-rail or panel mounting ability. They must have an operating temperature of at least 0 to 55ºC, without the use of cooling fans and must be able to work in relative humidity up to 95% without condensation.

7.6.1.2 Redundancy and fault recovery:

- Must comply with IEEE 802.1w for Rapid Spanning Tree Protocol

7.6.1.3 Remote management and monitoring:

- Must support SNMP V1/V2/V3 for different levels of network management security

7.6.1.4 Area switches must have at least two SFP uplink ports which are 1000Base-LX Gigabit Ethernet standard compatible. These ports must be compatible with Duplex LC-type connectors for single-mode fibre.

7.6.1.5 Area switches must have the number of copper ports as specified in the project scope of work and the tender bill of quantities. The copper ports must be 10BASE-T/100BASE-TX compatible in order to communicate with the PLCs. These ports must be capable of accepting RJ45 connectors on CAT-6 cable.

7.6.1.6 In terms of configuration, maintenance, management and monitoring features required, all area switches must:

- Have support for loading or saving configurations to a remote host
- Have port monitoring for debugging
- Have line-swap fast recovery to normal operation (within milliseconds) after devices are unplugged and then re-plugged into different ports
- Be configurable by Operating System (OS) independent web browser, using secure HTTPS

7.6.2 Minimum Requirements For Core Switches

7.6.2.1 Only industrial type switches will be accepted. No standard “commercial” or “Office” switches will be accepted. These switches

must have redundant, dual DC power units, must have at least an IP 30 rating, must have a rugged high-strength metal case and must be 19" rack-mounted switches. They must have an operating temperature of at least 0 to 55ºC, without the use of cooling fans and must be able to work in relative humidity up to 95% without condensation.

7.6.2.2 Redundancy and fault recovery:

- Must comply with IEEE 802.1w for Rapid Spanning Tree Protocol
- Must comply with IEEE 802.3ad (now 802.1AX) for link aggregation or port trunking and must have at least 4 trunks.

7.6.2.3 Broadcast isolation and network segmentation:

- Must comply with IEEE 802.1Q in terms of support for VLAN Registration Protocol (GVRP) to ease network planning

7.6.2.4 Quality of service:

- Must comply with IEEE 802.1p/1Q in terms of support for TOS/DiffServ in order to increase determinism

7.6.2.5 Multicasting:

- Must have IGMP Snooping and GMRP for filtering multicast traffic from industrial Ethernet protocols

7.6.2.6 Security and authentication:

- Must comply with IEEE 802.1X in terms of support for SSL to enhance network security

7.6.2.7 Remote management and monitoring:

- Must support SNMP V1/V2/V3 for different levels of network management security

7.6.2.8 Core switches must be managed, Layer 3 switches with the number of ports as specified in the project scope of work and the tender bill of quantities.

7.6.2.9 Core switches must provide support for a minimum of four trunked Gigabit SFP ports with 1000Base-LC, LC connectors.

7.6.2.10 Core switches must provide support for a minimum of eight SFP ports that will support a combination of Fast Ethernet ports (10/100Base-TX,) and Gigabit Ethernet ports (1000Base-T, 1000Base-LX).

7.6.2.11 In terms of configuration, maintenance, management and monitoring features required, all core switches must:

- Have support for loading or saving configurations to a remote host
- Have port monitoring for debugging
- Have line-swap fast recovery to normal operation (within milliseconds) after devices are unplugged and then re-plugged into different ports
- Be configurable by Operating System (OS) independent web browser, using secure HTTPS
- Be configurable by CLI by Local Serial console and remote SSH network connection
- Support ping commands to identify network segment integrity

7.7 Compliance With Standards

7.7.1 It is important that all equipment is selected and installations are done to industrial standards. These are usually harsh environments in terms of dirt, industrial activities such as welding, grinding, etc. and electrical interference such as lightning, capacitor switching, large drives starting and stopping, etc.

7.7.2 The complete installation and networking system must comply with IEEE 802.3-2005.

7.7.3 The equipment installed must comply with SANS 61000-4/IEC 61000-4 for EMC.

7.7.4 The equipment installed must comply with IEC 60068-2-6 for vibration (10 to 57 Hz – amplitude 0.15mm, 57 to 150 Hz – acceleration 2g).

7.7.5 The equipment installed must comply with IEC 60068-2-27 for shock (12 shocks semi-sinusoidal, 15g, 11ms).

7.7.6 All installations must comply with the requirements of SANS 10142-1.

7.8 Network Switch Data Sheets

7.8.1 For network switches supplied, the tenderer must supply the data sheets shown in Appendix A with his tender.

7.8.2 All installations must comply with the requirements of SANS 10142-1.

7.9 Redundancy Testing

7.9.1 All the core network switches and area switches that have been installed in a redundant configuration must to be tested by a network specialist and the results documented. The contractor must make the following equipment available to complete these tests:

- Two portable area switches as specified in 7.6.1
- Two portable computers, running from a CD ROM-booted operating system (e.g. Linux LiveCD)

7.9.2 The following ping test procedures must be followed using ICMP (Internet Control Message Protocol).

- Continuous ping messages will be sent form a portable test computer located at the core switch to a remote portable test computer that will be moved around all the network points (i.e. the area switches) to confirm the data throughput, latency (ping time) and network failover time.
- Confirm that the round-trip ping times with a packet size of 10kb does not exceed 2 milliseconds.
- Confirm that the continuous ping messages recovers within 3 seconds after either one of the redundant core switches has been powered down or powered up and after either one of the fly leads to the area switch has been disconnected form a core switch.
- Capture the result as indicated in the following example:

Port No	PING Time	SW0-A Switch Down	SW0-B Switch Down	SW0-A Link Down	SW0-B Link Down	Comments
1	<1ms	✓	✓	✓	✓	Location L2

7.10 Labelling

7.10.1 All labelling must comply with the requirements as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

APPENDIX 1

DATA SHEET - FIBRE "CORE" GIGABIT ETHERNET SWITCHES

DESCRIPTION	DATA
Manufacturer	
Model or Type	
Part or Order Number	
19" Rack-mount switch?	☐ Yes ☐ No
Comply with IEEE 802.1w for Rapid Spanning Tree Protocol?	☐ Yes ☐ No
Comply with IEEE 802.3ad (now 802.1AX) for link aggregation or port trunking?	☐ Yes ☐ No
Switch has at least 4 trunks?	☐ Yes ☐ No
Comply with IEEE 802.1Q i.t.o. support for VLAN Registration Protocol (GVRP)?	☐ Yes ☐ No
Comply with IEEE 802.1p/1Q i.t.o. support for TOS/DiffServ?	☐ Yes ☐ No
Comply with IEEE 802.1X i.t.o. support for SSL?	☐ Yes ☐ No
Support SNMP V1/V2/V3 for different levels of network management security?	☐ Yes ☐ No
Is it a managed, Layer 3 switch?	☐ Yes ☐ No
At least 8 SFP ports that will support a combination of Fast Ethernet ports (10/100Base-TX) and Gigabit Ethernet ports (1000Base-T, 1000Base-LX)?	☐ Yes ☐ No
Support for loading or saving configuration to a remote host?	☐ Yes ☐ No
Port monitoring for debugging?	☐ Yes ☐ No
Has line-swap fast recovery to normal operation (within milliseconds) after swapping devices?	☐ Yes ☐ No
Configurable by Operating System (OS) independent web browser, using secure HTTPS?	☐ Yes ☐ No
Configurable by CLI by Local Serial console and remote SSH?	☐ Yes ☐ No
Support ping commands to identify network segment integrity?	☐ Yes ☐ No

Local Agent?	☐ Yes ☐ No
Local agent contact details	
Guarantee period	

DATA SHEET – "AREA" ETHERNET SWITCHES

DESCRIPTION	DATA
Manufacturer	
Model or Type	
Part or Order Number	
Comply with IEEE 802.1w for Rapid Spanning Tree Protocol?	☐ Yes ☐ No
SFP Uplink ports which are 1000BASE-LX Gigabit Ethernet standard compatible?	☐ Yes ☐ No
Uplink ports compatible with Duplex LC-type connectors for single-mode fibre?	☐ Yes ☐ No
Support for loading or saving configuration to a remote host?	☐ Yes ☐ No
Port monitoring for debugging?	☐ Yes ☐ No
Has line-swap fast recovery to normal operation (within milliseconds) after swapping devices?	☐ Yes ☐ No
Configurable by Operating System (OS) independent web browser, using secure HTTPS?	☐ Yes ☐ No
Local Agent?	☐ Yes ☐ No
Local agent contact details	
Guarantee period	

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

VOLUME 3 : PROGRAMMABLE LOGIC CONTROLLER (PLC) PANELS

Johannesburg Water (SOC) Ltd.
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DOCUMENT CONTROL SHEET

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3 PROGRAMMABLE LOGIC CONTROLLER (PLC) PANELS

3.1 Scope

3.1.1 This specification covers the manufacturing, supply and installation of Programmable Logic Controller panels used for process monitoring and control applications at Johannesburg Water wastewater sites.

3.2 Abbreviations

3.2.1 In this specification the following abbreviations will apply :-

BS	:	British Standards
PLC	:	Programmable Logic Controller
I/O	:	Input/Output
CPU	:	Central Processing Unit
UPS	:	Uninterruptible Power Supply
MCC	:	Motor Control Centre
MCB	:	Miniature Circuit Breaker

3.3 Standards

3.3.1 All design standards for cabling shall be subject to the latest amendments and editions of the following standard specifications:-

SANS 10142-1	:	National Standards for the wiring of premises.
SANS 1091:2004	:	National Colour Standard.
SANS 1274-2005	:	Coatings applied by the powder-coating process.
BS 381C:1980	:	Paint colour chart.

3.4 General Requirements

3.4.1 The PLC control panel shall house the following items:-

3.4.1.1 The PLC and all I/O modules and racks.

3.4.1.2 Fibre-optic network interface modules.

3.4.1.3 All network switches and hubs.

3.4.1.4 All field instrumentation and MCC interface cables shall be marshalled in this panel.

3.4.1.5 All power supply and distribution circuitry and equipment.

3.4.1.6 All lightning and surge protection devices as required.

3.4.1.7 Marshalling terminals as required

3.4.1.8 Interposing relays as required.

3.4.2 The supply and installation shall in general comply with the relevant clauses in all specifications attached to the tender documentation.

3.4.3 The panels shall be free standing units with bottom cable entry (via a glanding plate) and have front door access (hinged and lockable).

3.4.4 The panel should be manufactured from sheet steel not less than 2,0 mm thick. The panel will have a door on the front which opens to practically the full width and height of the panel. The panel shall be free standing and shall not be more than 2 200 mm high, 2 400mm wide and 600mm deep and it should be sized to accommodate all the PLC and associated equipment required for the actual PLC I/O and future spare capacity as indicated in the PLC schematic diagram.

3.4.5 Once the door is open there should be no obstruction to prevent full access to every point inside the panel.

3.4.6 The panel shall be epoxy powder coated electric orange (Shade B26) finish. Interior chassis mounting plates will be finished in appliance white. All removable parts and hardware will be cadmium yellow passivized.

3.4.7 Each panel and control function should be clearly labelled with labels engraved on laminated engraving board with black letters on a white background. All labels must be attached with chrome plated, screws and nuts or screws and tapped holes. On the backing plate only tapped holes may be used. Screws with nuts on the backing plate will not be acceptable.

3.4.8 The panel must be vermin-proof and must have a protection rating of no less than IP 55.

3.4.9 This specification must be read in conjunction with the PLC Hardware Specification (Volume 2 of the Automation And Control Standards).

3.4.10 All labelling must comply with the requirements as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

3.5 Standard Features

3.5.1 Each panel shall have the following features as standard:-

3.5.1.1 Ventilation fans with air filters shall be mounted on the PLC panel at high level with no air outlets. The fans must pressurise the panel to prevent the ingress of dust.

3.5.1.2 Ventilation fans must have proper screw terminals in an enclosed terminal box. No exposed terminations, soldered connections or push-on lugs will be accepted.

3.5.1.3 A 230V AC switch socket outlet shall be mounted inside the panel (supplied from the UPS section). This socket must have a shaved earth which shall be used for the PLC programmer only.

3.5.1.4 Interior lighting at the top of the panel must be arranged to switch on, via a micro switch, when the panel door is opened. This light must be an LED

light with a CCT (Correlated Colour Temperature) of 4000K to 6000K. The light must be fitted with a diffuser and it must supply no less than 680 lm (Net luminous flux). The lamp must have proper screw terminals in an enclosed terminal box. No exposed terminations, soldered connections or push-on lugs will be accepted.

3.5.1.5 A substantial area of removable gland plates on the floor of the panel, split into two or more sections.

3.5.1.6 A sheet steel pocket welded onto inside of the door to hold A4 sized drawings, books etc.

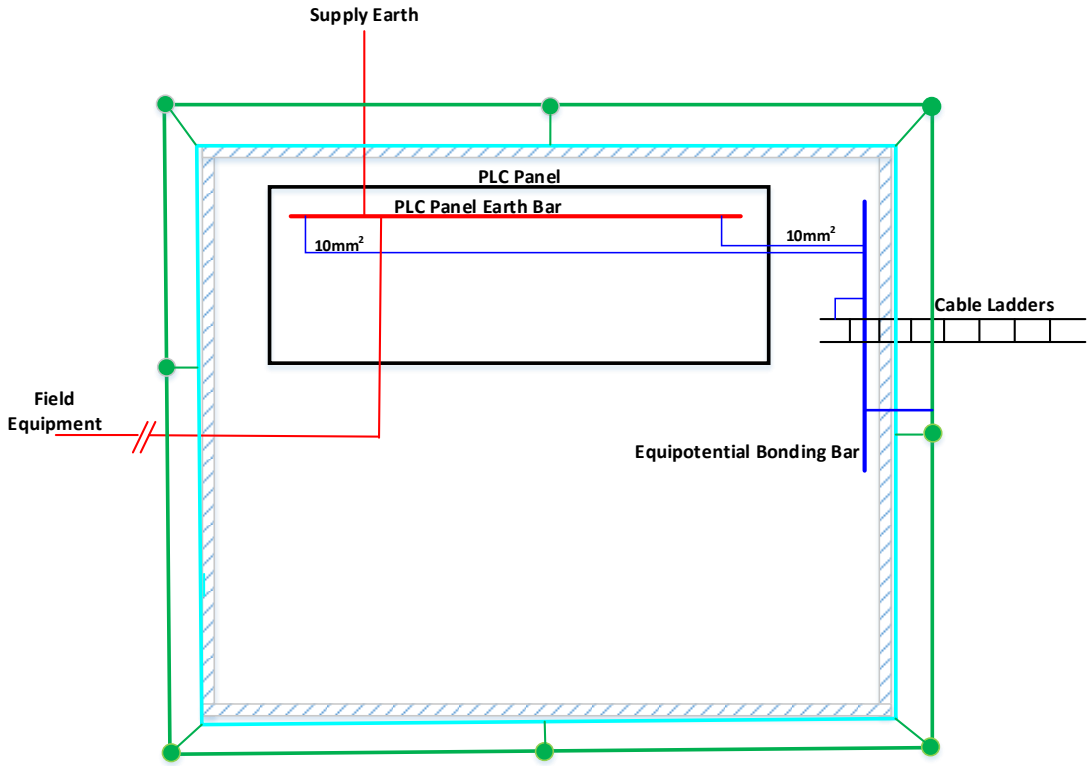
3.5.1.7 No holes may be drilled for tapping, riveting, bolts & nuts, etc. in any section of the panel where it will compromise the protection rating of the panel. I.e. only in the backing plate or in the glanding plate may holes be drilled. Where drilling is unavoidable, e.g. to affix labels, the holes must be sealed so that the protection rating of the panel is not compromised.

3.5.1.8 Bolts with nuts shall not be used to attach equipment to any mounting plate at any point. On mounting plates only bolts in tapped holes will be acceptable. Bolts with nuts will be allowed on enclosure doors however, where the bolts and nuts are easily accessible.

3.5.1.9 Where bolts are used on the door or any outside panels of the enclosure, a sealing method (e.g. rubber washers) must be used to ensure that the IP protection rating of the enclosure is not compromised.

3.5.1.10 Wherever bolts are used, the bolts must be as short as practically possible so that there are no long protrusions that can injure people or snag clothing, wiring, other equipment, etc. If bolts are cut to the correct length, the ends of the bolts must be neatly de-burred and smoothed so that there are no sharp edges that can cause injuries and so that the nuts can be easily screwed on and off. No more than four threads of the bolt end must be visible beyond the nut. It is however preferred that the correct length of bolts are used so that shortening is not required.

3.5.1.11 A copper earth bar running the full width (i.e. left-end to right-end) of the panel at the bottom with solid electrical connection to the panel doors and to the steel of the panel at two or more places and provided with terminals for connection of equipment and screen earth wires. This earth bar must be connected to the equipotential bonding bar of the building via at least 2 x $10mm^2$ earth conductors (one from each end of the panel earth bar), as shown in the sketch below.



3.5.1.12 Separate AC and DC distribution sections if both AC and DC are used.

3.5.1.13 A free-standing (i.e. not the PLC rack mounted) 24V DC Power supply for all analogue I/O cards or I/O sub-bases (where required), 24V DC I/O distribution (if required), field instrumentation supplies (if required), etc.

3.5.1.14 Where stopper plugs are used to seal holes that are not used, no plastic stopper plugs will be acceptable. All stopper plugs must be threaded, non-corrodible, metal plugs with rubber washers on both sides of the panel to ensure at least an IP65 seal (see examples below).

3.6 Wiring, Relays and Terminals

3.6.1 All terminals shall be screw-type terminals and shall be mounted on raised DIN terminal rail, secured to the chassis plate at the back of the panel.

3.6.2 Proprietary type wire strippers shall be used and no stranded conductor shall be terminated if one or more strands have been damaged.

3.6.3 Not more than one wire shall be connected to any terminal unless the terminal can accept pin lugs on either side of a screw or unless proper connecting material is used (see examples below).

3.6.4 Every wire shall be marked at both ends with a numbering system approved by the Engineer, and all terminating wires shall also be suitably crimped to a terminal lug. Not more than one wire shall be crimped into a single lug.

3.6.5 All wiring shall be flexible, tinned, annealed, multi-strand copper wire not less than:-

3.6.5.1 1,5mm² for 230V AC or 110V AC power

3.6.5.2 1,0mm² for 24V DC or AC power

3.6.5.3 0,5mm² for all PLC I/O wiring between modules and marshalling terminals

3.6.5.4 4,0mm² for earth drain

3.6.6 Irrespective of the minimum wire sizes allowed in this specification, contractors must ensure that all cables and wiring are capable of carrying the full system currents, inclusive of de-rating factors as specified in the latest version of SANS 10142.

3.6.7 All wire terminations must be done by using suitable lugs. No more than one wire may be crimped into a single lug. Where pin lugs are crimped onto the ends of wires, correctly sized pin lugs must be used, which fit into the terminals properly and such that the tightening of the terminal does not result in the loosening of the pin lug.

3.6.8 All panel wiring shall run in suitably sized slotted trunking for as much of their course as possible, thereafter in spiral band or similar conduit to its destination if the exposed run would exceed 100mm.

3.6.9 The distance between the terminals and the trunking or between equipment (such as relays, surge protection, circuit breakers, etc.) and trunking shall not be less than 50mm.

3.6.10 Control wiring should not run with power wiring and all cross-overs shall be at ninety degrees.

3.6.11 A block of terminals shall be allocated to each I/O module. The terminal block shall be labelled with the PLC rack number and module slot allocation.

3.6.12 The terminals allocated for the various I/O modules must be as per the design drawings submitted by the Engineer. If it forms part of the contractor's scope of work to submit design drawings, the terminals allocated for the various I/O modules must be approved by the Engineer. All terminals shall be sequentially numbered from top to bottom for each I/O channel for every type of I/O card.

3.6.13 Each analogue and digital input and output channel shall have surge protection units as specified in the Clean Power And Surge Protection Specification (Volume 5 of the Automation And Control Standards).

3.6.14 Internal wiring shall be colour coded as follows:-

3.6.14.1 230V AC Power

Live	Brown
Neutral	Blue
Earth	Green and Yellow

3.6.14.2 24V DC Power

Positive	Red
Negative	Black

3.6.14.3 Digital Inputs

230V AC	Yellow
24V DC	Red

3.6.14.4 Digital Outputs

230V AC	Grey
24V DC	Red

3.6.14.5 Relay Outputs

230V AC	Grey
24V DC	Red

3.6.14.6 Analogue Signals

Positive	Orange
Negative	Purple

3.6.15 A terminal section for AC and DC power distribution shall be included in the PLC panel where both voltages are used for PLC I/O. The terminal groups shall be clearly identified to indicate the various voltages.

3.6.16 A separate power distribution section shall be used for the AC and DC supplies where both voltages are used. Miniature circuit breakers (MCB's) shall be used to feed the various items of equipment such as PLC I/O cards, fans, lights, field instruments, etc. Fused terminals may be used if it is indicated as such on the design drawings submitted by the Engineer.

3.6.17 Two types of mains supplies shall be made available to the PLC panels: Raw Mains and UPS Mains. The raw mains incomer shall feed the non-critical items such as fans, 24V DC power supplies, 230V AC terminal section, 230V AC I/O modules, relay output modules, etc. The UPS supply shall feed the critical items required for PLC communications in the event of a raw mains power supply interruption. Such items are plugs (for PC), lights (inside the PLC panel), fibre-optic interface modules, PLC Processor, etc. Unless otherwise specified, PLC I/O and field instruments need not be supplied by UPS power.

3.6.18 All wiring must be continuous from one termination (in a terminal strip or device such as a relay, contactor, surge arrester, etc.) to the next. No spliced wiring will be accepted.

3.6.19 Where relays (not relays that are part of the PLC hardware, such as in I/O sub-bases) are used, such relays must be pluggable, so that relays can be replaced

without the need to disconnect wiring and the relays must have visible indication when it is energised.

3.7 Existing PLC Panels

3.7.1 All modifications and wiring changes to existing panels must comply with the specifications as laid down for new panels.

3.8 Factory Acceptance

3.8.1 Before delivery of the PLC systems and/or the PLC panels, a comprehensive system factory acceptance test must take place. The Engineer must be notified one week in advance of the proposed test.

3.8.2 The test shall comprise of at least, but not be limited to:

3.8.2.1 Checking the panel manufacturing and assembly for compliance with this specification.

3.8.2.2 Layout, numbering and labelling of equipment.

3.8.2.3 Wiring – sizes, numbering, colours, termination, etc.

3.8.2.4 Wiring as per drawings, I/O schedules, etc. (i.e. loop checks).

3.9 Loop Isolators

3.9.1 Loop isolators are required where the instruments and the relevant PLC are fed from different power sources. Loop isolators must provide isolation between the instrument signals and the power supply. Separately powered isolators are preferred.

3.10 Uninterruptible Power Supply (UPS)

3.10.1 An Uninterruptible power supply must be installed to isolate the PLC from the "raw" mains supply.

3.10.2 The UPS must comply with the UPS requirements as specified in the Clean Power And Surge Protection specification (Volume 5 of the Automation And Control Design Standards).

3.10.3 The raw mains incomer to the PLC panel shall feed the non-critical items such as fans, 24V DC power supplies, 230V AC terminal section, 230V AC I/O modules, relay output modules (if required), etc. The UPS supply shall feed the critical items that keep PLC communications established should the raw mains power supply be interrupted, such as plugs, lights, fibre-optic interface modules, PLC (CPU), etc.

3.10.4 Tenderers must satisfy themselves that the UPS rating is adequate to supply all the equipment which they are offering.

3.11 Over-Voltage/Lightning Protection

3.11.1 The function of the over-voltage/lightning protection units is to prevent damage

from occurring to the electrical and electronic devices due to destructive voltages, by resistive coupling, capacitive coupling or inductive coupling, arising from extraneous events such as lightning discharges, switching surges etc. All lightning and surge protection must be in accordance with the requirements in the Clean Power And Surge Protection specification (Volume 5 of the Automation And Control Design Standards).

3.11.2 The protection units on the 230V AC mains incomers of the PLC panel (if not provided on the mains elsewhere) shall consist of at least IEC Class II protection. Preferably Class I and Class II, or a combined Class I + Class II protection must be used.

3.11.3 Each individual supply from the 24V DC distribution and from the 230V AC distribution to field instruments or other field supplies must be equipped with at least Class II medium surge protection.

3.12 Spares

3.12.1 The tenderer will be required to provide at least 10% spare fuses and other consumable items which may be required during commissioning. In addition to commissioning spares, a recommended spare list for three years maintenance, should be submitted. This item must be completed so that spares may be ordered as part of the capital contract. Tenderers ignoring this condition may be disqualified.

3.13 Painting (Powder Coating Method)

3.13.1 **General**

Switchboards and panels shall be epoxy powder coated in accordance with Type 1 coatings to SANS 1274-2005.
Unless specified otherwise, a high gloss finish in the following colour shall be provided:
Colour - Light Orange, Colour No. B26, Munsell Ref. 2,5 YR C/14 to SANS 1091 : 2004 and Colour No. 381C-557 to BS 381C : 1980.
Paintwork must be guaranteed against blistering, peeling, cracking and general deterioration which can lead to rusting, corrosion, etc. for a period of no less than three years. If the tenderer cannot comply with this requirement, it must be clearly stated as such in the tender.

3.13.2 **Specifications**

The following specifications in accordance with SANS 1274-2005 shall be provided:-

Property	Requirement	Test Method
Thickness, minimum	50 micron	6,7
Marking Resistance (400g)	No marking	6.20
Impact Resistance, J, minimum	6,78	6.10
Water Resistance, h, minimum	720	6.13
Humidity resistance, h, minimum	1000	6.14
Resistance to salt fog, h, minimum	1000	6.16

3.13.3 **Surface Preparation**

Surface preparation of sheet steel components shall be carried out by means of the multi-bath zinc phosphate/chromate passivation treatment.

All fabricated sheet steel components are to be degreased and de-rusted ready for treatment.
A steel surface is considered ready for treatment when all dirt, grease, rust, mill scale, moisture or other contaminants have been removed in an alkaline degreaser to give a dry, clean, bright, metallic surface.
Steel plate less than 4mm thick - black steel sheet shall be pickled to white metal condition while pre-pickled, bright, cold rolled sheet steel shall be solvent cleaned. These surfaces shall be treated within eight hours in all cases while still uncontaminated and rust-free.
The prepared steel surface shall be treated by means of immersion in a heated zinc phosphate solution bath, rinsing and thereafter chromate passivated by means of immersion in the final treatment bath.

3.13.4 **Powder Coating**

A thermosetting powder consisting of epoxy/polyester resin shall be applied by means of an electrostatic spray gun to give a uniform coating thickness of 50 to 60 micron. Less than 50 micron will not be acceptable.

The powder coating shall be baked at a metal temperature of 185ºC so as to melt the powders to form a continuous film over the metal substrate.

3.14 Drawings And Diagrams

3.14.1 The tenderer must submit layout drawings, showing the PLC panel size, cable entry, location of equipment, details of equipment (such as fans, lights, plugs, trunking size, circuit breakers, fuses, terminals, etc.), panel colour, material of construction (e.g. 2mm mild steel), etc. for approval by the Engineer before any manufacturing commences.

3.14.2 The drawings must be accompanied with data lists of the proposed equipment. These data sheets must show the type, supplier, make, model, size, etc. of equipment where applicable. For example:

Terminals - Phoenix SK12, 4mm, white.
MCB's - Merlin Gerin, 5A, 10kA, single-pole.
Etc.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

E01 : ELECTRICAL MOTORS

Johannesburg Water

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Revision 4

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City of Johannesburg
Johannesburg Water (SOC) Ltd

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1	2009-05-12		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance

PARTICULAR SPECIFICATION: VOLUME E01: ELECTRICAL MOTORS

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E01.1 SCOPE

This specification shall cover all electric motors to be designed, supplied installed and tested that shall drive any of the items of equipment to be supplied under the contract. This specification shall be read together with those specifying the mechanical driven equipment.

E01.2 INTERPRETATIONS

E01.2.1 Abbreviations

In this Specification, the following abbreviations will apply:

ANSI : American National Standards Institute
ASTM : American Society for Testing and Materials
BS : British Standards Institution
SANS : South African National Standards

E01.2.2 Standards

The latest edition, including all amendments to until the date of tender, of the following particular national and international specifications, publications and codes of practice shall be read in conjunction with this specification and shall be deemed to form part thereof:

(a) SANS 1804-2 : Low-voltage three-phase standard motors

(b) SANS 60529 : Degrees of protection provided by enclosures (IP code)

(c) SANS 60034 : Rotating electrical machines

(d) BS 1486-2 : Heavy duty lubricating nipples

(e) SANS 60034-1 : Rotating electrical machines Part 1: Rating and performance

(f) ISO 281 : Rolling bearings - dynamic load ratings and rating life

E01.3 GENERAL REQUIREMENTS

(a) Electric motors shall be manufactured in South Africa and shall comply with the requirements of SANS 1804-2.

(b) Imported motors shall be accepted only if they form an integral part of the equipment offered. Where imported motors are offered they shall be submitted to the South African Bureau of Standards to be tested in accordance with the requirements of SANS 1804-2.

(c) The Engineer shall be provided with the appropriate certificates obtained from the South African National Standards stating that such motors do comply, prior with the installation of the motors. However, where tests reveal that motors do not comply, it shall be the responsibility of the Contractor to supply alternative motors that comply with the requirements of SANS 1804-2.

(d) Where imported motors are not normally kept in stock in South Africa, written proof shall be provided of the availability of replacement parts as well as the delivery period of the parts after placing the orders.

(e) All motors shall be standard catalogue models and shall be readily available.

(f) All motors shall where possible, be from the same manufacturer and shall have the same interchangeable frames. Variations in type and size shall, where possible, be limited to prevent stocking a variety of special spares.

(g) All motors shall be wound for direct-on-line (DOL) type of starting.

E01.4 WORKING VOLTAGE AND SUPPLY SYSTEMS

(a) The motors shall be capable of operating within ± 10% of the nominal supply voltage without risk of damage. All motors shall be suitable for operating continuously at the specified 3-phase voltage system under actual service conditions, including the ± 10% voltage tolerance, without exceeding the specified temperature rise determined by the resistance on a basic full load heat run.

(b) All motors shall be capable of operating continuously under actual service conditions at any supply frequency between 48 and 51 Hz together with any voltage between ± 5% of the nominal supply voltage.

(c) The slip-in speed of any motor at 80 percent of the nominal voltage at 50Hz shall not exceed a percentage agreed on by the engineer, and the motors shall be capable of operating at this voltage for a period of five minutes without deleterious heating.

E01.5 TEMPERATURE RISE

The temperature rise, as determined by resistance, of all motors, shall not exceed the following derated values:

Insulation class	E	B	F	H
Temperature rise (K)	50	60	80	100

E01.6 EFFICIENCY AND POWER FACTOR

(a) All motors supplied will be energy-efficient as described in SANS 60034-31: Selection of energy-efficient motors

(b) The efficiency of all motors shall be guaranteed by the contractor. Deviations from the guaranteed efficiency shall be within the limits specified in SANS 1804-2.

(c) The guaranteed efficiency of each motor size and rating shall be as determined in accordance with SANS 60034. A basic test certificate of efficiency will be accepted for a motor of identical size and rating or a basic test of efficiency shall be conducted if no certificate is available.

(d) The power factor of motors with a capacity of 20 kW or more shall not be less than 0,85 under all operating conditions.

E01.7 VIBRATION

(a) Motors shall be statically and dynamically balanced.

(b) All motors shall be checked for inadvertent vibration without load, and at full rated voltage at the manufacturer's works, and the vibration amplitude as measured shall be in accordance with SANS 60034-1.

(c) The ratio of axial to radial vibration shall not exceed 0,5.

E01.8 NOISE LEVEL

Unless specified differently all motors shall be of 'normal sound power', in compliance with SANS 60034.

E01.9 ENCLOSURE AND FRAME

(a) Each motor shall be ingress protected to the degree required by its application, and its enclosure shall be designed for the system of cooling associated therewith.

(b) Notwithstanding the requirements above, the minimum degree of protection shall be IP 55 to SANS 60529, or alternatively specified. Motors shall preferably be of the totally enclosed fan-cooled (TEFC) type.

(c) The motor cooling system must be of an aerodynamic design with minimal noise levels and superb airflow distribution over the frame with superior mechanical strength. All motor

cooling fan covers will be constructed in metal.

(d) All motors of the vertical-spindle type and exposed to the weather, shall be provided with a robust canopy of approved design by the Engineer.

E01.10 MOTOR TYPE

Motors shall be of the squirrel-cage induction type. Slip-ring induction motors or other approved types will be considered if the contractor is of the opinion that better results could be obtained by using such motors. Full electrical and mechanical details of each alternative shall be submitted with the tender documents. Alternative motors must be accepted by the Engineer in writing.

When motors are connected to VFD's with variable torque loads operated under usual service conditions, inverter-ready general-purpose motors must be supplied (IEC 60034-1)

When motors are connected to VFD's operating at extremely low speeds and/or with a constant torque load, or when operating over base speed, definite-purpose, inverter-duty motors must be supplied (IEC 60034-1).

Larger inverter-duty motors must be equipped with a constant speed auxiliary blower to provide adequate cooling at low motor operating speeds. The contractor must submit a statement from the motor supplier on the need for an auxiliary blower when omitted.

Inverter-duty motors above the 500 frame size should have both bearings insulated, and be equipped with a shaft grounding brush with a ground strap from the motor to the drive case. For frame sizes below 500, the contractor must check with the motor manufacturer regarding requirements for motor bearing insulation.

E01.11 RATING AND STARTING REQUIREMENTS

(a) Motors shall be adequately rated for the service for which they are intended, and due allowance shall be made for the temperature, altitude, climatic conditions and variations in the supply voltage. Motors shall not exceed 120% of the required capacity without prior approval from the Engineer.

(b) Not only shall motors be based on the full load requirements, but also the motor capacity and starting characteristics shall be compatible with the requirements of the driven equipment.

(c) Where motors are required to drive high inertia loads, the starting torque of the motor and the torque curve of the driven load shall be submitted to the Engineer for approval prior to manufacture. Such motors shall be capable of at least three starts per hour, with two consecutive starts from normal operating temperature, or more frequently if required by the Engineer.

(d) Motors shall be of the continuously running duty class S1 unless otherwise specified in the detailed specification or if a more onerous duty is dictated by the drive requirement.

(e) All squirrel-cage induction motors shall be suitable for direct on line starting at full voltage. Single-speed motors shall conform to SANS 60034-12, Design B characteristics unless approved by or dictated by the drive requirements.

(f) Unless otherwise approved, the 15% tolerance on locked-rotor torque permitted by SANS 60034-1 will not be accepted and shall be limited to 10%.

(g) Documentation shall include performance curves to suit the designed working conditions.

(h) When making a selection of the motor size for driven equipment, motor power shall be over-rated by a factor of thirty percent (30%) more than the demand of the driven equipment.

E01.12 BEARINGS

(a) All motors shall, wherever possible, be provided with pre-lubricated sealed bearings.

(b) Re-greasable bearings shall require only one lubrication per year. Grease lubrication of ball or roller bearings, where approved, shall be by means of hexagonal button-type grease

nipples to BS 1486- 2, Nos. 21A or 21B (industrial type).

(c) Grease-lubricated bearings shall have relief holes to ensure that the bearings have been correctly packed, which holes shall be positioned so that the excess grease can be easily removed. Cups shall be fitted to contain excess grease.

(d) Bearings shall be protected against eddy currents and shall be capable of withstanding vibrations caused by unbalanced loads.

(e) All bearings shall be designed for a minimum L_{10h}, basic life rating of 50 000 hours at the rated load and speed for the application in accordance with ISO 281.

E01.13 EARTHING

All motors shall be provided with a machined or spot-faced boss earth point, tapped to receive a bolt of not less than 10 mm in diameter for earthing purposes. This earth point must be located on one side of the motor, between the mounting feet.

A protective earth cable must be installed between the MCC earth bar and the motor earth point, sized in accordance with SANS1042-1.

Earth bonding must be installed between the motor frame and the motor support structure as well as the cable support structure.

E01.14 HEATERS AND DRAINAGE

Non-submersible motors that will be located outdoors or in a damp location such as in a drainage sump shall be provided with suitable means of drainage to prevent the accumulation of water due to condensation. They shall also be fitted with anti-condensation heaters suitable for a 220V AC supply if considered advisable by the manufacturer.

All motors shall be supplied with anti-condensation heaters (220V AC supply) to keep the motor temperature at 23°C when the motor is not operational to prevent moisture from condensing in the motor unless specified otherwise.

Heater terminal boxes shall be fitted on the motor frame and shall be of robust design, liberally sized and complete with suitable terminal block and mechanical cable gland or conduit entry.

E01.15 TERMINAL ARRANGEMENTS

(a) All motor terminal boxes must be oversized to fit a cable one size bigger than the standard cable as a minimum

(b) The terminal box must be installed with an OME supplied seal between the terminal box and the motor chassis

(c) Motor cable termination blocks must confirm to the IEC 60034-1 standard

(d) The line connections of each motor shall be brought out to a terminal box located in an approved position. In the case of two-speed motors, separate terminal boxes shall be provided for each speed.

(e) Terminal boxes shall be of the totally enclosed type designed to exclude the ingress of dust and moisture and sealed from the internal circuit of the motor, and shall be manufactured from sand-cast metal. The wall thickness of the terminal boxes and the dimension of the cable inlet shall be as specified in SANS 1804-2. The terminal box shall be so designed that the cable entry may be made in any one of four positions placed at right angles to one another.

(f) Winding termination in the motor terminal boxes shall be properly secured or fastened to avoid hot connections during operation.

(g) Terminal boxes shall be of ample size to allow the cable to be terminated in the box. Under no circumstances shall the cable be allowed to be in contact with the inside of the box or lid.

(h) Terminals shall be of a substantial design and shall be suited to receive cable lugs. Pinch-screw connections will not be accepted.

(i) The terminal arrangement shall permit the motor to be disconnected from its supply cable without damaging the cable tails and shall allow the supply cable and motor windings to be tested separately.

(j) The electrical clearance and creepage distances, with the correct cable terminations in position, shall comply with the requirements of SANS 60034.

(k) Terminal markings shall be clear and permanent. Irrespective of the direction of rotation required on the site, the connections shall be such that, when the supply leads L1 - L2 - L3 are connected to the motor terminals U - V - W respectively, the motor shall rotate in a clockwise direction when viewed from the driving end.

(l) Motors suited for only one-directional rotation, shall be clearly marked as such by an arrow fixed to the motor frame at the driving end.

(m) Before the contractor orders terminal boxes for electrical equipment, he shall supply details of the proposed boxes to the engineer for approval. These precautions are necessary to ensure that the size of the connecting blocks installed is sufficient to accommodate the cables supplied and connected by another contractor, and that sufficient space exists within the box to route cables conveniently.

E01.16 MOTOR/LOAD COUPLING

(a) Motors shall be coupled direct to the equipment to be driven by means of approved couplings and/or gearboxes unless specified differently. Refer to the relevant sections for specific specifications on transmission couplings and gearboxes. Vee-belt and chain drives will be considered only if direct coupling of the motor to the equipment is impossible or impractical.

Motors driving vee-belt or chain drives shall be fitted with heavy-duty bearings suited to the full side thrust at 120% of full load torque and short-term overloads of up to 250% of the full load torques during starting. The stiffness of the rotor shaft shall be checked to ensure that resonance and fatigue do not occur.

(b) Where applicable, the flanges of the motors and equipment shall be identical.

(c) The precision tolerance class shall apply to all flange-mounted motors with regard to concentricity, perpendicularity and shaft run-out.

E01.17 INFORMATION PLATES FOR MOTORS

In addition to the information required by SABS 948-1the following shall also be marked on the nameplates:

(a) Year of manufacture,

(b) The order number,

(c) Total mass of motor in kilogram,

(d) Diagram indicating the number, type and positions of heaters and temperature detectors if applicable,

(e) Bearing types and sizes, and

(f) Bearing grease interval or bearing replacement interval where pre-packed bearings are used.

E01.18 ADDITIONAL SPECIFICATIONS FOR TWO-SPEED MOTORS

The following additional specifications apply to all two-speed motors:

(a) Terminal markings shall be as per SANS 1804-2.

(b) The starting current shall not exceed six times the full load current of the high-speed rating.

E01.19 SUBMERSIBLE MOTORS

The following additional requirements apply specifically to all submersible motors:

All submersible motors shall be suited for submersion up to a depth of 1,5 times the depth of submersion shown on the drawings for each application, or as specified in the detail specifications.

All submersible motors shall have dynamically balanced rotors supported by maintenance-free, sealed-for-life ball bearings.

All motors shall be suitably coated to ensure the satisfactory operation of the motor under the specified class of service.

All terminal boxes shall be waterproof and suited for submersion up to the depth as specified for the motors.

An adequate length of waterproof cable, purpose-made for submersion, shall be supplied with each submersible motor. The coupling of this cable to the normal power-distribution cable, which usually is of the PVC type with steel-wire armour, shall be placed at least 1 m above the maximum water level by means of a purpose-made, weatherproof, outdoor junction box. The submerged cable shall be supported to minimize any movement of the cable, which results from turbulence caused by the operation of the equipment or the flow of the water.

Thermistor protection temperature switches shall be provided for submersible motors.

Seal monitors shall be provided for submersible motors, together with the required seal monitor relays. The cost for the seal monitor relays shall be deemed included in the rates tendered for the equipment.

E01.20 ADDITIONAL REQUIREMENTS

(a) The rotation speed of motors shall not exceed 1 500 rpm unless approved by the Engineer.

(b) Thermistor protection shall be provided for each winding of each motor. Motors rated below 22kW shall have no thermistor and heater protection devices installed on them. Motor rated 22kW and above shall have both thermistor and heater protection devices installed on them.

(c) Motors below 55kW shall be started by the DOL type method of starting. Motors including 55kW and above shall be started by the softer-starter type method of starting.

(d) A separate thermistor and heater terminal box shall be fitted on the motor frame next to the power terminal box and shall be of robust design, liberally sized and complete with suitable terminal block and mechanical cable gland or conduit entry.

(e) The minimum preferred class of insulation is Class F, derated in accordance with the relevant clause above.

E01.21 TECHNICAL DATA SHEETS

Details of all individual electric machines and equipment requiring electrical energy shall be indicated on the technical data sheet provided for in the tender Schedules (included in the technical data sheets.

E01.22 TESTING

Tests on completion (commissioning tests) shall be performed as described below in this specification.

E01.22.1 Performance Tests

(a) One motor of every type shall be tested for temperature rise and excess torque. Type test certificates on identical motors will be acceptable in lieu of these tests. Should type test certificates not be available, the first motor of each size manufactured shall be tested. All tests shall be in accordance with SANS 60034.

(b) The measurement of the temperature rise of the stator windings of motors for use on voltages up to 1 000 volts shall be by the increase in resistance method as is now permitted by SANS 60034.

E01.22.2 Routine Tests

(a) Each motor shall be tested at the manufacturer's works for light-run, locked rotor, insulation resistance, high voltage, air-gap clearances and Tan Delta on each complete stator.

(b) All tests shall be in accordance with SANS 60034.

E01.22.3 Test Certificates

(a) Four copies of all test certificates, showing the results of all tests performed, shall be supplied at a date not later than the delivery date of the motors.

(b) The test certificates shall contain power factor and efficiency figures for 125%, 100%, 75%, 50% and 25% of full load conditions as calculated from the test results.

E01.22.4 Witnessing of Tests

All type and routine tests on motors larger than 45 kW shall be witnessed by the Engineer.

E01.22.5 Testing of Terminal Box Assembly

(a) Proof shall be given to show that a prototype terminal and cable box assembly of the type being supplied on medium voltage motors has been tested under internal short-circuit conditions and that the pressure relief diaphragm ruptured protecting the case of the terminal box from serious damage. In addition, that a through fault current test was made to demonstrate that the complete assembly is capable of handling the short-circuit current without damage. The fault current for these tests shall have been 45 000 ampere for a duration of 0.25 seconds.

(b) These type tests shall have been witnessed by an independent authority.

E01.23 DRAWINGS FOR APPROVAL

The following drawings shall be submitted for approval:

(a) Dimensioned outline and foundation drawings of the motors. (Shaft diameter, shaft height and motor weight to be clearly shown).

(b) Detailed drawings of the bearing arrangement, showing all lubrication pipes, coolers and pumps.

(c) Cross-sectional dimensioned drawings of the cable boxes.

(d) Detailed drawings of the motor base plate showing full constructional details with dimensions.

(e) For motors of 250 kW and larger fully dimensioned drawings of the shaft showing all tolerances.

(f) For motors designed for voltages of 3.3 kV and above, drawings showing the end winding bracing arrangements.

E01.24 STORAGE

The contractor must ensure that the storage requirements as specified by the manufacturer are adhered to strictly so as avoid voiding of the warranty. Every effort must be taken to ensure the motor is protected against ingress of water, vermin or anything that may affect its future operation. The following are only given as guidelines, the contractor is expected to exercise due care in the storage and handling of electric motors.

(a) The motor should be store upright in its normal position, free of dust, dirt, gasses and corrosive atmospheres.

(b) Motors should be stored under roof on a concrete base, normally in a store environment. Do not remove the motor from the wooden pallet.

(c) For bigger units, which cannot be housed in a store or relevant building, shed must be built with a proper concrete floor. Do not remove the motor from the wooden pallet.

(d) Store the bigger units close to the final position within access with overhead crane or mobile crane.

(e) Do not stack any objects on top of or against the motor.

(f) Motors must be stored in places free from vibrations in order to avoid damage to the bearings.

(g) The motors space heaters/ anti condensation heaters and similar accessories must be switched on at all times to avoid condensation and corrosion within the enclosure.

(h) If painting has been damaged during transportation, it must be repainted to avoid rusting.

(i) Ensure all machined surfaces and shaft extensions are covered with grease or a rust inhibiting substance.

(j) For slip-ring motors, the brushes must be lifted to avoid condensation between contact surfaces and slip rings.

(k) Before operation all brushes and contact surfaces have to be inspected and brush seating confirmed.

(l) When any motor is kept for extended period, the shaft must be manually turned on monthly intervals.

(m) For big machines with frames greater than or equal to 400mm, the shaft should be rotated monthly at any number of turns and then put at rest at 180 degrees difference from previous stationary position.

(n) When a motor is not immediately required in operation, it should be protected against moisture, high temperature and impurities in order to avoid damage to the insulation system.

(o) If the ambient contains high humidity, periodical insulation resistance inspection is recommended during storage.

(p) The following guidelines show the approximate insulation resistance values that can be expected from a clean and dry motor at 40° Celsius ambient.

(q) Minimum insulation resistance = rated voltage (kV) + 1 (Mega ohm) using 2 times the rated voltage.

(r) These periodical measurements should be recorded and be available prior to installation.

E01.25 ERECTION AND INSTALLATION

E01.25.1 Erection

(a) When motors are erected, care shall be taken to ensure that adequate tolerance margins are made available to ensure interchangeability with replacement motors.

(b) A minimum of 10 mm of packers shall be provided under the motor frame or motor bedplate to allow for adjustments in height.

(c) Before holding-down bolts are grouted in, the motor shall be lined up and the bolts shall be properly centred in the hole of the bedplate.

(d) The bending radius of the motor supply cable should not be exceeded when installing the cable (SANS10142-1).

(e) Motor supply cables must be supported and should not hang from the terminal box/gland.

E01.25.2 Bearing Inspection

(a) The Engineer shall inspect motors having ball/roller bearings.

(b) The grease shall be examined to ensure that it is not hard.

(c) Providing that no roughness is felt when the shaft is rotated by hand and that the motor runs without undue noise or vibration, the bearings will be considered acceptable.

(d) Should the bearings fail or exhibit the symptoms of brinelling during the guarantee period,

the Contractor, free of charge, without delay, shall change them.

E01.25.3 Alignment

(a) After erection, the alignment of the half-couplings between the motor and the driven machine shall be measured. In the case of a pedestal, bearing motor the air gap clearance between the rotor and the stator shall also be measured. A record shall be kept of these figures and they shall be submitted to the Engineer for approval.

(b) A horizontal sleeve bearing or limited end-float roller bearing motor shall be run uncoupled from its load to ensure that it rotates at the axial position indicated on the shaft and that the rotor is free to move to either side of this position. Particular attention shall be paid to ensure that the free running position and the rotor end-float are in agreement with the axial movement of the flexible coupling.

E01.25.4 Drying Out

(a) The Contractor shall dry out all motors larger than 100 kW and all smaller motors which have stood in the open during rain or have been flooded or whose cold insulation resistance is below 1.5 MΩ, before they are connected to the supply. If a motor is flooded, the motor bearings shall be replaced as a matter of urgency.

(b) The method of drying the motor shall be by placing the motor in a heating oven.

Sufficient heat shall be applied to produce a temperature of 60ºC but not greater than 80ºC for a Class A or 90º C for Class B insulation systems. Insulation resistance measurements and temperature readings shall be taken regularly every half hour at the start of dry-out until the motor attains an even temperature and thereafter every hour.

The characteristic dry-out curve of insulation resistance versus temperature shall be plotted and dry-out may be considered complete four hours after the resistance readings have started to rise from the steady minimum value, providing that the winding temperatures have remained steady during this period.

(c) The Contractor shall provide all equipment and the personnel required for the drying-out operation.

(d) In the case of motor smaller than 100kW, the onus remains on the Contractor to satisfy himself that a motor is dry before it is connected to the supply.

(e) Any motor, which fails as a result of being commissioned in a damp condition, shall be repaired at the cost of the Contractor.

E01.25.5 Double Shaft Extensions

The unused shaft extensions of a double-ended shaft motor shall be covered with an approved rust preventative after the motor is commissioned.

E01.26 TESTING AND COMMISSIONING

The contractor must supply a Manufacturers Test Certificate with each motor supplied.

The contractor must do a visual inspection as well as an insulation test on each motor before installation.

The contractor must do a direction test on each motor before handing the installation over. Where equipment can be damaged when rotated in an incorrect direction, the equipment must be disconnected from the motor before the direction check is done.

All test results must recorded and submitted to the Engineer for approval. The Engineer must be informed timeously off all tests to allow witnessing.

E01.27 MEASUREMENT AND PAYMENT

No separate payment will be made for electric motors for equipment unless otherwise specified in the detail specifications. All direct and indirect costs associated with such motors shall be deemed included in the rates tendered for the equipment.

Where separate payment is required for electric motors and specified as such in the detail

specifications, the following payment items shall be applicable:

Item	**Unit**
Supply and delivery electric motors	No

The unit of measurement shall be the number of motors supplied.

The tendered rate shall include full compensation for the design, manufacture, corrosion protection, supply, handling, transport, testing and delivery of each complete motor as specified in the detail specification to ensure satisfactory operation after installation.

Separate items will be scheduled for different sizes/types of motors required.

Item	**Unit**
Installation, test and commission of electric motors	No

The unit of measurement shall be the number of motors installed.

The tendered rate shall include full compensation for the installation and coupling of the motor to the required load. The tendered rate shall include full compensation for all required installation material.

Separate items will be scheduled for different sizes/types of motors required.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

E02 : ELECTRICAL CABLE RACKS

Johannesburg Water

Johannesburg Water (SOC) Ltd.
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Revision 5

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City of Johannesburg
Johannesburg Water (Pty) Ltd

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Prepared	Senior Electrical Engineer	B Pieterse	August 2019	
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RECORD OF REVISIONS

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1	2009-05-12		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance

PARTICULAR SPECIFICATION: VOLUME E02: ELECTRICAL CABLE RACKS

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E02.1 SCOPE

This specification covers the supply, delivery and installation of cable ladders for industrial installations. Only cable ladders are to be supplied. Cable trays shall not be acceptable. Cable ladders are not recommended for large cables and open ground as they expose the cable to theft.

E02.1.1 Statutory Documents and Standards

Cable ladders shall be manufactured in accordance with the requirements of the latest editions of the following standards:

(a) SANS 10044	:	Welding
(b) SANS 10064	:	Preparation of steel surfaces for coating
(c) SANS 1274	:	Coatings applied by the powder process
(d) SANS 10162-1	:	The structural use of steel Part 1: Limit-states design of hot-rolled steelwork
(e) SANS 10162-2	:	The structural use of steel Part 2: Limit-states design of cold-formed steelwork
(f) SANS 10162-4	:	The structural use of steel Part 4: The design of cold-formed stainless steel structural members
(g) SANS 10142-1	:	The wiring of premises Part 1 – Low voltage Installations

E02.1.2 Particular Specifications to be read in conjunction with this specifications

This specification shall be read in conjunction with the following specifications:-

(a) E06	:	ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION

E02.2 CABLE LADDER MATERIAL

All cable ladders shall, unless otherwise specified, be heavy-duty cable ladder standard pattern.

Cable ladders used inside Elutriation Terrace pump stations or in areas within 50m or less of Ferric Chloride, Hypochlorite or Chlorine shall be manufactured from corrosion resistant GRP (Glass Reinforced Polyester) in which vinylester resin is used. All GRP cable ladders shall consist of a 75 mm high side rail. The minimum thickness of the material that the cable rack is to be manufactured from, shall at least be 4mm. Cross rungs shall be spaced at maximum intervals of 300 mm (centre-to-centre). All screws, bolts and nuts shall be hexagonal to ISO Metric commercial standards. All bolts, nuts, spring washers, etc. shall be 316 grade stainless steel for all applications, except for Ferric Chloride areas, where 304 grade stainless steel must be used. Racks for instrumentation and control cabling shall contain pigmentation to produce an electric orange rack. A sample of the rack material must be approved by the engineer before manufacturing commences. Sections of rack, bends, t-pieces etc. shall be joined together with the correct dowels and resins as specified by the supplier. Wherever racking is drilled or cut, the exposed areas of GRP must be sealed with the same resin to ensure that the material does not fray. Channels or other sections used for securing of cable ladders should as far as possible be made from the same GRP material. Where this is not possible, 316 grade stainless steel support systems shall be used for all applications, except for Ferric Chloride areas, where 304 grade stainless steel must be used.

Cable ladders used inside de-watering buildings shall be metal cable ladders, manufactured from corrosion resistant, powder coated, 3CR12 grade stainless steel. All cable ladders shall consist of at least 75 mm high side rail. The minimum sheet thickness of the material that the cable rack

is to be manufactured from shall at least be 2mm. Cross rungs shall be spaced at maximum intervals of 300 mm (centre-to-centre). All screws, bolts and nuts shall be hexagonal to ISO Metric commercial standards. All bolts, nuts, spring washers, etc. shall be 316 grade stainless steel. Metal racks for instrumentation and control cabling shall be powder coated electric orange. If GRP ladder racking (as described in item 6.5.2 above) is cheaper than 3CR12 grade ladder racking, the GRP racking should be used inside de-watering buildings as well.

Cable ladders used for all applications other than those mentioned above shall be heavy-duty metal cable ladders, manufactured from 3CR12 grade, powder coated, stainless steel. All metal cable ladders shall consist of at least 75 mm high side rail. The minimum sheet thickness of the material that the cable rack is to be manufactured from shall at least be 3mm. Cross rungs shall be spaced at maximum intervals of 300 mm (centre-to-centre). All screws, bolts and nuts shall be hexagonal to ISO Metric commercial standards. All bolts, nuts, spring washers, etc. shall be 316 grade stainless steel. Racks for instrumentation and control cabling shall be powder coated electric orange.

E02.3 CABLE LADDER ACCESSORIES

E02.3.1 General

Cable ladder accessories shall be considered to be horizontal bends, vertical bends, internal bends, external bends, Tee-pieces, cross-pieces, reducers (transition pieces), support struts and fasteners. The accessories shall have dimensions that correspond to the dimensions of the linear sections to which they are connected. The radii of all bends shall be 1 m minimum.

The inside dimensions of horizontal angles or connections shall be large enough to ensure that the allowable bending radius of the cables are not exceeded. Sharp angles shall be 45º metered.

E02.4 INSTALLATION

Cable ladders shall be installed within accessible civil constructed cable ducts. These ducts may form part of the scope of works or may be existing.

Cable ladders are required to be installed within the cable ducts in the motor control centre rooms, on site electrical reticulation, and on access platforms to the mechanical equipment.

Cable ladders shall be installed within accessible cable ducts and shall be supported by a strut channel section securely fixed to the wall. The corrosion protection shall be of the same system as that of the cable ladder. Only vertical installation of cable ladder will be allowed in cable ducts. All cable must be installed on cable ladders and no loose cables will be accepted.

Cable ladders shall be supported with the struts, channels, brackets, clamps, cantilever arms and nuts/bolts/washers. Unless otherwise agreed, drilling into or welding onto metal columns, trusses and other metal building structures are not allowed and suitable clamps must be used to fix the cable ladders to the building structure.

The platform mounted cable ladder reticulation shall be installed at minimum of 150 mm from the supporting concrete structure.

Crevice corrosion of the metal elements in contact with concrete surface shall be eliminated by means of a suitable layer of non-shrink grouting.

Unless otherwise agreed, all screws, bolts and nuts shall be hexagonal to ISO Metric commercial standards. All bolts, nuts, spring washers, etc. shall be stainless steel 316.

All cable ladders shall be spliced with splice sets. The corrosion protection of splices shall be of the same system as that of the cable ladder.

All cable racks not installed in closed ducts or inside buildings will be installed with flat (vertical installation) or peaked covers (horizontal installation). The corrosion protection of covers shall be of the same system as that of the cable ladder.

All cable ducting must be covered with anti-theft covers. All exposed cable on cable ladders must

be covered with anti-theft covers.

All overhead cable ladders crossing a walkway must be at least 2000mm above floor level.

Structural designs must be done for any cable bridges. Support material must be corrosion protected to the same standard as the cable ladder. The design must be approved by the Engineer.

E02.5 EARTH BONDING OF CABLE RACKING

All cable rack joints must be equipotential bonded. Both the ends of cable racking must be bonded to an equipotential bonding bar. Where cable racks enter a lighting protected structure, the bonding conductor must be connected to the rack as close as possible to the point of entrance. All bonding conductors must be equal to 6 sq. mm copper PVC insulated wire.

The bonding conductor cable will be a composite stranded cable made up of tinned copper wires and galvanised steel wires that are braided-interwoven to form the cable. The complex braided and interwoven wires of steel and copper make it very difficult to separate and is unattractive and uneconomical to copper thieves and scrap dealers. The conductor must be insulated in clear PVC.

E02.6 CORROSION PROTECTION

All cable ladders and the cable ladder accessories shall be coated as specified below.

The preparation of the metal surfaces of the cable ladders and cable ladder accessories shall be in accordance with the latest edition of SANS 10064, prior to the application of protective coating.

Corrosion protection shall conform to the coating system stated below:

E02.6.1 Powder Coating Systems

All cable ladder shall be coated in the colour B26 – orange

E02.6.1.1 Paint System 1: Powder Coating, seven (7) stage zinc phosphate treatment, pure epoxy primer, polyester finishing coat, thickness 140 µm.

Paint System	Host Material	Preparation	Primer Coat	Finishing Coat	Dry film Thickness
			(70 µm)	(70 µm)	(µm)
No 1	304 L SS	7 stage zinc phosphate pre-treatment	Epoxy	Epoxy	140

E02.6.1.2 Upon the completion of the corrosion protection specified, the Contractor shall be required to perform the following quality control testing procedures:-

- Impact testing in accordance with SABS 6: Part J,
- Cross hatch adhesion test
- Bend test

E02.6.1.3 The corrosion protection shall form part of the quality control system as approved by the Engineer and the Tenderer shall submit a certificate of compliance upon the delivery of all cable rack supplied. The tenderer will supply a sample of all cable rack to Johannesburg Water for testing purposes.

E02.6.1.4 Epoxy Powder Coat Products

Item	Product type	Powder – Lak
1	Epoxy primer	23-007
2	Pure Epoxy / Polyester finishing coat	Series 3000

E02.7 INSPECTION

After installation, a visual inspection should be conducted with the Engineer. The contractor must compile a butt list with all items not to the satisfaction of the Engineer.

E02.8 MEASUREMENT AND PAYMENT

Item	Unit
Supply and deliver cable ladder	m

The unit of measurement shall be per linear length in meter of cable ladder supplied and delivered. Separate items shall be scheduled to include for each size of cable ladder required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete cable ladder.

Item	Unit
Install cable ladder	m

The unit of measurement shall be per linear meter of cable ladder installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size of cable ladder installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the cable ladders installed under the Contract.

Item **Unit**

Supply and deliver horizontal bends ..... No

The unit of measurement shall be the number of horizontal bends supplied and delivered. Separate items shall be scheduled to include for each size of horizontal bend required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete horizontal bends.

Item **Unit**

Install horizontal bends ..... No

The unit of measurement shall be the number of horizontal bends installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size horizontal bend installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the horizontal bends installed under the Contract.

Item **Unit**

Supply and deliver vertical bends ..... No

The unit of measurement shall be the number of vertical bends supplied and delivered. Separate items shall be scheduled to include for each size of vertical bend required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete vertical bends.

Item **Unit**

Install vertical bends ..... No

The unit of measurement shall be the number of vertical bends installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size of vertical bend installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the vertical bends installed under the Contract.

Item **Unit**

Supply and deliver internal bends ..... No

The unit of measurement shall be the number of internal bends supplied and delivered. Separate items shall be scheduled to include for each size of internal bend required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete internal bends.

Item **Unit**

Install internal bends ..... No

The unit of measurement shall be the number of internal bends installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size of internal bend installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the internal bends installed under the Contract.

Item **Unit**

Supply and deliver external bends ..... No

The unit of measurement shall be the number of external bends supplied and delivered. Separate

items shall be scheduled to include for each size of external bend required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete external bends.

Item **Unit**

Install external bends ..... No

The unit of measurement shall be the number of external bends installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size of external bend installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the external bends installed under the Contract.

Item **Unit**

Supply and deliver Tee-pieces ..... No

The unit of measurement shall be the number of Tee-pieces supplied and delivered. Separate items shall be scheduled to include for each size of Tee-piece required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete Tee-pieces.

Item **Unit**

Install Tee-pieces ..... No

The unit of measurement shall be the number of Tee-pieces installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size of Tee-pieces installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the Tee-pieces installed under the Contract.

Item **Unit**

Supply and deliver cross-pieces ..... No

The unit of measurement shall be the number of cross-pieces supplied and delivered. Separate items shall be scheduled to include for each size of cross-piece required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete cross-pieces.

Item **Unit**

Install deliver cross-pieces ..... No

The unit of measurement shall be the number of cross-pieces installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size of cross-pieces installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the cross-pieces installed under the Contract.

Item **Unit**

Supply and deliver reducers (transition-pieces) ..... No

The unit of measurement shall be the number of transition pieces supplied and delivered. Separate items shall be scheduled to include for each size of transition-piece required under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the complete transition-pieces.

Item Unit

Install reducers (transition-pieces) ..... No

The unit of measurement shall be the number of transition-pieces installed. Separate items will be scheduled in the Schedule of Quantities differentiating each size of transition-pieces installed under the Contract.

The tendered rates shall include for all labour, handling, the cutting at points of change in direction, jointing, etc, for the complete installation and inspection of the transition-pieces installed under the Contract.

Item **Unit**

Supply and deliver cable ladder support struts material **m**

The unit of measurement shall be per linear meter of material supplied and delivered. Separate items will be scheduled in the Schedule of Quantities differentiating each size of cable ladder support struts supplied and delivered under the Contract.

The tendered rates shall include for the manufacture, supply, delivery, handling and inspection of the cable ladder support struts material.

Item **Unit**

Install cable ladder support struts **m**

The unit of measurement shall be per linear meter of material supplied and installed. Separate items will be scheduled in the Schedule of Quantities differentiating each cable ladder support struts installed under the Contract.

The tendered rates shall include for all labour, handling, cutting, welding, painting, drilling and mounting, etc., for the complete installation and inspection of the cable ladders support struts installed under the Contract.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

E04 : ELECTRICAL LOW VOLTAGE DISTRIBUTION BOARDS AND MOTOR CONTROL CENTRES

Johannesburg Water (SOC) Ltd.
PO Box 61542
Marshalltown
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PARTICULAR SPECIFICATION: VOLUME E04: ELECTRICAL LOW VOLTAGE DISTRIBUTION BOARDS AND MOTOR CONTROL CENTRES

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E04.1 INTRODUCTION

This specification is for the supply of low voltage (400V) distribution switchboards.

E04.2 SCOPE

E04.2.1 General

The scope of work includes the furnishing of all labour, material and services for the design, supply, manufacture, testing and inspection at works, delivery to site, off-loading and rectification of defects developing during the warranty period for equipment as specified below.

E04.2.2 Work to be Included

The work includes, but shall not be limited to the items listed below.-

(a) All work in E04.2.1 above.

(b) Documentation, as called for in the vendor QA and document requirement list and drawings and data.

(c) The supply of one complete set of any special tools required per switchboard that will be required for operation or maintenance purposes, including three spare sets of each type of fuse.

(d) Recommended spares for one year's operating period and the prices of it.

(e) Technical assistance if requested during checking for operational readiness.

E04.3 STANDARDS

In general, work and materials shall be in accordance with the latest practice and in particular in accordance with the latest revision of the following specifications, and any amendments thereto, the SANS specification taking precedence:

(a) SANS 10142-1 : The wiring of premises Part 1: Low-voltage installations

(b) SANS 60439-1 : Low-voltage switchgear and controlgear assemblies Part 1: Type-tested and partially type-tested assemblies

(c) SANS 60439-2 : Low-voltage switchgear and controlgear assemblies Part 2: Particular requirements for busbar trunking systems (busways)

(d) SANS 60439-3 : Low-voltage switchgear and controlgear assemblies Part 3: Particular requirements for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards

(e) 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

(f) SANS 60947-1 : Low-voltage Switchgear and Control gear Part 1: General rules

(g) SANS 60947-2 : Low-voltage Switchgear and Control gear Part 2: Circuit-breakers

(h) SANS 60947-3 : Low-voltage Switchgear and Control gear Part 3 Switches, disconnectors, switch-disconnectors and fuse-combination units

(i) SANS 60947-4.1 : Low-voltage Switchgear and Control gear Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters

(j) SANS 60947-4.2 : Low-voltage Switchgear and Control gear Part 4-2: Contactors and motor-starters - AC semiconductor motor controllers and starters

(k) SANS 60947-4-3 : Low-voltage Switchgear and Control gear Part 4-3: Contactors and motor-starters - AC semiconductor controllers and contactors

			for non-motor loads
(l)	SANS 60947-5-1	:	Low-voltage Switchgear and Control gear Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
(m)	SANS 62262	:	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
(n)	SANS 60529	:	Degrees of protection provided by enclosures (IP code)
(o)	IEC 60228	:	Conductors of insulated cables
(p)	BSS 3858	:	Binding and identification sleeves for use on electric cables and wires
(q)	SANS 1507-1	:	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 1: General
(r)	SANS 1507-2	:	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 2: Wiring cables
(s)	SANS 1574-1	:	Electric Cables – Flexible Cords and Flexible Cables Part 1: General
(t)	SANS 1574-3	:	Electric Cables – Flexible Cords and Flexible Cables Part 3: PVC-insulated cables for industrial use
(u)	SANS 1619	:	Small power distribution units (ready-boards) for single-phase 230 V service connections
(v)	SANS 61643-11	:	Low-voltage surge protective devices Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods
(w)	SANS 61643-12	:	Low-voltage surge protective devices Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application principles
(x)	SANS 61238-1	:	Compression and mechanical connectors for power cables for rated voltages up to 30 kV (Um = 36 kV) Part 1: Test methods and requirements
(y)	SANS 60730-2-7	:	Automatic electrical controls for household and similar use Part 2-7: Particular requirements for timers and time switches
(z)	SANS 62053-61	:	Electricity metering equipment (a.c.) - Particular requirements Part 61: Power consumption and voltage requirements)
(aa)	BSS 1322	:	Aminoplastic Moulding Materials
(bb)	SANS 60076-1	:	Power transformers, Part 1: General
(cc)	SANS 1091	:	National colour standard
(dd)	SANS 61869-1	:	Instrument transformers Part 1: General requirements
(ee)	SANS 61869-2	:	Instrument transformers Part 2: Additional requirements for current transformers
(ff)	SANS 61869-3	:	Instrument transformers Part 3: Additional requirements for inductive voltage transformers
(gg)	IEC 60051/BS 89	:	Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for ammeters and voltmeters
(hh)	BS EN 60255	:	Measuring relays and protection equipment. Common requirements
(ii)	SANS 156	:	Moulded-case circuit-breakers
(jj)	SANS 1195	:	Busbars
(kk)	BS159	:	High-voltage busbars and busbar connections

E04.3.1 Particular specifications to read in conjunction with this specification

This specification shall be read in conjunction with the following specifications:-
E26: ELECTRICAL COLOUR CODING OF EQUIPMENT
G02: PARTICULAR SPECIFICATION FOR CORROSION PROTECTION
E06: ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION
E08: WIRING

E04.3.2 Mandatory Requirements

All equipment and services shall comply with the mandatory requirements of:

(a) Occupational Health and Safety Act 85 of 1993 (as amended).

E04.4 SYSTEM DETAIL

Busbar voltage	400V ±10% as per system voltage on the site
Frequency	50 Hz
Phase rotation	R-Y-B-R
Phases	3Ph+N, with Protective Earth (PE)
Earthing system	TN-S

E04.5 GENERAL REQUIREMENTS

This section will be applicable to the following equipment:

(a) Motor Control Centres (MCC).

(b) Main Distribution Boards (MDB).

(c) Auxiliary Distribution Boards (ADB).

The following is described in separate sections:

(a) Flush Mounted Distribution Boards.

(b) Surface Mounted Distribution Boards

(c) LV Kiosks (Switch Cubicles)

E04.5.1 Manufacturing and Construction Details

E04.5.1.1 General

(a) Electrical panels will be floor standing unless specified differently.

(b) All floor-standing switchboards will be positioned above a cable trench with bottom entry cables.

(c) Electrical switchboards positioned inside Electrical Distribution/MCC rooms shall be manufactured with 2mm thick mild steel.

(d) Electrical switchboards positioned outside Electrical Distribution/MCC rooms shall be manufactured from 2mm thick stainless steel (3CR12) as a minimum. Heaters will be installed in the switchboards to prevent condensation.

(e) In special applications, the Electrical switchboards will be manufactured to the Engineers specification.

(f) All switchboards shall be of ample size to accommodate all the specified switchgear and provide space for future switchgear. For every 4 (or part of 4) circuit breakers of a kind on a switchboard, space for an additional circuit breaker of similar size shall be allowed unless future space requirements are clearly specified.

(g) All specified external dimensions for switchboards shall be strictly adhered to.

(h) The Contractor or Manufacturer shall obtain the opinion of the Engineer before manufacturing any switchboard.

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

(j) In general, flush and surface mounted switchboards shall be mounted 2000mm above finished floor level - measured to the top of the switchboard. The upper ends of switchboards may not be higher than 2100mm above finished floor level.

(k) Unless otherwise agreed or stated in this Specification, all screws, bolts and nuts shall be hexagonal to ISO metric commercial standards and shall be rustproof. Loose 'bolts and nuts' shall not be used on steelwork. Blind threaded fastening system bushings or equivalent shall be used for thread sizes M5 and above. Studs projecting from the exterior surfaces of the board shall have chrome or cadmium plated dome nuts. Self-tapping screws shall not be utilised for any purpose on any equipment.

(l) The short-circuit current levels as indicated on drawings shall be deemed the maximum fault current occurring at the panel under symmetrical short circuit conditions on the line side of the final limiting device in a circuit. The duration of the maximum short circuit currents shall be deemed a minimum of one second. Evidence (in the form of certificates from testing authorities recognised by Johannesburg Water) of the ability of the 400V switchboards offered to withstand satisfactorily the prospective fault conditions shall be furnished with the tender.

(m) Switchboards shall be designed to confine internal arcing faults and to direct arcs and gases arising from these away from the operator.

(n) The general structure of the panel shall be designed and fabricated to ensure that no excessive vibration caused by the operation of any component is transmitted to any other components, thereby causing spurious tripping of any device.

(o) Measures shall be taken to prevent electrolytic corrosion where dissimilar metals are in contact with each other.

(p) Bolts shall be of the correct size for the holes provided and shall be fitted with matching sizes of washers and lock washers. Where removable covers are provided with bolt fastening, the nuts shall be either welded in position or securely fixed by means of a mechanical fixing device. Self-tapping screws, captive head nuts or cage nuts are not acceptable.

E04.5.1.2 Panel Subdivision

(a) The Electrical panel will be constructed as one or more fully interchangeable modular, rigid, free standing columns, bolted together to form an extensible, composite, vermin proof unit of uniform appearance.

(b) Panels shall be designed to permit the addition of identical columns.

(c) Columns widths will be 600, 700, 800, 900 or 1000 mm for design flexibility. Columns will be 600 or 800mm deep. Increase in depth of certain sections of panels for high current ratings shall be subject to the Engineer's approval.

(d) The overall height of the column may not be more than 2300mm.

(e) Each column shall be divided horizontally into buckets.

(f) Panels will be split into transportable section with lengths not exceeding 3000mm for ease of transportation.

(g) A channel iron frame (minimum 100mm x 50mm) shall be provided under each panel

section of transportable length, which shall be so constructed that it can be used for lifting the transportable section without distortion taking place.

(h) All panel section of transportable length shall be fitted with lifting lugs and shall have sufficient strength to withstand all stresses occurring during transportation, installation and operation without distortion or damage.

E04.5.1.3 Internal Form of Separation

(a) The minimum internal Forms of Separation for any Electrical switchboards shall be Form 3b, as described below:

i. Separation of busbars from all functional units;

ii. Separation of all functional units from one another;

iii. Separation of terminals for external conductors from the functional units, but not from those of other functional units;

iv. The power cable connections are disposed in the same compartment;

v. Maintenance services require extra care, as placed in the same compartment the connections of other units might be powered;

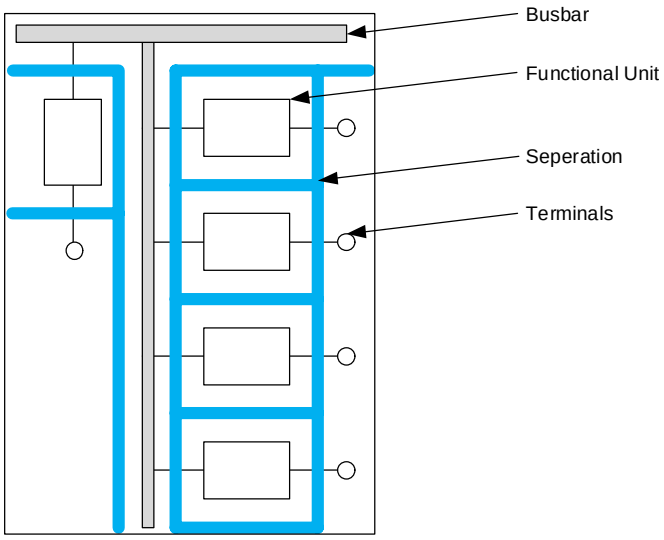

Figure 1: Form 3B

E04.5.1.4 Buckets

(a) Buckets will be equipped and wired as per the drawings issued by the Engineer.

(b) The buckets will be sized to accommodate all components with ease.

(c) Buckets will be fixed pattern with components permanently mounted to the chassis plate of the bucket.

(d) All bucket design and construction shall be based on natural cooling by convection or radiation. Attention shall be given to ventilation to prevent the accumulation of heat in buckets where power electronic drives (soft starters and VSD's) or other heat generating equipment (i.e. control transformers) are contained. Extraction ventilation fans should be installed in these cases to remove heat from the cubicle. The filtered extraction fan should be placed as high as possible in the compartment door with a filtered air inlet opening as low as possible in the compartment door. The fan and opening must be sized to ensure all generated heat is extracted from the bucket. Natural convection cooling will not be accepted.

(e) Spare buckets shall be equipped generally as detailed on the drawings issued by the

Engineer, and shall include all circuit breakers, busbars, wiring, instruments, etc., with the exception that, in the case of withdrawable circuit breakers, only the breaker cradle shall be furnished.

E04.5.1.5 Doors

(a) Buckets shall have doors suitably constructed to ensure rigidity and shall be a neat fit in the framework and around the circuit breaker escutcheon plate.

(b) Doors shall be fitted with robust steel or brass hinges with at least two 6mm square recessed quick close/open latches. Hinges shall be provided at 500mm intervals per door with a minimum of two hinges per door. Each door shall be fitted with an equal number of hinges and latches. At least one of these latches shall be lockable with a padlock.

(c) Doors and covers shall be provided with a high-density neoprene gasket to form a firm seal. The neoprene seal shall be a nominal 5mm thick compressed to 3mm on closing of the door. The entire switchboard shall be effectively dust and splash proof to IP 54.

(d) All hinged doors shall be fitted with a robust mechanism to latch and hold the door in the wide-open position, to minimise inadvertent contact with live parts during maintenance operations.

(e) All hinged doors shall open to a minimum of 135° from the closed position, to facilitate easy access for maintenance.

(f) Doors should be the same width as the MCC column. A single door shall not exceed the width of 800mm. Where the column width exceeds 800mm, two doors must be installed.

(g) The Bucket door shall be interlocked with the circuit breakers to prevent opening of the door when the circuit breaker is in the "ON" position. A non-apparent door interlock defeat shall be provided for the opening of the door with the circuit breaker in the “ON” position for testing and maintenance. In addition, there shall be provision for attaching a padlock to the operating handle in the “OFF” position that prevent the circuit breaker from being operated. Should more than one padlock be fitted, a safety lockout hasp must be used.

(h) All access doors are to be effectively and permanently earthed to the main panel enclosure, by means of a suitable braided copper earth strap, not less than 6mm^2, crimped with properly sized lugs and bolted at each end to the door and enclosure.

(i) All equipment mounted on bucket door will be flush mounted.

E04.5.1.6 Busbar Compartments

(a) The Busbar compartment shall contain the three phases and the neutral busbars, duly marked L1, L2, L3 and N or identifiable by colour coding Red, White, Blue and Black.

(b) The protective earth busbar shall be located in a separate compartment, and shall be duly marked PE.

(c) Provision shall be made for expansion or contraction of the busbars and the housing due to loadings, temperature changes and short circuit conditions. The busbars shall allow for expansion on both the left and right-hand side.

(d) The busbar compartment shall have bolted covers on the front of the panel for access to the busbars, insulators and joints. Removable covers shall be provided with captive screws.

(e) All busbars and droppers shall be securely supported by heavy, high di-electric, non-hygroscopic material with bracing to withstand stresses due to short circuits of one second duration and at least equal to the interrupting rating of the circuit breaker protecting the busbars.

(f) Busbar standoff insulators and support will be injection moulded (Polyamide 66 fibreglass reinforced (30%) (Halogen free)). Threaded inserts will be galvanized steel.

(g) The Busbar shall be supported by insulators made of flameproof and leakage-proof

material. Busbars, insulators and supports shall be braced to withstand the mechanical and thermal effects of fault currents.

(h) Busbar insulators shall be mounted in such a way that they can be easily removed and replaced.

(i) In addition to any support/bracing required by the electrical conditions, the busbars shall also have sufficient support to prevent stresses being transmitted to the circuit breakers or any components by cable terminations. Particular attention must be paid to the termination arrangements of any multiple incoming three-core cables to ensure adequate glanding space.

(j) The following minimum air clearances shall be observed for busbars and other current carrying or live parts:

i. Phase – Earth : 30mm

ii. Phase – Phase : 45mm

Where these clearances cannot be attained, suitable insulating barriers shall be employed In addition, all busbar work (including connections to, from and between equipment) shall have applied solid insulation suitable for the rated voltages. GPO-3 (Glass Polymer laminate) insulation shall be used wherever possible. GPO-3 is constructed with fiberglass-reinforced thermoset polyesters. It must feature a combination of beneficial electrical and mechanical properties. These attributes include Dielectric strength, flame resistance, arc and track resistance, high-flex strength and high-impact strength. They maintain stability, will not melt under heat and have excellent overall electrical properties.

(k) The busbar compartment shall be constructed to ensure that fire or other faults cannot spread between the various sections. All insulation used on electrical conductors/connections and wiring shall be flame retardant types, constructed of low toxicity materials.

(l) The busbar compartment must have suitable sealing arrangement at each end as well as between the busbar compartment and buckets.

E04.5.1.7 Cable termination points

(a) Suitable termination points shall be provided to enable any multiple three-core cables to be terminated without cross-overs of different phases and with minimum lengths of cable "tails".

(b) All cable termination points and associated connections shall be suitably braced to withstand the available fault currents without damage. If necessary cable support clamps shall be provided for the individual cable tails after the cable gland.

E04.5.1.8 Cable Gland Plates

(a) Sectionalised removable gland plates shall be fitted and shall be fixed by means of captive nuts or screws and so located that ample space is available for the satisfactory entry and termination of cables

(b) Cable entry shall be at the bottom of the board.

(c) All gland plates are to be connected to the main panel earth bar via suitably sized copper conductors and unused sections shall be left blank.

(d) Gland plates for three-core cable of cross-sectional area 70mm^2 and above shall be minimum 5mm thickness.

(e) Mild steel gland plates shall be galvanised.

(f) Where single core cables are used, gland plates are to be of non-magnetic material or slit to mitigate effect of eddy currents.

(g) The cable gland compartments shall have removable covers attached with standard 6mm

square recessed quick close/open latches.

E04.5.1.9 Labelling and markings

(a) The panel shall be provided with an identity label, engraved with 30mm high black on white characters and shall be mounted on top of the switchgear.

(b) Each buckets shall be labelled on the left top door corner with the reference letter(s) of that compartment, using durable designation label with 30mm high black letters on a white background. The labels shall have two designation letters, the first referring the column, numbered from A, left to right and the second referring to the bucket, numbered from 1 top to bottom.

(c) All buckets shall be clearly labelled with suitable inscriptions indicating their function. All labels shall have black characters at least 6mm high on white background.

(d) Incomers shall be labelled "Incomer from ……....” as indicated on the drawings issued by the Engineer, using engraved black characters at least 6mm high on white background.

(e) Standby bus coupler (where applicable) shall be labelled "Standby Bus Coupler", using engraved black characters at least 6mm high on white background.

(f) All removable covers protecting live equipment shall be fitted with warning labels as well as ID tags to ensure the covers are replaced in the original position after removal. Warning labels shall be engraved white characters 6mm high on a red background.

(g) All electrical components/equipment shall be labelled (with designations corresponding to those of the Engineer’s schematic diagrams) to facilitate recognition.

(h) The labels for equipment mounted on doors shall be identified with white trifoliate labels having black lettering engraved on them, with a maximum height of 3mm letters.

(i) The equipment labels shall be secured by means of high quality double-sided tape.

(j) The labels for all equipment, installed behind panels, shall be fixed to the chassis close to the equipment.

(k) If this equipment is positioned too close to each other to accommodate descriptive engraved labels, the equipment may be identified by a code or number label, which shall be fixed close to the equipment. The code or number shall be identified on a legend board, which shall be installed on the switchboard behind a protective cover.

(l) The types of labels for equipment behind the doors or covers shall be subject to the Engineer's approval.

(m) Danger labels shall be white lettering 6mm high engraved on a red background.

(n) All labels and label brackets shall be affixed by machine screws. Adhesive labels are not acceptable.

(o) Over and above labelling requirements of this specification, the labelling requirements of SANS 10142-1 must be met.

E04.5.1.10 Insulation Materials

(a) Any insulation, filling putty, etc., used shall be selected such that it can withstand without harmful effect (mechanically or electrically), all temperatures encountered within the MCC.

E04.5.2 Electrical Details

E04.5.2.1 Busbars and Connections

(a) Busbars and connections shall generally comply with SANS 1195 for air clearances. Notwithstanding the contents of the above-mentioned specifications, all solid copper work shall be made of hard drawn high conductivity copper of constant cross-section throughout

their lengths with a maximum design current density of 1,66A/mm².

(b) The Phase and Neutral busbars shall be manufactured with flat copper bars with a standard rectangular conductor profile, of the same cross-section over the whole width of the panel.

(c) Busbar droppers shall be manufactured with flat copper bars with a standard rectangular conductor profile, of the same cross-section over the whole length of the dropper. The use of flexible conductors as droppers from the main busbars to circuit breakers shall not be permitted.

(d) All busbar joints shall be silver plated or tinplated. High pressure bolted lap joints shall be used and all bolts shall be of the high tensile type.

(e) All fixed busbar joints (separation links) between adjacent sections shall be maintenance-free.

E04.5.2.2 Earth Bar

(a) A protective earth bar shall extend the whole length of each Electrical panel and shall be duly marked PE. The earth bar shall at least, be bolted to the switchgear housing at each column.

(b) Stranded clear insulated aluminium earth wire (equal to 70mm^2 copper wire) with crimp type terminals shall be provided at both ends of the protective earth bar for connection to the substation earth bar/earthing system.

E04.5.2.3 Control Wiring

(a) Each Electrical panel shall be equipped and completely wired at the factory and, only after satisfactory testing, be split, if necessary, for transportation.

(b) Control and instrumentation wiring shall be silicone insulated throughout and of flexible, stranded, annealed, untinned copper construction. All wiring shall comply with the table below. Conductors shall comply with SANS 1411, Part 1, Table 4, Class 5.

CT Wiring	-	2.5mm^2 phase coloured, common return black insulated, earth green/yellow
General Control Wiring	-	(AC) 1.0mm^2 grey
	-	(DC) 2.5mm^2 (positive – red, negative – black)
Control Neutral	-	(AC) 1.0mm^2 (same size as phase wiring) – black
LED's and PLC Inputs	-	(AC) 0.75mm^2 grey
	-	(DC) 0.75mm^2 (positive – red, negative – black)

(c) Notwithstanding the above-mentioned requirements, the vendor shall ensure wire size used is amply rated for the applicable current, under ambient conditions.

(d) All control/instrument panel wiring shall terminate by means of suitably sized compression crimp lugs on screw-type terminals. Terminals of the pressure pad type are not accepted. The minimum voltage rating of the control wiring shall be 600/1000V grade to SANS 1507 and SANS 1411 Parts 1 and 3.

(e) Wiring shall be run in plastic trunking. Only where a space problem exists will loomed wiring be acceptable.

Note: Stick-on harness holders are not acceptable.

(f) Conductors passing through holes in compartments shall be protected by means of neoprene grommets. Bevelling of sheet steel will not be accepted as a substitute.

(g) Conductors shall be general-purpose 600/1000V grade PVC-insulated copper wire to SANS 1507 and SANS 1574. Aluminium conductors are not acceptable.

(h) Single or solid conductor wire shall not be used.

(i) Joints or splices in any wiring are not acceptable.

(j) Panel and equipment terminals, labels, etc., shall be accessible after the wiring has been completed.

(k) Connections to equipment on swing doors shall be arranged to give a twisting motion and not a bending motion to the conductor.

(l) Single pole and double pole moulded-case circuit breakers shall be wired in a way that the supply to the switchboard is equally balanced.

(m) Stripping of insulation shall not result in damage to the conductors. The stripping tools used shall be of the type, which permits the length of strip to be pre-set. Control wiring shall be terminated with pre-insulated, crimped or compression type lugs. Crimping tools shall be of the type, which will not release the termination during normal operation until the conductor crimp has been correctly formed. Any damaged wiring will be rejected.

(n) Lugs shall be of the hooked blade type when used in conjunction with screw clamp spring loaded insertion type terminals, ring tongue type when used with stud or direct screw mounted connections and wire pin when used with pinch screw type connections such as indicating lamp fittings.

(o) Not more than two conductors shall be connected to any side of a terminal.

(p) Each terminal strip shall be provided with not less than 10% spare terminals, with a minimum of two, unless otherwise approved.

E04.5.2.4 Power Wiring and Cable Terminations

(a) Power wiring on the "live" side of the circuit breakers (from the busbar dropper to the circuit breaker terminals) shall be as short as possible, sized to carry the maximum current continuously of the frame size of the respective circuit breaker and shall be a flexible copper conductor. The flexible connection shall be provided on all such connections and shall be designed to prevent the transmission of any forces that may arise between the busbar droppers and the circuit breaker. In terms of SANS 60439, this connection is deemed a fault free zone and the design and use of the flexibles shall in no manner compromise this zone.

(b) Power wiring on the "load" side of the circuit breaker terminals to cable termination terminal shall be as short as possible, sized to carry the maximum current continuously of the frame size of the respective breaker and shall be a flexible conductor. The flexible connection shall be provided on all such connections and shall be designed to prevent the transmission of any forces that may arise between the circuit breaker and the cable termination terminal. In terms of SANS 60439, this connection is deemed a fault free zone and the design and use of the flexibles shall in no manner compromise this zone.

(c) Terminals that are on the live side of fuses and isolating switches shall be completely shrouded to prevent accidental contact.

(d) Power circuit wiring and connections in a switchboard shall be rated to the full frame size rating of the associated equipment, i.e. fused switch, contactor, circuit breaker, etc., and not to the circuit or fuse rating.

(e) Power wires shall bear the colour along their entire length of the phase to which they are connected.

(f) Neutral connections shall have the same rating as the phase connections unless otherwise

approved.

(g) Power wiring terminations shall use an appropriate crimped accessory (the pressed tubular type of accessories). Stamped, folded, split-barrel type accessories are not acceptable.

(h) Terminations for power wiring and cabling shall be provided with pressure type clamping connections or bolted connections capable of accepting crimped or compression type lugs on conductors.

(i) In addition, hexagonal die type hydraulic crimping shall be used for all wiring greater than 16mm² in size.

(j) Cables shall be made off directly onto circuit breakers, switches, contractors, thermal-overloads, etc. Terminals or solid copper terminating conductors shall be provided where necessary. Provision shall be made for bracing and fixing of the cable leads to prevent vibration.

(k) A predrilled solid copper bar shall be provided for terminating all external power cables above 70mm, or where three or more cables in parallel are specified. The arrangement shall be suitable for accepting cable lugs of conductors up to 630mm².

E04.5.2.5 Wire Numbering

(a) Each end of every wire shall be marked with a wire number by means of plastic cable ferrules (black lettering on a white or yellow base).

(b) All wires shall be identified on both ends with a wire marker. The wire marker shall consist of a transparent flexible tube that slides over the wire with a wire identification label (black letters on a rigid white PVC tag) which slides into a label pocket on the tube. The tube must be correctly sized for the wire diameter.

(c) Split or open type marking ferrules shall not be used.

(d) Cable/wire marking ferrules shall correlate to the appropriate schematic or wiring diagrams.

(e) For all control wires without lug terminations, the numbered ferrule must not fall off when disconnecting the wire and in this regard, the use of one strand of wire to retain the ferrule is acceptable.

(f) All cables shall be identified on both ends with a cable marker. The cable marker shall consist of printed stainless steel band fixed to the cable with stainless steel strapping.

E04.5.2.6 Terminals and Connections

(a) All terminals will be of the screw-type. Terminals of the pressure pad type are not accepted Minimum rating for terminal blocks shall be 40A. Terminal strips/blocks shall be marked with designations corresponding with the suppliers/buyers drawings. Generally, terminal numbers shall be the same as the relevant wire number. No more than two wires may be connected to any one side of a terminal. Ten percent (10%) additional spare terminals shall be furnished.

(b) Terminals are to be provided for all door-mounted components, diodes, etc.

(c) Power connections on any equipment shall not use "Philips/Star" type screw/socket heads. Hexagon socket head cap screws (Allen type socket heads) are preferred.

(d) Where a large number of control terminals are mounted in close proximity, the terminals shall be in vertical rows with a minimum of 125mm below rows. Spare terminals shall be mounted at the bottom of the row unless the cabling drawing shows otherwise.

(e) Terminals shall be provided for all cores of external control cable as indicated on the drawings whether internally connected or not.

E04.5.2.7 Air Circuit Breakers (ACBs)

(a) ACBs shall be of the withdrawable type with self-aligning disconnecting devices with the disconnecting fingers preferably mounted on the breaker for ease of maintenance. The draw out mechanism shall hold the circuit breaker rigidly in the fully connected, test and fully disconnected positions.

(b) Safety shutters shall be provided to shield the fixed part automatically when the draw out parts removed preventing access to the conductors (main and auxiliary circuits). These shutters shall be clearly labelled indicating busbar and cable sections and in addition "live" section shall be labelled "400V – LIVE". ACBs shall be equipped with inter-phase barriers.

(c) Each Incoming ACB from a transformer and each Bus Section ACB shall be equipped with a protection unit incorporating:

i. Overload protection (IDMT)

ii. Thermal overload protection

iii. Instantaneous short-circuit protection

All protection devices will be delivered with protection settings adjusted to the minimum level. The protection unit shall be fitted with a transparent cover that can be sealed in the closed position to prevent tampering with the settings.

(d) The Contractor shall take particular care to ensure that the ACB protection is correctly co-ordinated with the upstream and downstream protective devices.

(e) Current and time delay set points on ACBs shall be accessible from the front of the ACB without removing the ACB from its cradle and shall only be adjustable when the cubicle door is open.

(f) Interlocks shall be provided to ensure the following:

i. That the main circuit breaker cannot be removed from or to the fully connected position unless the ACB is open;

ii. That the compartment doors cannot be opened should any accessible portion of the ACB frame be energised;

iii. That the ACB cannot be closed unless in the fully connected, test or fully disconnected positions.

(g) Mechanical restrictions shall be provided to inhibit mismatch of ACBs of different ratings.

(h) Provision shall be made for the padlocking of any ACB in any one of the fully connected, test or fully open positions. In addition, all ACBs shall have padlocking facility to prevent the close push button being operated when padlocked.

(i) ACBs employed as incomers and bus-section switches shall incorporate captive key interlocks to prevent paralleling of incoming supplies. Locks with captive keys must be built into the ACB's to prevent both Incomers and the Bus-coupler circuit breakers in the "ON" position at the same time. Padlocks will not be accepted for this application.

(j) The ACBs supplied shall be three pole, magnetic operated. The mechanism shall be of the stored energy type having hand charged spring with mechanical and electrical releases for closing.

E04.5.2.8 Moulded Case Circuit Breakers (MCCBs)

(a) MCCBs shall be of the manually operated type with thermal and instantaneous magnetic protection. Trip functions shall be resettable via the MCCB switching handle.

(b) Each MCCB shall be fitted with a vari-depth operating handle.

(c) Flash barriers shall be furnished to increase creepage distance between phases and shall be furnished on all circuit breaker cradles between the phases on both sides of the MCCB.

(d) The thermal trip elements of each MCCB shall be calibrated for the maximum ambient

temperature at 40°C.

(e) Current ratings of MCCBs shall be detailed in the Single Line Diagram drawings.

(f) MCCBs shall be selected according to rating and the fault level as specified by the Engineer.

(g) The name of the MCCB manufacturer shall be furnished by the tenderer at tender stage.

(h) Each MCCB shall be provided with suitable insulation between the terminals of the MCCB and the back plate/chassis onto which the MCCB is mounted, such that any loose nut, screw, etc., which may fall between the MCCB terminals and back plate cannot cause a short circuit.

(i) Where interlocking is called for between the MCCBs this shall be effected using captive keys in the breaker or a mechanical interlock.

(j) All outgoing circuits shall be equipped with individual core balance earth leakage units arranged to shunt trip each respective outgoing circuit.

(k) Outgoing circuits rated 125A and above shall have IDMT 375 mA earth leakage units EPC type Elsec T. Outgoing circuits rated 100A and below shall have instantaneous 250 mA earth leakage units - EPC type Elsec – X. All earth leakages must be of the manual reset type.

(l) All circuit breakers, except bus couplers, shall be connected with the switched side to the load, i.e. with reference to power flow incoming to "LINE" and outgoing to "LOAD".

(m) The incoming terminals/shutters of all 400V circuit breakers shall be effectively shrouded and marked "400V LIVE" with white characters on a red ground.

E04.5.2.9 Miniature circuit breakers (MCBs)

(a) Miniature circuit breakers (MCBs) shall be confined to auxiliary circuits such as control and indication in which the prospective short-circuit current will not exceed 5kA (3ph at 440Vac), or 7.5kA (1p at 24Vdc). They shall be of the thermal and magnetic trip free type. Where the prospective short-circuit current exceeds the above values, cascaded circuit breakers should be used. All cascaded circuits must be marked with the wording "Warning: This is a cascaded system. Never replace any circuit breaker in the system with another circuit breaker that is not identical in manufacturer, type and rating."

(b) Auxiliary contacts on MCBs

i. Provide the position (open/closed/tripped) remote indication functions of the associated MCB.

ii. Clip on (no tool required) to the left-hand side of the MCB. The type that connects to the MCB operating lever is preferred.

iii. Shall be of good quality and will not interfere with the operation or tripping of the MCB.

E04.5.2.10 Surge Arrestors

(a) All Electrical switchboards shall have a surge arrestor fitted to each phase on the incoming circuit breaker. The surge arrestors shall be fitted to the LIVE side of the circuit breaker.

E04.5.2.11 Instruments and Meters

(a) Incoming CBs shall be equipped with the following as a minimum requirement:

i. A single 96mm x 96mm 5A secondary, combined maximum demand and instantaneous ammeter. The maximum demand portion shall have a thermal movement with 15-minute time lag and drag pointer having a reset facility. It shall have a built-in saturation transformer for increased overload capacity to 90 times

rated current for one second;

ii. A 96mm x 96mm voltmeter connected to measure phase-to-phase voltage and phase to neutral voltage via a multi-position selector switch and a set of fuses suitably rated for voltage and short circuit current;

E04.5.2.12 Current Transformers

(a) All current transformers shall conform to SANS 61869-2. For protection purposes, class 10P CT's are to be used and for indicating purposes class 1 CT's are to be used and for metering purposes class 0.5 CT's are to be used. In general, current transformer mechanical and thermal ratings shall be co-ordinated with the short circuit ratings of the equipment.

E04.5.2.13 Fuses

(a) Fuse protection shall be used in cases were capacitive loads are switched i.e. Power factor correction or static capacitors panels.

(b) Fuses shall not be used for purposes other than voltmeter or kWh meter protection, unless specifically authorised. All short circuit protection shall be provided by means of circuit breakers and fast blow fuses for protecting the incoming side of the devices. In cases where the fault current level is excessively high, HRC fuses in conjunction with CB's should be considered to reduce the fault level and afford better protection for electrical personnel.

E04.5.2.14 Limit Switches

(a) Limit switches shall be metal encapsulated precision switches with robust and compact explosion-proof structures.

(b) Cables shall be equipped with a strain-relief device and safely cast into the enclosure. Switches shall have bottom, side or lateral cable outlets as per the requirement of the application. The integrated basic switch shall have a single-pole changeover contact with a high switching accuracy and a precise repeatability of the switching point.

(c) It shall have high vibration resistance and long mechanical life. It shall have a high protection class that would allow the switch to be used in all processes of Johannesburg Water wastewater treatment plants.

E04.5.3 Mounting of Equipment

E04.5.3.1 Clearance and Access

(a) A minimum clearance of 50mm shall be maintained between items of equipment and the side of the compartment.

(b) Where extra equipment is specified after the design has been finalised, this clearance requirement may be altered subject to the Engineer's approval.

(c) No piece of equipment shall be mounted in any position where it is not visible and accessible to a viewer looking into the compartment through the door opening.

E04.5.3.2 Mounting of Circuit Breakers

(a) All moulded case circuit breakers shall be flush mounted with only toggles protruding.

(b) Miniature circuit breakers may be installed in clip-in trays mounted on the frame.

(c) Special provision shall be made for large main switches.

(d) Circuit breakers shall be installed so that the toggles are in the up position when "ON" and down when "OFF".

E04.5.3.3 Mounting of Contactors

(a) Contactors shall only protrude through the panel in special cases. Plastic covers or other coverings will not be required.

E04.5.3.4 Instrumentation

(a) All metering instruments shall be mounted flush in the front panel unless otherwise specified.

(b) In certain instances it may be required that instruments be mounted flush in the door. In these instances, the back of metres shall be covered by removable covers of isolating material fixed to the door to protect the terminals of instruments and to prevent accidental contact.

(c) Equipment mounted normally on the surface, e.g. time switches and relays shall be mounted behind the front panel. In these cases, hinged access panels shall be provided in the front panel.

E04.5.3.5 Fuse-Links and Carriers

(a) Fuses shall be of the high rupturing capacity type and shall be mounted on insulated draw-out carriers, which shall hold the fuses positively and remain firmly fixed after withdrawal. In all cases, the top terminal shall be the live terminal. This applies also for MCB's.

(b) DC circuits shall have fuses in the positive and negative leads.

(c) Fuses shall be so positioned that they are readily accessible to a person standing on the floor.

(d) Fuses for instrumentation shall be mounted on the outside of the compartment door adjacent to or below the instrument.

(e) Fuses shall be provided with labels giving their rating and duty.

(f) Solid link holders shall be coloured white.

(g) One spare fuse of each type and size used in each board shall be fitted on clip holders on the inside of the front panel.

E04.5.3.6 Control Equipment

(a) All equipment performing control functions, e.g. control relays, transducers, and time relays not requiring adjustment, shall be mounted behind the front panel.

E04.5.3.7 Current Transformers

(a) Current transformers shall be accessible and easily removable.

(b) 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 directly to the protective conductor (earth bar).

(c) Current transformers shall be naturally air-cooled, and shall be able to withstand the maximum fault current for the duration of time taken by the functional unit to clear, with protective devices set at the maximum time delay settings.

E04.6 MOTOR CONTROL CENTRE

A Motor Control Centre (MCC) is an assembly of one or more enclosed sections having a common

power bus and principally containing motor control units that serves to govern in some predetermined manner the performance of an electric motor. Motor control centres are in modern practice a factory assembly of several motor starters. A motor control centre can include variable frequency drives, programmable controllers, metering apparatus etc. Motor Control Centre is used for controlling of various motors of a particular plant.

E04.6.1 MCC Buckets

(a) The following types of motor starters will be used:

i. Direct-on-line (DOL) type motor starting;

ii. Star/Delta (S/D) type motor starting;

iii. Forward/Reverse type motor starting;

iv. Soft starting (SS) type motor starting;

v. Variable Speed Drive (VSD) type motor starting.

(b) The main contactors on Star/Delta and Forward/Reverse type starters will be mechanically interlocked. The type of motor starting required shall be project specific and shall be indicated in the MCC schedule/s to be issued by the Engineer.

(c) All the protection devices, i.e. overloads, circuit breakers, motor thermistors, motor heaters, gearbox oil flow switches etc. on mechanical equipment shall be hard wired onto the individual motor starter circuits.

(d) Only one motor will be controlled from any MCC bucket.

E04.6.2 Busbars

(a) Main busbars in MCCs shall be rated for 2000 amps as a minimum.

(b) Busbar droppers in MCCs shall be rated for the maximum possible current (determined by the breaker frame size) in that section with a minimum rating of 1000 amps.

E04.6.3 Earth bar

(a) The earth bar shall be rectangular, with a minimum cross sectional area of 400mm² (10mm x 40mm).

E04.6.4 Power wiring

(a) The minimum MCC power wiring size shall be 25mm².

E04.6.5 Circuit Breakers

(a) Air circuit breaker (ACBs) will be used for Incomer circuit breakers on MCCs.

(b) Bus coupler circuit breakers on MCCs will use an air circuit breaker (ACBs).

(c) Moulded Case circuit breakers (MCCBs) will be used for outgoing feeders on MCCs up to a maximum rating of 800 amps.

E04.6.6 Instruments and Meters

(a) Incoming CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVArh, kW, kVAr, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.

(b) Each bucket shall be equipped with a suitably sized 5A current transformer (CT) operated

96mm x 96mm 90° movement suppressed maximum demand ammeter having an overload rating of 40 times the rated current for one second. The CT primary current rating will match (equal) the outgoing feeder circuit breaker current rating. The CT secondary current rating will be 5A.

E04.7 MAIN DISTRIBUTION BOARD

A Main Distribution Board is a panel from where electrical energy is taken out to distribute power to various consumer points. It has a single incoming power sources from a distribution transformer and includes feeder circuit breakers and protection devices to the consumers.

E04.7.1 Busbars

(a) Main busbars in MDBs shall be rated for 2000 amps as a minimum.

(b) Busbar droppers in MDBs shall be rated for the maximum possible current (determined by the breaker frame size) in that section with a minimum rating of 1000 amps.

E04.7.2 Earth bar

(a) The earth bar shall be rectangular, with a minimum cross sectional area of 400mm² (10mm x 40mm).

E04.7.3 Power wiring

(a) The minimum MDB power wiring size shall be 25mm².

E04.7.4 Circuit Breakers

(a) Air circuit breakers (ACBs) shall be used as Incomer circuit breakers on MDBs.

(b) Moulded Case circuit breakers (MCCBs) will be used for outgoing feeders on MDBs up to a maximum rating of 800 amps.

E04.7.5 Instruments and Meters

(a) Incoming CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVArh, kW, kVAr, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.

(b) Feeder CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVArh, kW, kVAr, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.

E04.8 AUXILIARY DISTRIBUTION BOARD

An Auxiliary Distribution Board is a panel from where electrical energy is taken out to distribute power to various consumer points. It has a single incoming power sources from a Main Distribution Board and includes feeder circuit breakers and protection devices to the consumers.

E04.8.1 Busbars

(a) Main busbars in ADBs shall be rated for 1000 amps as a minimum unless otherwise specified/approved by the engineer.

(b) Busbar droppers in ADBs shall be rated for the maximum possible current (determined by

the breaker frame size) in that section with a minimum rating of 600 amps unless otherwise specified/approved by the engineer.

E04.8.2 Earth bar

(a) The earth bar shall be rectangular, with a minimum cross sectional area of 250mm² (10mm x 25mm) unless otherwise specified/approved by the engineer.

E04.8.3 Power wiring

(a) The minimum ADB power wiring size shall be 16mm² unless otherwise specified/approved by the engineer.

E04.8.4 Circuit Breakers

(a) Air circuit breakers (ACBs) shall be used as Incomer circuit breakers on ADBs unless otherwise specified/approved by the engineer.

(b) Moulded Case circuit breakers (MCCBs) will be used for outgoing feeders on ADBs up to a maximum rating of 800 amps.

E04.8.5 Instruments and Meters

(a) Incoming CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVArh, kW, kVAr, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.

(b) Feeder CBs shall be equipped with a suitably sized 5A current transformer operated 96mm x 96mm 90° movement suppressed maximum demand ammeter having an overload rating of 40 times the rated current for one second. The CT primary current rating will match (equal) the outgoing feeder circuit breaker current rating. The CT secondary current rating will be 5A.

E04.9 FLUSH MOUNTED DISTRIBUTION BOARD

E04.9.1 Internal for of Separation

(a) The internal for of separation will be specified by the Engineer.

E04.9.2 Bonding Tray

(a) Bonding trays for flush mounted switchboards shall be of rigidly constructed 1,6mm thick galvanised steel, braced and reinforced.

(b) Formed gussets shall be provided at the corners. All the tray joints shall be properly welded or securely bolted with a brass or cadmium plated steel earth connecting stud and nut.

E04.9.3 Expanded Metal

(a) Where switchboards are to be built into 116mm thick walls, expanded metal shall be spot welded to the rear of the bonding trays.

(b) The expanded metal shall protrude at least 150mm on each side to prevent plaster from cracking.

E04.9.4 Knock-Outs

(a) Ample knockouts shall be provided in the top and bottom ends of each switchboard tray to allow for the installation of conduits for the specified and future circuits.

(b) Knockouts shall be allowed for any size of specified conduit.

(c) Provision shall however be made for termination of at least 2 x 25mm diameter conduits at top and 2 x 25mm diameter conduits at the bottom of each tray.

E04.9.5 Architrave Frame

(a) The architrave frame shall be of 2,0mm thick sheet steel with bevelled edges.

(b) The architrave frame shall accommodate the chassis, panels and doors.

(c) The architrave shall overlap the bonding tray by at least 25mm on each side.

(d) The architrave frame shall be fixed to the tray in such a fashion to allow for depth adjustment and irregularities of the wall.

E04.9.6 Extension Frames

(a) Semi-flush mounted switchboards shall be equipped with extension frames.

(b) Generally, the frame depths shall be 50mm but may be altered to suit each application.

E04.9.7 Chassis

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

(b) The chassis position shall be adjustable in the horizontal plane.

E04.9.8 Panel (Faceplate)

(a) A suitably stiffened panel manufactured of 2,0mm thick sheet steel shall be installed in the architrave frame for flush mounting of switchgear.

(b) The panels shall have machined punched slots for housing the specified and future switchgear, instruments, fuse holders, isolating switches, indicator lamps, etc. In exceptional cases, contractors will be allowed to protrude through the panel.

(c) Blanking plates shall be provided in positions where future switchgear will be installed.

(d) The distance between the inside of the closed doors and the panels shall be not less than 40mm.

(e) No equipment may be mounted on the panel (faceplate) unless it is permanently hinged to the switchboard frame.

E04.9.9 Fixing of Panels

(a) The panel for each switchboard shall be secured to the architrave frame by means of captive fasteners. Alternatively, the panel may be secured to the architrave frame by means of two pins at the bottom and a latch or lock at the top of the panel. Self-tapping screws or dome nuts will not be allowed.

(b) Where it is required that equipment be mounted on the panel, the panel shall be securely hinged to the switchboard frame.

E04.9.10 Panel Handles

(a) Two chromium plated handles shall be provided on each front cover.

(b) The handles shall be mounted at the top and bottom of each panel.

E04.9.11 Hinged Panels

(a) Where hinged panels are specified, the hinges shall be fixed to the architrave frame and the panel shall be secured by means of studs and hexagonal chromium plated nuts or by means of a suitable lock or latch, which can be operated with a screwdriver.

(b) The panel shall be removable when it is in the open position.

E04.10 SURFACE MOUNTED DISTRIBUTION BOARD

This section refers to surface mounted sub-switchboards and not to floor standing main switchboards in substations or sub-main switchboards.

E04.10.1 Internal for of Separation

(a) The internal for of separation will be specified by the Engineer.

E04.10.2 Switchboard Tray

(a) Surface mounted switchboards shall be equipped with a 1,6mm sheet steel reinforced tray.

(b) Securing lugs shall be provided to fix the tray to walls or any other structure.

(c) A solid brass or cadmium plated steel earth connection stud and nut shall be provided.

E04.10.3 Construction

(a) All joints shall be welded or securely bolted.

(b) The tray shall be square and neatly finished without protrusions.

(c) The front tray sides shall be rounded with an edge of at least 20mm to accommodate flush doors.

(d) The requirements for chassis, panels and doors shall be as specified for flush mounted switchboards.

(e) The doors shall be hinged and shall fit flush in the frame in the closed position.

(f) Knockouts shall not be provided unless specifically called for.

E04.11 LV KIOSKS (SWITCH CUBICLES)

LV kiosks shall be of sufficient size to accommodate all the specified equipment.

E04.11.1 Framework

LV kiosks shall be manufactured of mild steel sheet metal with a minimum thickness of 2mm or cold rolled 3CR12 sheet metal with a minimum thickness of 1,6mm. Fibre re-inforced or other corrosion proof material (e.g. glass fibre) may also be used if adequately reinforced.

E04.11.2 Ventilation

Two ventilation slots or grilles, approximately 150 x 125mm and covered on the inside with copper mesh, shall be provided on opposite sides of the cubicle.

E04.11.3 Doors

Doors shall be provided in the front and back panels and shall swivel through 180º. Rigid padlocks and base plates for security latches shall be provided on the doors. Openings for security latches shall be blanked with chromed brass discs.

E04.11.4 Warning Sign

Warning and danger signs shall be mounted on each door in compliance with the requirements.

E04.11.5 Base

The kiosk shall be mounted on a well-finished concrete base, with minimum height of 150mm above ground level in the case of mild steel and any of the other specified acceptable materials. The kiosk can be made for direct mounting into the ground in which case it shall be equipped with a base, forming part of the structure, for this purpose. The switch cubicle shall protrude at least 10mm past the edges of the base to prevent water collecting on the base.

E04.12 STANDBY SUPPLIES

(a) Where standby power from a diesel-generator set or other source is available and has to be connected to some of the equipment on a panel, the panel shall be divided into electrically separate sections with sheet metal division plates to isolate power and mains power sections. The section doors must be appropriately colour coded to provide visual distinguishing.

(b) A means shall be provided to isolate both the standby and mains power supplies simultaneously. For this purpose, either a 6-pole rotary switch or mechanically and electrically interlocked circuit breakers or contactors may be used. Electrical interlocking alone is not sufficient. Rotary switches may only be used on panels where the fault level does not exceed 10kA.

(c) A separate 3-pole circuit breaker shall be provided as main switch for both the standby power section and the mains power section in addition to the isolator of (b) above.

Where a 6-pole rotary switch is used as isolator for the incoming supplies, this switch may be located in the standby section of the switchboard in which case the rotary switch can also serve as the isolator for the standby section. This arrangement is acceptable where the equipment on the mains power section of the switchboard can be turned off whenever it is necessary to work on the standby section of the switchboards.

(d) The main switches to the standby and mains power sections shall be interlocked with the doors providing access to those sections to ensure that the door can only be opened when the switches are in the OFF position.

E04.13 ELECTRICAL SUBSTATION FIRE PROTECTION SYSTEM

It is the duty of the Contractor to appoint a trained and competent fire engineering company to design, supply, install, commission, and test and certify a fire protection system for each electrical substation building forming part of the contract.

Each fire protection system will consist out of a fire detection and an extinguishing system as described below. Both systems will be of the highest quality and latest technology, supplied by a reputable manufacturer. The contractor will submit written proof that local support is available to maintain the system and to supply spare parts as required.

E04.13.1 Fire Detection System

The fire detection system must:

(a) Utilise a sub-micron combustion particle detector that detects a fire at its initial stage, before the presence of smoke. This allows preventative action can be taken before any catastrophic event occurs.

(b) Utilise detectors suitable for dusty plant environments and must be impervious to false alarms caused by dust particles in substation buildings with sheet metal roofs where no ceilings are present.

(c) Cover the substation building, all electrical cabinets and all cable trenches.

(d) Only when there is a second alarm from a second detector the system will trigger the gas.

(e) Double Knock system (Trigger an alarm on the first detector activation and trigger the operation of a fire extinguishing system on a second detector activation).

(f) Alert a control and alarm signalling system in case of a fire or a system fault.

(g) Be designed and installed to conform to SANS/ISO 10139 and SANS 369 Parts 1 and 2.

E04.13.2 Fire Extinguishing System

The fire extinguishing system must:

(a) Utilise an automatic system to flood the substation building with a concentration of a gaseous extinguishing agent to extinguishing a fire burning in Class A, B, and C hazards by lowering the oxygen content below the level that supports combustion as quickly as possible.

(b) Utilise a non-toxic, human friendly extinguishing agent. The use of an extinguishing agent that does not support human life must be approved in writing by the Engineer. In this case, other safety measures such as a lockout system should be integrated to ensure safe entrance into the protected substation.

(c) Utilise an efficient extinguishing agent that is electrically non-conductive and that will not adversely affect the protected electrical equipment. No powder or other residue should remain after actuation of the system.

(d) Audible and visual warnings must alert personnel to vacate the protected substation area before discharging the agent.

(e) Utilise a colourless, odourless environment friendly extinguishing agent that is sustainable against impending global warming regulations.

(f) Utilise an extinguishing agent that has a low refill cost.

(g) Should be fully approved by the local authority to an internationally accepted engineering standard.

E04.13.3 Other measures

(a) All points where cable or other services enter the substation building must be properly sealed with a fire rated medium of at least one-hour or as per local standards and regulations.

(b) All ventilation and air conditioning devices must be tripped in the event of first detection of a fire.

(c) All ventilation openings and doors in the substation building should be sealed in the event of first detection of a fire.

(d) A room integrity test needs to be carried out to validate the hold-time for the extinguishing agent as per the room's natural leakage.

(e) All detection, alarm and extinguishing circuits are to be monitored for system faults.

(f) The substation fire protection system should operate a local audible and visual alarm system and report to a central 24-hour manned operations or security room.

(g) A local handheld fire extinguisher should also be installed within the substation as per local regulations. The type and number should conform to local standards and regulations.

E04.13.4 System Maintenance

(a) The contractor will include a fire protection system maintenance contract for a period of one year after commissioning. A trained and competent fire engineering company must do the maintenance.

(b) Thereafter a trained and competent fire engineering company should be contracted to inspect the system on a three-month basis. It should check that the system is operational in terms of its design and take corrective action in the event of a fault.

(c) The Client should visually check the system once a month for any faults reported on the control panel and anything that might appear out of the ordinary. The Client should immediately report to a competent fire engineering contracting company of any concerns or faults to ensure immediate rectification.

(d) A mandatory annual room integrity test should be carried out as per SANS 1520 Part 1.

(e) Should any physical alterations be made to a substation, a review on the fire protection system must be done to see if its performance has been compromised and appropriate actions should be made to ensure the integrity of the system.

E04.14 QA REQUIREMENTS

The vendor / contractor will be responsible for the following.

TABLE OF CONTENTS			
SECTION	**DESCRIPTION**	**REQUIRED (YES OR NO)**	**WHEN REQUIRED**
DRAWINGS & DESIGN (2 SETS OF EACH)	DESIGN CALCULATIONS		
	GA DRAWINGS	YES	ORDER + 3 WEEKS
	DETAIL DRAWINGS	YES	CONSTRUCTION
	AS BUILT DRAWINGS	YES	COMPLETION
	BROCHURES	YES	CONSTRUCTION
	SKETCHES		
	SCHEMATIC DIAGRAMS	YES	ORDER + 3 WEEKS
	RISK ASSESSMENT BY VENDOR	YES	CONSTRUCTION
	DATA SHEETS	YES	TENDER
	DESIGN CRITERIA	YES	CONSTRUCTION
QUALITY CONTROL DOCUMENTS (2 SETS OF	QUALITY CONTROL PLAN	YES	ORDER + 3 WEEKS
	MANUFACTURING PROGRAM	YES	ORDER + 3 WEEKS

EACH)			
MATERIAL CERTIFICATES		YES	MANUFACTURE
CERTIFICATES OF INSPECTION TESTING AND ACCEPTANCE	PRESSURE TEST CERTIFICATE	YES	DATA BOOK
	ELECTRICAL HAZARD CERTIFICATE		
	ELECTRICAL TEST CERTIFICATES	YES	DATA BOOK
	INSTRUMENT CALIBRATION CERTS.		
	VENDORS CERTIFICATE OF CONFORMANCE	YES	COMMISSIONING
	NON-CONFORMITY / CONCESSION REPORTS	YES	COMMISSIONING
MANUALS	OPERATING / MAINTENANCE MANUAL	YES	COMPLETION
	DATA BOOK	YES	DELIVERY – 1 WEEK
	DRAWINGS	YES	COMPLETION
	WARRANTY/GUARANTEES CERTIFICATES	YES	COMPLETION

E04.15 DRAWINGS AND DATA

(a) The vendor / contractor will supply shop drawings to the Engineer prior to manufacturing.

(b) No switchboard manufacturing may start if the drawings are not approved by the Engineer in writing. Should the vendor / contractor start manufacturing without approved shop drawings, any changes required by the Engineer will be for the vendor / contractor's account.

(c) The following will be included in the shop drawings as a minimum:

i. General arrangement drawings

ii. Schematic diagrams

iii. Equipment lists, including the make, catalogue number and capacity of all equipment such as isolators, circuit breakers, fuses, contractors, etc.

iv. All labelling information on a separate sheet.

(d) The approval of the shop drawings shall not relieve the Contractor of his responsibility to the Client to supply the switchboards according to the requirements of this specification or to the requirements of the Detailed Technical Specification.

(e) The vendor / contractor will supply three hard copies and one soft copy of the equipment data book including all items as specified in the Vendor QA and document requirement list.

(f) Data books will be supplied to Johannesburg Water within 7 days from delivery of equipment. Johannesburg Water will review the data books within 14 days from issue and notify the Vendor of its acceptance or rejection of it.

(g) All drawings and documentation shall be in accordance with Johannesburg Water specifications bound in book format.

(h) A complete set of "As Built" drawings of all switchboards shall be submitted to the Engineer immediately after completion of the installation. The following information shall be presented:

i. Items (i) and (iv) of the previous paragraph.

ii. Terminal strip numbers, numbers and colours of conductors connected to the terminal strips and numbers and colours of the conductors utilised for the internal wiring.

iii. A separate schedule of all equipment.

(i) Where "As Built" drawings are modified during the execution of the contract, the Contractor shall at his own expense modify or replace such drawings. Accurate drawings of the equipment shall be forwarded to the Engineer.

E04.16 PAINTING AND PROTECTIVE COATING

E04.16.1 Powder Coating Systems

(a) Paint system 1: Powder Coating, seven Stage zinc, Phosphate pre-treatment, pure epoxy primer, Polyester finishing coat, and thickness 140 µm.

Paint System	Host Material	Preparation	Primer (70µm)	Finishing Coat (70µm)	Thickness µm
No 1	Mild Steel	7 stage phosphate pre–treatment	Epoxy	Epoxy	140

(b) On completion of the paint job, the powder manufacturer must carry out the following tests on the test panels:

i. SABS 6J impact test

ii. Cross hatch adhesion test

iii. Bend test

(c) The powder manufacturer must issue a Certificate of Compliance for each paint job, which should be included in the contract documentation.

(d) The preferred corrosion protection systems are applied onto cold rolled mild steel plate with a thickness of 2.0mm.

E04.16.2 Epoxy Powder Coat Products

Item	Product Type	Powder - Lak
1	Epoxy Primer	23-007
2	Pure Epoxy / Polyester Finishing Coat.	Series 3000

E04.16.3 General

(a) All chassis plates shall be painted white.

(b) All mild steel gland plates shall be galvanised for improved cable earthing.

(c) All panel doors on equipment supplied from a normal supply must be painted Electric Orange (B26).

(d) All panel doors on equipment supplied from an emergency supply must be painted Signal Red (A11).

(e) All panel doors on equipment supplied from an UPS supply must be painted Dark Violet (F06).

(f) Specific external colours will be provided by Johannesburg Water.

(g) Before the installation is handed over, the Contractor shall ensure that all paint surfaces are clean and undamaged.

E04.17 PERFORMANCE AND GUARANTEE

(a) The performance of the items supplied in terms of this specification, as defined by the order, shall be warranted by the Vendor and, if specified, be tested in accordance therewith.

(b) The vendor shall not be specifically required to conduct a performance test on site.

(c) A minimum warranty period of 12 months is required.

E04.18 INSPECTION AND TESTING

E04.18.1 Factory Acceptance Test

(a) The Johannesburg Water Representative shall have access, at all reasonable times, to those parts of the manufacturing facilities engaged in the manufacturing of items in terms of this specification. He is authorised to witness any stage of manufacture, tests and inspect documentation.

(b) The Johannesburg Water Representative is authorised to reject any items not manufactured to the requirements of the specification.

(c) All equipment shall be inspected at the vendor's works prior to delivery, to ensure compliance with the specification.

(d) No unit shall be considered complete until acceptance by Johannesburg Water.

(e) The minimum testing / pre delivery checklist shall be as follows:

i. The Johannesburg Water representative must carry out a clause-by-clause check of each switchboard, prior to delivery.

ii. This switchboard checklist is intended to assist this process but does not relieve him/her of the responsibility described above.

DETAILED INSPECTION ROUTINE

Order No. : _____

Supplier/Vendor : _____

Project : _____

Motor Control Centre Designation : _____

Inspected by : _____

Date : _____

		Comments
Overall Appearance		
□		
□	**Paint work : Compliance with Annexure A5**	
□	**Paint thickness**	
□	**Door fittings good**	
□	**Dust sealing effective (neoprene seals)**	
□	**Board fully assembled**	
□	**Overall height less than specified height**	
□	**Channel iron base frame (less than 3000m)**	
□	**Lifting lugs provided**	
□	**Equipment supplied in accordance with specification (contractors, overloads, circuit breakers, relays, etc.)**	

		Comments
Busbars		
☐	**Correct cross-section**	
☐	**Correct phasing with incomer/feeders**	
☐	**Rigidly supported/braced**	
☐	**Properly insulated**	
☐	**Joints tightened**	
☐	**Transport section joints supplied (Fishplates, nuts and bolts, control wiring and terminals, etc.)**	
☐	**Droppers from main bars to circuit breakers adequately rated, braced, insulated**	
☐	**Nothing unnecessary mounted on bus bars**	
☐	**Main earth bar, min 70mm²**	
☐	**Control busbars generally as above, separate from power busbars**	
☐	**Air clearances adequate throughout**	
Single Line Diagram Check		
☐	**As per approved single line diagram**	
Outgoing Circuit		
☐	**Correct size/rating for MCCB's**	
☐	**Correct size/rating for ACB's**	
☐	**Correct earth leakage relays**	
☐	**Correct current transformer and associated ammeters**	
☐	**Correct overload relays**	
☐	**Correct setting on overload relays**	
☐	**Reasonable provision for cable termination power and control mounting of equipment**	
☐	**Correct conductor sizing, power and control, and correct colouring**	
☐	**Correct indicator lights and colours**	
☐	**Air clearances correct throughout**	
Incoming Circuits		
☐	**Correct size/rating of ACB's**	
☐	**Correct metering and proper mounting**	
☐	**Connection of power factor meter**	
☐	**Fuses on volt meter, where applicable**	
☐	**Reasonable provision for termination of incoming cable/gland plate**	
☐	**Air clearances correct throughout**	
	Incomer status signal to PLC	
	Interlocks	
Pressure and Injection Tests		
☐	**Primary injection test for correct operation of all protection and overload relays**	
Operational Test		
☐	**Mechanical operation of all circuit breakers, preferably with doors closed**	
☐	**Shunt trip of all circuit breakers**	
☐	**Operation of overload relay**	
☐	**Correct operation of all interlocks**	
☐	**Correct operation of indicator lights**	

		Comments
□	**Correct operation of earth fault/overload alarm system, including general alarm panel**	
	Correct signals to PLC terminals	
	Correct interlocks	
	Door interlocks	
General Checks		
□	**Marking of control wires and power conductors**	
□	**Main Motor Control Centre label**	
□	**Cubicle labels fitted – designation and cubicle number**	
□	**Component labels fitted**	
□	**Warning labels on all removable covers giving access to live 400V conductors**	
□	**Labels for indicator lights, pushbuttons, etc.**	
□	**Terminal strip labels**	
□	**Incoming side of circuit breakers label**	
□	**Incoming circuit label – "FROM _____"**	
□	**No 'Philips' (star) screws**	
□	**No self-tapping screws**	
□	**Grommets fitted on all open holes**	
□	**Correct paint specification**	
□	**All documentation submitted**	
□	**Arc venting arrangements satisfactory**	
□	**Door latches fitted**	

(f) Specific testing and inspection requirements relating to switchgear boards are as follows:

i. Prior to shipment, the switchgear boards shall be completely assembled, wired, adjusted and tested by the supplier in the presence of the engineer and the client representative.

ii. Testing shall include primary injection tests of all current transformers, pressure tests to prove quality of insulation, functional tests of all mechanical and electrical components and electrical circuitry and any other tests required to ensure compliance with this specification.

iii. The supplier shall give one week's notice of readiness for final tests to the Johannesburg Water representative. The vendor shall ensure that the equipment is ready for final testing before requesting the presence of the Johannesburg Water representative at such a test. Repeat inspections necessitated by the lack of readiness of the equipment may be charged to the vendor at the discretion of the Johannesburg Water representative.

E04.18.2 <u>Site Acceptance Test and Commissioning</u>

(a) A Site Acceptance Test (SAT) must be conducted at the place of installation prior to switching the DB on. The test shall include (as a minimum) the following:

i. A visual inspection to ensure all the design specifications are adhered to;

ii. Insulation resistance test;

iii. Function testing of all components.

iv. All switchboards must be thermal imaged a minimum of 1 week after being put on service. The image must be taken in normal operating conditions. The image must be analysed for hot spots and must be part of the Operations and Maintenance

Manuals presented at the end of the project.

E04.19 MEASUREMENT AND PAYMENT

Item Unit

Supply and deliver Switchboards or Motor Control Centres ..... No

The unit of measurement shall be the number of MCC's or boards supplied and delivered.

The tendered rate shall include full compensation for the manufacture, supply, testing and delivery of the boards as specified in the detailed specification.

Item Unit

Install Switchboards or Motor Control Centres ..... No

The unit of measurement shall be the number of MCC's or boards installed.

The tendered rates shall include full compensation for the installation of the specified boards, including all required installation material to install the MCC or board in the required position including a heavy-duty strut, mounted 400mm below the gland plate. All incoming and outgoing cables shall be attached to this strut by means of K-clamps or approved equivalent clamps.

Item Unit

Commission Switchboards or Motor Control Centres ..... No

The unit of measurement shall be the number of MCC's or boards.

The tendered rates shall include full compensation for the site testing and commissioning of the specified boards including the keeping of all commissioning records in triplicate, including all material, test equipment and labour required for the testing and commissioning.

Item Unit

Supply and install extra circuits on Switchboards and Motor Control Centres ..... No

The unit of measurement shall be the number of circuits supplied and installed.

The tendered rate shall include full compensation for the manufacture, supply, testing and installing of extra circuits in switchboards or motor control centres (spare space being available on the board).

Item Unit

Supply and deliver level control equipment ..... No

The unit of measure shall be the number of level control systems supplied and delivered.

The tendered rate shall include full compensation for the supply, manufacturing, testing and delivery of all the material required for the level control system, including all float level switches, will the required length of cable attached to them, mounting brackets, terminal box and mounting equipment together will all material to facilitate a complete level control system.

Separate items will be measured for systems with different numbers of level switches.

Item Unit

Install level control equipment ..... No

The unit of measure shall be the number of level control systems installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the level control system including the required brackets, junction boxes, cables etc. for a complete working system.

Item Unit

Modify existing motor starter panels ..... No

The unit of measure shall be the number of motor starters to be modified.

The tendered rate shall include full compensation for the supply and delivery of all material and labour required to modify the motor starter panel as detailed in the detail specification.

Item Unit

Supply and install PLC/Scada alarm and status signals ..... No

The unit of measure shall be the number of MCC's for which a siren and alarm light has been installed.

The tendered rate shall include for the full compensation for the supply, delivery, installation and commissioning of the specified siren and alarm light including all required installation material including cables required to render a fully operational system.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

E07 : ELECTRICAL INDUSTRIAL WELDING PLUGS, COUPLERS AND SOCKET OUTLETS

Johannesburg Water

Johannesburg Water (SOC) Ltd.
PO Box 61542
Marshalltown
2107

Revision 4

August 2019

City of Johannesburg
Johannesburg Water (SOC) Ltd

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ACTION	FUNCTION	NAME	DATE	SIGNATURE
Prepared	Senior Electrical Engineer	B Pieterse	August 2019	
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Approved	Regional Maintenance Manager	T Thabeng	August 2019	

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2	2012-05-30		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance
1	2009-05-12		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance

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E07.1 SCOPE

This specification covers the procurement, supply, delivery, installation testing and commissioning of the required industrial welding plugs, couplers and socket outlets for industrial purposes.

E07.2 STANDARDS

E07.2.1 National Standards

The latest edition, including all amendments up to date of tender of the following particular national specifications, publications and codes of practice shall be read in conjunction with this specification and shall be deemed to form part thereof:

(a)	SANS 1222	:	Enclosures for electrical equipment classified by IP code
(b)	SANS 1239	:	Plugs, socket-outlets and couplers for industrial purposes
(c)	SANS 6309	:	Plugs, socket-outlets and couplers for industrial purposes
(d)	SANS 1091	:	National colour standard
(e)	SANS164-2		Plug and socket-outlet systems for household and similar purposes for use in South Africa Part 2: Two-pole and earth and 2 pin (Class II), 16 A 250 V a.c. system.
(f)	SANS 10142-1	:	The Wiring of Premises Part 1 – Low Voltage Installations

E07.2.2 Particular specifications to be read in conjunction with this specification

(a)	E26	:	ELECTRICAL SPECIFICATION FOR COLOUR CODES
(b)	G02	:	PARTICULAR SPECIFICATION FOR CORROSION PROTECTION
(c)	E06	:	ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION
(d)	E08	:	WIRING

E07.3 GENERAL REQUIREMENTS

Switched 400V 3-phase, 3-wire and earth 63A industrial welding socket outlet plus a switched 230V, single phase, 3-wire 16A industrial socket outlet shall be supplied. A 4-core cable shall be used with an earth included in the supply cable.

E07.3.1 Single phase 16A household and similar purpose socket outlet

Applied to general household, commercial and light industrial installations up to 250Vac 16 A.

(a) Compliance: SANS 164-2/SANS10142-1

(b) Wall mounted socket;

(c) Be of the two-pole earthing contact type;

(d) Incoming power supply via a 2-pole earth leakage protection unit located in the upstream distribution board;

E07.3.2 Single phase 16A industrial socket outlet

(e) Wall mounted socket;

(f) Pin and sleeve configuration;

(g) 2 pole, 3-wire with 2P+E 230V ac, 16A;

(h) Incoming power supply via a 2-pole earth leakage protection unit located in the upstream distribution board;

(i) Ingress protection IP67 (SANS 1222);

(j) Switched locally on the socket outlet;

(k) Mechanical interlock to prevent plugs from being engaged or disengaged under load;

(l) Lockable by a padlock (40mm) at the switch-off position.

E07.3.3 Three phase 63A industrial welding socket outlet (5-pin)

(a) Compliance: SANS 60309-1

(b) 415Vac 3phase, neutral and protective earth (5 pin), 63A current rating

(c) Housing: Powder coated die-cast aluminium

(d) Colour: Electric orange RAL B26

(e) Wall mounted socket with top cable entry with removable flange;

(f) Pin and sleeve configuration;

(g) 3-phase earth leakage protection unit mounted in the feeder cubicle in the MCC/DB;

(h) Rated ingress protection IP55 (SANS 1222);

(i) Switched locally on the socket outlet, lockable by a padlock (40mm) at the switch-off position;

(j) Mechanical interlock: The isolator cannot be “Switched ON” without the plug inserted and the plug cannot be removed while the isolator is in “ON” position

(k) Matching metal clad plug top, 415Vac 3-phase 5 pin, 63A, IP55 to be supplied with the socket outlet.

Where pilot wire connections are required, they shall disconnect before the main phase connectors disconnect.

The equipment enclosures shall be IP55 to SANS 1222. Socket outlets that are exposed to the atmosphere or installed in damp areas, shall be minimum rated at IP 56 or as otherwise specified by the engineer. All sockets shall be constructed of corrosive resistant materials.

Both types of sockets shall be mounted on a 304 stainless steel heavy duty pedestal. The socket outlet mounting height shall be 1200 mm above finished ground level.

A purpose made metal junction box of IP65 rating to SANS 1222 fitted with a canopy shall be provided and mounted on the stand above the socket outlet in such a way that the junction box does not interfere with the use of the socket outlet. The supply cable to the welding socket shall be terminated in the junction box. Where the cross sectional area of the cores of the supply cable to the welding socket outlet exceeds 16 mm^2, the cable core size from the junction box terminals to the socket outlet shall be 16mm^2, 4-core. The 16A single-phase socket shall have its own dedicated supply.

The junction box including the canopy and the welding socket stand shall be powder coated /painted B26 – Light Orange (1673-Y48R) to SANS 1091.

E07.4 TESTING AND COMMISSIONING

During testing and commissioning, the contractor shall:

(a) Perform a visual inspection to ensure that the installation complies to the requirements specified herein as well as in detailed specifications;

(b) The rating of all equipment is as specified;

(c) Test all earth leakage protection units supplied to confirm the tripping current.

E07.5 MEASUREMENT AND PAYMENT

Measurement and payment will distinguish between supply / delivery and installation / commissioning of industrial welding plugs, sockets, connectors etc.

Item	**Unit**
Supply and deliver of welding plugs and switched socket outlets complete with plugs	No

The unit of measurement shall be the number of plugs and switched socket outlets including stands and junction boxes supplied and delivered.

Separate items shall be scheduled in the schedule of quantities for different types of switched socket outlets.

The tendered rate shall include all costs related to the supply and delivery of the specified switched socket outlet and plugs and shall include for the stands and junction boxes required.

Item	**Unit**
Install and commission welding plugs and switched socket outlets	No

The unit of measurement shall be the number of plugs and switched socket outlets including stands and junction boxes installed and commissioned.

Separate items shall be scheduled in the schedule of quantities for different types of switched socket outlets and whether the plug must be installed on a cable or whether the plug must be handed over to the employer.

The tendered rate shall include full compensation for the installation of the switched socket outlet and plugs as detailed in the detail specification including all required material and labour to render a complete and working installation, including all labour and material required for installing the plug on the cable as detailed or for handing over the plug (free issue) to the employer and obtaining a receipt therefore.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

E08 : ELECTRICAL WIRING

Johannesburg Water

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Revision 4

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City of Johannesburg
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PARTICULAR SPECIFICATION: VOLUME E08: ELECTRICAL WIRING

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E08.1 SCOPE

This specification covers the wiring requirements of electrical installations.

E08.2 STANDARDS

The latest edition, including all amendments to until the date of tender, of the following particular national and international specifications, publications and codes of practice shall be read in conjunction with this specification and shall be deemed to form part thereof:

(a) SANS 10142-1 : The wiring of premises Part 1: Low-voltage installations

(b) SANS 1411-2 : Materials of insulated electric cables and flexible cords: Part 2 – Polyvinyl Chloride (PVC)

(c) SANS 1507 : Electric Cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)

E08.3 GENERAL REQUIREMENTS

PVC insulated conductors for general wiring shall consist of high conductivity annealed copper wire strands with polyvinyl chloride insulation. The insulation shall be compounded and stabilised to comply with SANS 1411-2 as amended.

Conductors shall be finished in the required colours and shall be manufactured in accordance with SANS 1507 as amended.

Any special requirement regarding the type and size of wiring to be installed in a specific installation shall be specified.

E08.4 DRAWING OF CONDUCTORS

Wiring shall only be carried out after the wireway installation is completed, but before painting has commenced. No conductors shall be installed before the wireways have been cleaned of all debris and moisture. Wireways shall contain no sharp edges.

When conductors are drawn through conduit, care shall be taken that they are not kinked or twisted.

E08.5 WIRING METHOD

All wiring shall be carried out according to the loop-in system. When earth continuity conductors are looped between terminals of equipment, the looped conductor ends shall be twisted together and ferruled to ensure that earth continuity is maintained when the conductors are removed from a terminal.

When connecting more than one conductor in a terminal, the strands shall be securely twisted together. Under no circumstances shall strands be cut off.

E08.6 SIZE OF CONDUCTORS

The following minimum conductor sizes shall be used:

Bell circuits = 1.5 mm^2
Clock circuits = 1.5 mm^2
Lighting circuits = 1.5 mm^2
Plug circuits = 2.5 mm^2
All the above = 2.5 mm^2 earth conductor
Motor circuits = As specified

E08.7 DIFFERENT PHASES

With the exception of three-phase outlets, circuits connected to different phases shall not be present at light, switches or socket-outlet boxes.

E08.8 TESTING AND COMMISSIONING

The contractor shall supply factory test certificates for each drum of cable supplied under the Contract.

After the installation is complete, the contractor and the Engineer shall inspect the installation. The Engineer must be notified in advance of the inspection dates. The contractor will keep a snag list, reflecting all items not acceptable to the Engineer. The contractor will correct the snag items as required to the Engineers approval, updating the snag list as the items are completed and signed off by the Engineer.

On completion of his work, the Contractor will issue an Electrical Certificate of Compliance (CoC). All tests deemed necessary to issue the CoC should be included. The Contractor shall make all arrangements, pay all fees and provide all equipment for these tests. The Contractor shall notify the Engineer timeously so that he may witness the tests.

Each installed cable shall be tested in accordance with:

(a) The Occupational Health and Safety Act (OHSA) 1994;

(b) The requirements of the Local and Supply Authorities.

E08.9 MAINTENANCE INSTRUCTIONS AND GUARANTEES

E08.10 MEASUREMENT AND PAYMENT

Item **Unit**

Supply and deliver LV conductors .....m

The unit of measurement shall be the linear length of conductor supplied and delivered.

The tendered rate shall include full compensation for the supply and delivery to site of the specified conductors. Conductors will be measured linearly along the full length installed in the wireway and sufficient provision will be made in the quantities for conductor slack at outlet boxes and distribution board trays. No extra will be allowed for jointing, overlapping and wastage at connections.

Separate items shall be scheduled for each conductor size.

Item **Unit**

Install LV conductors in conduit .....m

The unit of measurement shall be the linear length of conductors installed in conduit.

The tendered rate shall include full compensation for the handling, inspection, pulling in conduit the specified number and sizes of conductors, cutting and testing of the conductors. Sufficient provision will be made for conductor slack at outlet boxes and distribution board trays to make the necessary connections to equipment.

Separate items shall be scheduled for each size of conductor.

Item **Unit**

Install LV conductors in trunking .....m

The unit of measurement shall be the linear length of conductors installed in trunking.

The tendered rate shall include full compensation for the handling, inspection, installing in trunking the specified number and sizes of conductors, the grouping of these conductors into circuits using plastic cable ties, cutting and testing of the conductors.

Separate items shall be scheduled for each size of trunking and for each size of conductor.

This rate shall furthermore include for the supply of all cable ties, clamps and other materials

necessary to ensure that the wiring conforms to the specification.

Item **Unit**

Install LV conductors in power skirting.....m

The unit of measurement shall be the linear length of conductor installed in power skirting.

The tendered rate shall include full compensation for the handling, inspection, installing in power skirting the specified number and sizes of conductors, the grouping of these conductors into circuits using plastic cable ties, cutting and testing of the conductors. Sufficient provision will be made for conductor slack at power outlets.

Separate items shall be scheduled for each type of power skirting and for each size of conductor.

This rate shall furthermore include for the supply of all cable ties, PVC sleeving for earth conductors and other materials necessary to ensure that the wiring conforms to the specification.

Item **Unit**

Install LV conductors in floor ducting .....m

The unit of measurement shall be the linear length of conductors installed in floor ducting.

The tendered rate shall include full compensation for the handling, inspection, installing in floor ducting the specified number and sizes of conductors, the grouping of these conductors into circuits using plastic cable ties, cutting and testing of the conductors. Sufficient provision will be made for conductor slack at power outlets. Were cables are exposed to the sun they shall be strapped, using stainless steel strapping.

Separate items shall be scheduled for each type of floor ducting and for each size of conductor.

This rate shall furthermore include for the supply of all cable ties, PVC sleeving for earth conductors and other materials necessary to ensure that the wiring conforms to specification.

Item **Unit**

Supply conductor terminals..... No

The unit of measurement shall be the number of conductor terminals supplied.

The tendered rate shall include full compensation for the supply and delivery to site of the specified terminals complete with mounting rail and all hardware required to fasten the terminals and mounting rail. Separate items shall be scheduled for each size of terminal.

Item **Unit**

Install conductor terminals ..... No

The unit of measurement shall be the number of conductor terminals installed.

The tendered rate shall include full compensation for the handling, inspection and installation of the specified terminals and mounting rail. Separate items shall be scheduled for each size of terminal.

Item **Unit**

Supply PVC insulated multicore cables .....m

The unit of measurement shall be the linear length of cable installed.

The tendered rate shall include full compensation for the supply and delivery of the cables. Separate items shall be scheduled for the different types and sizes of cables.

Item **Unit**

Install PVC insulated multi core cables.....m

The unit of measurement shall be the linear length of cable installed.

The tendered rate shall include full compensation for the supply and delivery of the cables. Separate items shall be scheduled for the different types and sizes of cables.

Item **Unit**

Supply and install the terminations for PVC multicore cables ..... No

The unit of measurement shall be the number of terminations installed.

The tendered rate shall include full compensation for the supply and installing of the terminations as specified.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

E09 : ELECTRICAL BUILDING INSTALLATION

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Revision 4

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City of Johannesburg
Johannesburg Water (SOC) Ltd

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PARTICULAR SPECIFICATION: VOLUME E09: ELECTRICAL BUILDING INSTALLATION

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E09.1 GENERAL

The Particular Specification shall be read in conjunction with the Detailed Technical Specification.

Where the Detailed Technical Specification is in contradiction with this Particular Specification, the former shall apply to this contract.

E09.2 STATUTORY DOCUMENTS AND STANDARDS

E09.2.1 Standards

The installation shall be erected and carried out in compliance with:

(a) SANS 10142-1	:	The wiring of premises Part 1: Low-voltage installations
(b) SANS 60529	:	Degrees of protection provided by enclosures (IP Code)
(c) SANS 10400-FR	:	National Building Regulations and Building Standards Act (Act 103 of 1977), as amended
(d) SANS 60529	:	Degrees of protection provided by enclosures (IP Code)

E09.2.2 Regulations, Acts and Bylaws

The installation shall be erected and carried out in compliance with the latest edition of the following:

(a) Occupational Health and Safety Act (Act 85 of 1993) and Regulations;

(b) Construction Regulation;

(c) Applicable By-Laws and Regulations as implemented by the Local Authority;

(d) Fire Regulations as implemented by the Local Authority.

E09.2.3 Particular Specifications to be read in conjunction with this specification

This specification shall also be read in conjunction with the following specifications:-

(a) E02	:	ELECTRICAL CABLE RACKS
(b) E06	:	ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION
(c) E08	:	WIRING

In addition, the Contractor shall issue all notices and pay all the required fees in respect of the installation to the local authorities, and shall exempt the Employer from all losses, costs or expenditures that may arise because of the Contractor's negligence to comply with the requirements of the regulations enumerated in paragraph 9.2.

It is assumed that the Contractor is conversant with the above-mentioned requirements. Should any requirements, by-law or regulation, which contradict the requirements of this document, apply or become applicable during erection of the installation, such requirement, by-law or regulation shall overrule this document and the Contractor shall immediately inform the Engineer of such a contradiction. Under no circumstances shall the Contractor carry out any variations to the installation in terms of such contradictions without obtaining the written permission to do so from the Engineer.

E09.3 ARRANGEMENTS WITH THE SUPPLY AUTHORITY

It shall be the responsibility of the Contractor to issue all notices and pay all monies that are due for the electrical builders / temporary supply connection, except where otherwise specified. If, according to the contract, these monies are reclaimable from the Employer, then these claims by the Contractor shall be substantiated with official receipts.

It shall be the responsibility of the Contractor to make the necessary arrangements at his own cost with the local supply authority and to supply the labour, equipment and means to inspect, test, commission and to hand over the installation.

The Contractor shall supply and install all signage, notices and warning signs that are required by the appropriate laws, regulations and/or by this document.

E09.4 FIXING AND SUPPORTING OF EQUIPMENT AND MATERIALS

(a) It is the responsibility of the Contractor to position and securely fix conduits, wiring ducts, cables and cable channels, switchboards, fittings and all other equipment or accessories as required for the installation. The Contractor shall provide and fix all supports, clamps, brackets, hangers and other fixing materials.

(b) All supporting steelwork shall be wire-brushed and given one coat of rust resisting primer, followed by one coat of high quality enamel paint before any other equipment is fixed.

(c) Supports, brackets, hangers, etc. may only be welded to steel structural members where prior permission has been obtained. Drilling of holes into or welding onto steel structural members is only allowed where prior permission has been obtained.

(d) All methods of suspension or supports shall be submitted to the Engineer for approval and for reference to the Structural Engineers where necessary, prior to manufacture or installation.

(e) Supporting of any rotating equipment shall incorporate anti-vibration mountings of the type and selection specified in the applicable clauses referring to equipment bases herein.

(f) Supports shall preferably be strut channel, shall be of mild steel sections, purpose fabricated for their application. Under no circumstances whatsoever will sheet metal straps be accepted as a supporting method. All supports shall cradle the item to be supported; supports shall not be riveted or welded to the equipment. Rod hangers shall not exceed 3000mm in length and be of minimum diameter 12mm. For longer suspensions use mild steel angles. Angle profile supports shall be of 38 x 5mm minimum section.

(g) Where holes in equipment exist, bolts and fixing screws as specified shall be used. Where sizes are not specified, the largest bolt or screw that will fit into the hole shall be used.

(h) Anchor bolts shall be used for fixing supports to brick or concrete walls, it not being permissible to utilise gunpowder shot-driven bolts for this purpose unless prior permission has been obtained.

(i) Where the fixing holes in brick or concrete walls are smaller than 10mm diameter and where the mass of the equipment is less than 15kg, wall plugs may be used to fix conduits, cables and other equipment. Aluminium, fibre or plastic plugs only may be used. Wooden plugs are not acceptable. Plugs installed in seams between bricks are not acceptable. A masonry drill of the correct size shall be used to drill holes for plugs. Round headed screws shall be used throughout.

(j) Where the fixing holes are 10mm and larger or where the mass of the equipment is 15kg or more, equipment shall be fixed by means of expanding anchor bolts or by means of bolts cast into the concrete.

(k) Galvanised screws, bolts and nuts shall be used to fix galvanised equipment.

(l) No shot-fired or explosion driven tools will be allowed.

E09.5 ELECTRICAL CONDUIT INSTALLATION

E09.5.1 General

Where conduits are to be installed in concrete, this shall be done while the building work is still in progress. Surface mounted conduit shall only be installed after the concrete has cured sufficiently.

E09.5.2 Other Services

Conduits may not be installed closer than 150mm to pipes containing gas, steam, hot water or other materials which may damage the conduits. Conduits may not touch pipes or other service installations in order to prevent electrolytic corrosion. Where doubtful situations of this nature occur or where there are installation incompatibilities, the matter shall be reported to the Engineer immediately.

E09.5.3 Galvanised Conduit

Galvanised conduit and accessories shall be used under all circumstances:

Conduit and accessories shall be hot-dipped galvanised to SANS 32: Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants and SANS 121: Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods.

E09.5.4 Debris

Care shall be taken to prevent any debris or moisture from entering the conduit during and after installation of the conduits. All conduit ends shall be sealed by means of a solid plug, which shall be screwed to the conduit end. All conduits shall be cleaned to remove all oil, moisture or other debris that may be present, before conductors are installed.

E09.5.5 Defects

Each length of conduit shall be inspected for defects and all burrs shall be removed. All conduits that are split, dented or otherwise damaged or any conduits with sharp internal edges shall be removed from site. The Contractor shall ensure that conduits are not blocked.

E09.5.6 Conduit Ends

Conduit ends shall be cut at right angles to ensure that ends butt squarely at joints. Threads shall not be visible at joints and connections except at running joints for steel conduits.

E09.5.7 Joints

All conduit ends shall be reamed and all joints tightly screwed. Only approved couplings shall be used. Running joints with long threads shall be kept to a minimum and locknuts shall be provided to ensure a strong mechanical and a continuous electrical joint for steel conduits.

E09.5.8 Finish

All joints shall be painted with cold galvanizing paint to prevent them from rusting in damp areas, and in cases where the installation is exposed to the weather for any length of time. Where the galvanising finish was damaged, the area shall first be cleaned and a coat of cold galvanizing paint applied subsequently. Additional coats of paint shall only be applied after the undercoat has been completed.

E09.5.9 Continuity

Mechanical and electrical continuity shall be maintained throughout the conduit installation. The use of conduits as earth continuity conductors are not allowed.

E09.5.10 Inspection Type Accessories

Inspection type couplings, elbows and tees shall not be used except with the written consent of the Engineer. All outlet boxes and draw boxes shall however be of the inspection type.

E09.5.11 Position of Outlets

All accessories such as socket outlets, switches, lights, etc., shall be accurately positioned. It is the responsibility of the Contractor to ensure that all accessories are installed level and

square at the correct height from the floor, ceiling or roof level as specified. It shall be the responsibility of the Contractor to determine the correct final floor, ceiling and roof levels in conjunction with the Main Contractor. Draw boxes shall not be installed in positions where they will be inaccessible after completion of the installation. Draw boxes shall be installed in inconspicuous positions to the approval of the Engineer. All installed draw boxes shall be pointed out to the Engineer. The positions of all draw boxes shall be indicated on the 'as-built' drawings.

E09.5.12 Draw Wires

Galvanised steel draw wires shall be installed in all unwired conduits, e.g. conduits for future extensions, telephone installations and other services.

E09.5.13 Bends

A maximum of two 90º bends or the equivalent displacement will be allowed between outlets and/or draw boxes. Draw boxes shall be installed at maximum intervals of 12m in straight conduit runs. All bends shall be made without heating the conduit or without reducing the diameter of the conduit. The inside diameter of a bend shall not be less than three times the outside diameter of the conduit.

E09.5.14 Wall Sockets

Where more than one socket outlet is connected to the same circuit, the conduit shall be looped from one outlet box to the following on the same circuit. Where a metal channel is used, the conduit may be installed from the channel directly to the outlet box on condition that the conductors can be looped from one outlet to the next without the jointing of wires.

E09.5.15 Luminaires

Conduit end may not be used to solely support luminaires. Where luminaires are specified which are fixed directly to the pendant box, the pendant box shall be fixed independently of the conduit installation except where the pendant box is cast into concrete.

E09.5.16 Withdrawal of Conductors

To ensure that all electrical conductors shall be easily withdrawable from conduits, the Engineer reserves the right to have the conductors on any circuit removed at his discretion and replaced at the cost of the Contractor. If the conductors are damaged during removal, the damaged conductors shall be replaced and the cost of the replacement shall be borne by the Contractor.

E09.5.17 Temperature Differences

Should the conduit installation be subject to temperature gradients at the same time, an expansion joint shall be installed in a suitable position to accommodate expansion and contraction. The conduit at the higher temperature shall be insulated from the rest of the installation with a suitable material. The above conditions for example apply where conduits leave cold rooms.

E09.5.18 Flush Mounted Outlet Boxes

The edges of flush mounted outlet boxes shall not be deeper than 10mm from the final surface. Where this is not the case, an extension box which ends flush with the surface, shall be screwed to the outlet box. This method shall be used in partitions and clad surfaces.

E09.5.19 Excess Holes

All excess holes in draw boxes, distribution boxes, switchboards, cable ducts or trunking, power skirting, etc., shall be securely blanked off to render the installation vermin proof.

E09.5.20 PVC Conduit

The use of PVC conduit shall not be allowed, only if stated in the Detailed Technical Specification portion of the document.

E09.5.21 Terminations

E09.5.21.1 Switchboards, Power Skirting, Etc.

A female bush and two lock nuts shall be installed where conduits terminate in pressed steel switchboards and distribution boxes, cable ducts, power skirting, etc. The conduit end shall only project far enough through the hole to accommodate the bush and lock nut.

E09.5.21.2 Draw Boxes

A female bush and lock nut must be used to terminate conduits at draw boxes and outlet boxes without spouts.

E09.5.22 Open Roof Spaces

E09.5.22.1 Sequence of Work

Conduits and wiring in open roof spaces above ceilings other than concrete slabs must be installed before the ceilings and walls are painted and before removable ceiling tiles are installed. In roof spaces where access is limited after installation of the ceiling. It is the responsibility of the Contractor to ensure close liaison with the Main Contractor in connection with the work.

E09.5.22.2 Fixing

All conduits is open roof spaces shall be installed parallel and at right angles to the roof members and shall be fixed to the structures at intervals not exceeding 1 metre. Approved saddles shall be used throughout. Clout nails, clamps or wood screws shall be used to secure the saddles to wooden roof members. Saddles which comply with the requirements of this specification shall be used to secure conduits against concrete slabs. Written permission shall be obtained to secure conduits to steel beams in which case saddles shall be fixed by means of bolts, nuts and lock washers or purpose made saddles shall be used.

E09.5.22.3 Cross-Overs

Crossovers in conduit routes shall be minimised. Where crossovers are unavoidable offset one conduit only to cross the other conduit. Where several conduits enter the same draw box, they shall as far as possible be installed parallel to each other.

E09.5.22.4 Draw Boxes

Install draw boxes with metal cover plates where required and as far as possible near gangplanks. The use of socket and switch boxes instead of draw boxes in open roof spaces is unacceptable.

E09.5.22.5 Positions of Accessories

Install conduits in open roof spaces, which is accessible after completion of the building to allow wiring or inspection from a position above the conduits. Install conduits in ceiling voids with less than 900mm clear space between the ceiling and the roof, to permit wiring and inspection from a position below the conduits. Loop conduits between outlet boxes.

E09.5.22.6 Incandescent Luminaires

Where luminaires are secured directly to draw boxes in false ceilings or where ceiling roses or special connections are used, flush mounted, rear entry round draw boxes that are independently fixed to roof beams, shall be provided.

E09.5.22.7 Conduit Ends

All conduit ends for lighting outlets in ceilings shall be securely supported.

E09.5.22.8 Fluorescent Luminaires

Draw boxes for fluorescent luminaires shall be installed as specified in the previous paragraph but luminaires shall be installed as specified in paragraph 9.5.22.6.

E09.5.23 Installation in Concrete and Screeds

The Contractor must position all conduits and accessories casted in concrete in good time to prevent building delays.

In order not to delay building operations, the Contractor shall ensure that all conduits and accessories that casted in concrete are positioned in good time. The Contractor or his representative must attend when the concrete casting.

E09.5.23.1 Draw Boxes

Draw boxes, expansion joints and round ceiling boxes shall be installed where required and shall be neatly finished to match the finished slab and wall surfaces. Ceiling draw boxes shall be of the deep type. In hollow tile slabs, rear-entry draw boxes shall be used. In columns where flush mounted draw boxes are installed, the conduits shall be offset from the surface of the column immediately after leaving the draw box.

E09.5.23.2 Cover Plates

Where possible draw boxes and/or inspection boxes shall be grouped together under a common approved cover plate. The cover plate shall be secured by means of screws.

E09.5.23.3 Fixing to the Shuttering

All conduits, draw boxes etc., shall be securely fixed to the shuttering to prevent displacement when concrete is cast. Wire will not be accepted for securing boxes to the shuttering where off-shutter finishes are required. All draw boxes and outlet boxes shall be plugged with wet paper before they are secured to the shuttering.

E09.5.23.4 Concrete Floor Slabs

Conduits will not be allowed in concrete floor slabs of boiler rooms (or boiler houses), laundries, dewatering buildings, pump stations or other damp areas. Equipment in damp areas shall only be supplied from above by means of multi-core PVC-insulated cables which shall either be installed in galvanised steel ducting or on galvanised cable trays. All socket outlets and three phase outlets in damp areas shall be supplied from above.

E09.5.23.5 Screeds

The installation of conduits in floor screeds shall be kept to a minimum. Where conduits are installed in screeds, the top of the conduit shall be at least 20mm below the surface of the screed. Where the screed is laid directly on the ground, galvanised conduits shall be used. This ruling will always be applicable to the lowest floor of a building. A minimum distance of twice the outside diameter of the conduit shall be left free between adjoining conduits. Conduits shall be secured to the concrete slab at intervals not exceeding 2,0m.

E09.5.23.6 Inspection

All draw boxes, conduits, etc., which are installed in concrete shall be cleaned with compressed air and provided with draw wires two days after removal of the shuttering. Errors that occur during the installation of the conduits, or any lost draw boxes, or blocked conduits, shall be immediately reported to the Engineer in order that an alternative route can be planned and approved by the Engineer before the additional concrete is cast. Any additional cost shall be to the Contractor's account.

E09.5.24 Surface Installation

Except where installed in ceiling spaces, the installation of conduit on the surface of walls and concrete slabs will only be allowed when authorised, in writing, by the Engineer. Where surface conduits are specified, saddles shall be of the hospital (spacer) type.

E09.5.24.1 Building Lines

All conduits shall be installed horizontally or vertically as determined by the route and the Contractor shall take all measures to ensure a neat installation. Where conduits are to be installed directly alongside door frames, beams, etc., that are not true, conduits shall be installed parallel to the frames, beams, etc. When in doubt, the Contractor shall consult the Engineer before installation is commenced.

E09.5.24.2 Saddles

Conduits shall be firmly secured by means of saddles spaced at maximum intervals of 2000mm with at least two saddles per run. Saddles shall be submitted to the Engineer for

approval prior to commencement of installation. Where saddles are used to secure vertical lengths of conduit connected to surface mounted switch boxes or socket outlet boxes, the saddles shall be spaced so that the intervals between the box and the first saddle, between any two successive saddles and between the last saddle and the ceiling or roof are equidistant. Conduits shall be secured within 250mm before and after each 90° bend.

E09.5.24.3 Joints

Joints will not be allowed in conduit lengths not exceeding 3500mm when these conduits are installed on the surface of a wall. Threads shall not be visible at joints of completed installations, except where running joints are used. Running joints will be allowed only when absolutely necessary. All running joints shall be provided with lock nuts and shall be painted with red lead immediately after installation.

E09.5.24.4 Accessories

Inspection bends or tee pieces shall not be used. Non-inspection type bends may be used in the case of 40mm or 50mm diameter conduits. All draw boxes supporting luminaires or other equipment shall be fixed independently of the conduit installation.

E09.5.25 Flexible Conduits

In installations where the equipment has to be moved frequently to enable adjustment during normal operation, for the connection of motors or any other vibrating equipment, for the connection to thermostats and sensors on equipment, for stove connections and where otherwise required by the Engineer, flexible conduit shall be used for the final connection to the equipment.

The lengths of flexible conduit shall be as short as possible to comply with the requirements of the particular connection but shall not exceed 600mm, except when specified or approved by the Engineer.

Flexible conduit shall preferably be connected to the remainder of the installation by means of a draw box. The flexible conduit may be connected directly to the end of a conduit if an existing draw box is available within 2000mm of the junction and if the flexible conduit can easily be rewired.

Flexible conduit shall consist of metal-reinforced plastic conduit or PVC covered metal conduit with an internal diameter of at least 15mm, unless approved to the contrary. In false ceiling voids, flexible conduit of galvanised steel construction may be used. Connectors for coupling to the flexible conduit shall be of the gland or screw-in type, manufactured of either brass or cadmium or zinc plated mild steel. The requirements of paragraphs 9.5.9 are applicable.

Where the possibility exists that the conduit can come into contact with moisture, suitable covering and/or packing shall be installed to isolate the conduit from the moisture.

Flexible conduit connections shall be provided with an internal or external earth wire connection as required by the local Supply Authority, with preference given to internal earth wires where no specific local regulations apply.

E09.5.26 Stove connection

A freestanding stove, rated above 16A must be plugged in by means of a stove coupler (see figure 1). The stove coupler, which shall comply with SABS IEC 60309-with a minimum of 45Amp single-phase and 16 A per phase for three-phase. The open end of the connector tube shall point downwards.The switch-disconnector for the cooking appliance shall

(a) be in the same room as the appliance,

(b) be at a height above floor level of not less than 0, 5 m and not more than 2, 2 m,

(c) not be above the cooking appliance,

(d) be within 3 m of the appliance, but within 0, 5 m of the appliance if the switch-disconnector's purpose is not clearly indicated, and

(e) not be fixed to the appliance.

Figure 1: Stove coupler

E09.5.27 Expansion Joints

Where conduits cross expansion joints in the structure, approved type draw boxes which provide a flexible connection in the conduit installation shall be installed.

The draw box shall be installed adjacent to the expansion joint of the structure and a conduit sleeve, one size larger than that specified for the circuit, shall be provided on the side of the draw box nearest the joint. The one end of the sleeve shall terminate at the edge of the joint and the other shall be secured to the draw box by means of locknuts.

The circuit conduit passing through the sleeve shall be terminated 40mm inside the draw box. The gap between the sleeve and the conduit at the joint shall be sealed to prevent the ingress of wet cement.

The conduit boxes shall be drilled and tapped and the earth wire shall be bonded to the boxes by means a 2,5mm^2 copper wire(minimum) with lugs and brass screws.

Draw boxes at the expansion joint shall be provided with a suitable steel cover plate fixed to the boxes by means of screws. The cover plates shall be installed before the ceilings are painted by others.

E09.5.28 Chases and Builder's Work

Except where otherwise specified, the Contractor shall be responsible for the builder's work connected with conduits, outlet boxes, switchboard trays, bonding trays and other wall outlet boxes as well as the necessary chasing and cutting of walls and the provision of openings in ceilings and floors for luminaires and other electrical outlets. The Contractor shall notify the Main Contractor of his requirements and the responsibility lies with the Contractor to ensure that these requirements are met.

Electrical materials to be built in must be supplied, placed and fixed in position by the Contractor when required by the Main Contractor. The Contractor shall also ensure that these materials are installed in the correct positions.

Where no Main Contractor is on site the Contractor is required to cover conduits installed in chases by a layer of 4 : 1 mixture of coarse sand and cement, finished 6mm below the face of the plaster and roughened. In all cases chases shall be deep enough to ensure that the top of conduits are at least 12mm below the finished plaster surface.

The Contractor is responsible for the cutting of chases and the building-in of conduits or other equipment. , He will be held responsible for all damage as a result of this work and will be required to make good to the satisfaction of the Engineer. Chases shall be made by means of a cutting machine.

Under no circumstances shall face brick walls or finished surfaces be chased or cut without the written permission of the Engineer. Where it is necessary to cut or drill holes in the concrete structure, then prior permission of the Structural Engineer shall be obtained to ensure that the structure is not weakened.

The Contractor shall maintain close co-operation with the Main Contractor and all his Contractors throughout the course of the contract. Should the Contractor not comply with this requirements, any additional costs resulting from lack of his co-operation will be recovered from him.

E09.5.29 Connections to Switchboards

Wherever possible conduits connected to switchboards shall terminate in a common fabricated sheet steel draw box installed in the vicinity of the switchboard. In open roof spaces this draw box shall be placed in a roof space of not less than 900mm clearance. Lighting and plug circuits may be separately grouped in common conduits or metal ducts (trunking) from the distribution board to the draw box.

The draw box shall be of sheet steel with a minimum thickness of 1,6mm and shall be provided with a removable cover plate.

E09.5.29.1 Flush Mounted Switchboards

Where flush mounted switchboards are required, the recessed switchboard tray shall be built into the brick or concrete wall. All conduits from the floor or roof shall be fully recessed and shall be bonded directly to the tray.

E09.5.29.2 Surface Mounted Switchboards

Where surface mounted switchboards are specified but where the conduits can be fully recessed, the conduit shall be connected to a recessed connection box installed behind the switchboard. An opening with the same dimensions as the connection box shall be cut in the back of the switchboard and be provided with a suitable grommet.

E09.6 CABLE TRAYS AND LADDERS

Please revere to the specification E02: Electrical Cable Racks.

E09.7 WIRING DUCTS

E09.7.1 Responsibility of the Contractor

The Contractor shall supply and install all wiring ducts as specified or as required by the cable and wiring installation including the necessary supports, hangers, fixing materials, bends, angles, junction T-pieces end caps, etc.

E09.7.2 Materials and Finishes

Wiring ducts shall be rolled from 1,2mm minimum sheet steel and shall be finished as follows:

(a)	In boiler rooms (or boiler houses), laundries, dewatering buildings, pump stations or other damp areas damp areas.	Stainless steel 3CR12 and epoxy powder coated
(b)	False ceiling voids	Pre-galvanised
(c)	Vertical building ducts	Hot-dipped galvanised to SANS 32 and SANS 121
(d)	Surface mounted in plant rooms, substations, service tunnels, basement, offices	Epoxy powder coated or electro-galvanised
(e)	Undercover industrial applications	Hot-dipped galvanised to SANS 32 and SANS 121.

The abovementioned finishes shall apply unless specifically to the contrary in the Detailed Technical Specification. Epoxy powder coats shall comply with paragraph EO9.12.9. Hot-dipped galvanised or electro-galvanised wiring ducts shall be cold galvanised at all joints, sections that have been cut and at places where galvanising has been damaged. Powder coated ducts shall likewise be touched up at joints, cuts and damaged portions using spray canisters recommended by the manufacturers of the channels.

E09.7.3 Cover Plates

All wiring ducts shall have metal snap-in cover plates. Cover plates for wider ducts shall be fixed by means of screws that shall permanently be tapped into the cover plates spaced at suitable intervals to prevent warping. The finish of the covers shall comply with paragraph EO9.7.2

E09.7.4 Connections

Adjoining lengths shall be correctly aligned and securely joined by means of fishplates and mushroom bolts, washers and nuts or connection pieces that are pop-riveted to both adjoining sections. All adjoining sections shall be rectangular and shall butt tightly. Covers shall fit tightly across the joint.

E09.7.5 Support for Conductors

All conductors in inverted wiring ducts shall be retained by means of metal clips or metal spacer bars at not less than 1m centres.

E09.7.6 Vermin Proofing

All wiring ducts shall be vermin proof after installation. Holes shall be covered by means of screwed metal plugs or by means of metal strips that are bolted or pop-riveted to the channel. Wooden or other plugs which are driven into holes or other temporary plugs or covers are not acceptable.

E09.7.7 Earth Continuity

Electrical and mechanical continuity shall be maintained throughout the wiring duct installation. A tinned copper bonding strip ($6mm^2$) shall be installed across each joint and secured to both adjoining ducts by means of galvanised bolts, nuts and washers. The duct shall be bonded to the earth bar of the associated switchboard.

E09.7.8 Internal Finishes

All bends shall be of easy sweep design with 45^o gussets. Burrs and sharp edges shall be removed and the inside edges of all joints shall be lined with rubber cement or other suitable rubberised or plastic compound to prevent conductor insulation laceration.

E09.7.9 Services

Multiple duct runs or internal metal partitions shall be used where conductors for power, control and other services are present.

E09.7.10 Vertical Installation

Where vertical duct lengths exceed 5m, conductors shall have intermediate fixings.

E09.7.11 Number of Conductors

Wiring ducts shall be large enough to ensure that the combined total cross-sectional area (including insulation) of all conductors does not exceed 40% of the cross-sectional area of the duct.

E09.7.12 Fixing

The Contractor shall supply and install all hangers, supports or fixings for the ducts. Ducts up to 75 x 75mm shall be supported at maximum intervals of 1m and larger channels at maximum intervals of 2m. Duct runs shall be carefully planned to avoid clashes with other services and to ensure that all covers can be removed after completion of the entire installation. The method of fixing the ducts or supports to the structure shall comply with paragraph E09.4 with particular

reference to paragraphs E09.4.f and E09.4.h. Purpose made cable clamps, hangers, etc. shall be used as required.

E09.7.13 Installation in Concrete

The installation of wiring ducts in concrete will not be allowed.

E09.7.14 Fire Barrier

Where wiring ducts pass through walls, non-asbestos filling shall be installed around the conductors to serve as a fire barrier.

E09.7.15 Conduit Connection

All conduit connections shall be terminated by means of two lock nuts and a brass female bush. All holes through which conductors pass shall be equipped with grommets.

E09.8 INSTALLATION OF LUMINAIRES

E09.8.1 Positions

The mounting positions of luminaires shall be verified on site. All luminaires shall be placed symmetrically with respect to ceiling panels, battens, beams, columns or other architectural features of the space. The layout as shown in the documents shall generally be adhered to but any discrepancies or clashes with structural or other features must be referred to the Engineer before commencing erection of the installation. Should the Contractor neglect to refer such discrepancies to the Engineer, costs incurred as a result of subsequent alterations to suit the architectural features shall be to the Contractor's account.

E09.8.2 Cover Plates

Cover plates shall be fitted over all draw boxes and outlets for luminaires that are not covered by the luminaire canopy, lamp-holder, ceiling rose or similar accessories.

E09.8.3 Hanger and Supports

Where provision has not been made for the fixing of luminaires, the Contractor shall supply the necessary supports, hangers, conduit extensions, angle brackets or any fixing method approved by the Engineer.

E09.8.4 Suspended Cable Channels

Luminaires (especially fluorescent luminaires) may also be suspended from ceilings by means of suspended metal channels. The channel may be supported by conduits or threaded rods.

Should metal rods be utilised, these shall be screwed to anchor bolts fixed in the roof slab.

Wiring shall either be installed in conduits fixed to the metal channel or in the metal channels. Purpose-made clamps shall be used to fix the fittings to the cable channel.

E09.8.5 False Ceilings

In all cases where luminaires are fixed to false ceilings, the Contractor shall ensure that the ceiling is capable of carrying the weight of the luminaires before commencing installation.

Should any doubt exist in this regard, the matter shall be referred to the Engineer.

In cases where the mass of the luminaire is not carried by the ceiling but by a support or other suspension method, provision shall be made to prevent relative movement between the ceiling and luminaire, ceiling rose or connection point.

E09.8.6 Fluorescent Luminaires Fixed to Concrete Slabs

Fluorescent luminaires to be installed directly against concrete slabs or walls shall be fixed to the outlet box and at two additional points. The additional fixing can be effected by:

(a) bolts built into the ceiling or wall,

(b) screws and approved plugs, or

(c) anchor bolts.

Shot-fired fixings are not acceptable. If specified or where approved by the Engineer, fluorescent fittings may be fixed to metal channels installed against concrete slabs or walls. The metal channel fixing may in this case be short-fired or fixed by any of the abovementioned methods. Purpose-made clamps shall be used to fix fittings to cable channels.

E09.8.7 Fluorescent Luminaires Fixed to False Ceilings

When fixing fluorescent luminaires to false ceilings, a gap shall not be visible, except where the ceiling tile is of non-fire resistant material, between the fitting and the ceiling. The luminaire shall be fixed directly to the ceiling beams by means of 40mm round-head wood screws and washer or alternatively be fixed to 50 x 76mm wooden supports that are fixed to the ceiling beams. In the case of tiled ceilings with exposed or concealed T-section supports, the luminaires shall be fixed to the metal supports by means of butterfly screws, pop-rivets or bolts with nuts and washers. Self-tapping screws may not be used.

E09.8.8 Continuous Rows of Luminaires

In cases where fluorescent luminaires are installed in tandem, only one connection outlet need be supplied per circuit. All luminaires shall be coupled to one another by means of nipples or brass bushes and lock nuts to ensure that wiring is not exposed and that earth continuity is maintained. Luminaires on the same circuit may be wired through the channel formed by the fitting canopies. In this case silicon-rubber insulated conductors shall be used and internal connections shall be made at terminal blocks.

Screw connectors are not acceptable. The wiring for any other circuits or outlets, even though these may be in the same row may not be installed through the fitting canopies. The Contractor shall ensure that continuous rows are straight and parallel to the relevant building lines.

E09.8.9 Recessed Luminaires

Where recessed luminaires are required, the Contractor shall maintain close liaison with the Ceiling Contractor. In the case of tiled ceilings, the luminaires shall be installed while the metal supports are being installed and before the tiles are placed in position. The Contractor shall be responsible for the co-ordination of the cutting of ceiling tiles with the Main Contractor and the Ceiling Contractor concerned. All mounting rings and other accessories shall fit closely into cut-outs to ensure a proper finish.

E09.8.10 Special Ceilings

In cases where special ceilings e.g. aluminium strips, decorative glass, metal leaves, etc., are to be installed, the Contractor and the manufacturer of the ceiling shall agree upon the method of fixing of luminaires to the ceiling.

E09.8.11 Waterproof Luminaires

Waterproof and flameproof luminaires shall be screwed directly to the conduit end. Draw boxes that may be required must be approved by the Engineer beforehand.

E09.8.12 Bulkhead Luminaires

Surface mounted bulkhead luminaires shall not be screwed directly to conduit ends. The conduit shall terminate in a round draw box at the top or back of the fitting. The PVC-insulated conductors shall terminate in a porcelain terminal strip in the draw box. Asbestos or silicon-rubber insulated conductors shall be used from the terminal strip to the luminaire lamp-holder. Porcelain-screw connectors will also be allowed.

E09.9 INSTALLATION OF LIGHT SWITCHES

E09.9.1 Mounting

All light switches shall be installed 1400mm above the finished floor level unless specified to the contrary. Mounting heights given shall be measured from the finished floor level to the centre of the switch.

E09.9.2 Doors

Unless specified to the contrary, switches adjacent to doors shall be installed on the side containing the lock. If the position of the lock is not shown on the drawings, the position shall

be verified before the switch box is installed. Switch boxes in brick or concrete walls, shall be installed 150mm from the door frame. Light switches installed in partitions or door frames shall be of the type designed for that purpose.

E09.9.3 Walls

Where the lower portion of a wall is face brick and the upper portion plastered, light switches shall be installed wholly in the plaster, provided that the lower edge of the plaster is not higher than 1600mm above the finished floor level. In general where different wall finishes are used in the same area, switches shall be installed within the same finish and not on the dividing lines between finishes.

E09.9.4 Switch Boxes

Switches shall be installed in standard rustproof (galvanised) pressed steel switch boxes with the necessary knock-outs for the proper termination of conduits. The installation of switch boxes shall comply with the requirements of paragraph E09.5 of this specification. Boxes shall be flush mounted or recessed as specified for the whole installation.

E09.9.5 Cover Plates

Cover plates which overlap the switchbox and which fit tightly against the wall finishes shall be installed in the case of flush mounted switch-boxes. All fixing screws in cover plates and switch grids shall be supplied and securely fitted.

E09.9.6 Escutcheon Plates

Where flush mounted switches are installed in special wall finishes, e.g. wood or board panels, acoustic tiles or other cladding, etc., and where the wall finishes have to be cut to accommodate the switch, it may be necessary to fix an escutcheon plate to the wall to cover the cut-outs. The escutcheon plate shall fit closely around the switch box and shall be fixed independently of the switch box and cover plate. Bevelled cover plates that overlap the switch boxes shall be used. Cover plates shall be fixed to the switch boxes and shall fit firmly against the escutcheon plate.

E09.9.7 Surface Mounted Switches

Surface mounted switches shall consist of a metal switch-box, cover plate and switch specially manufactured for the purpose. Switch boxes shall be fixed to the surface as described in paragraph E09.4 of this specification.

E09.9.8 Cutting of Cover Plates

Cover plates shall under no circumstances be cut unless specifically authorised in exceptional cases by the Engineer.

E09.9.9 Partitions

Light switches installed in partitions shall preferably be of the type designed for this purpose to be accommodated in the partition design. Switches installed in the metal support do not require switch boxes. Switches may not be flush mounted in partition walls without switch boxes.

E09.9.10 Waterproof Switches

Switches that are exposed to the atmosphere or are installed in damp areas, shall be of the waterproof type.

E09.9.11 Appearance

The sides of adjacent switches, plugs, push-buttons, etc., shall be parallel or perpendicular to each other and uniformly spaced. A common escutcheon plate shall be used for flush mounted outlets and accessories where the cover plates do not cover the cut-outs in the finishes.

E09.10 INSTALLATION OF SOCKET OUTLETS

E09.10.1 Mounting Heights

Unless otherwise specified socket outlets (flash or service mounted) shall be installed at the

following heights above finished floor level:

Socket outlets in general	300mm
Above working counter (kitchens, laboratories and prep areas)	1200mm
Shops	300mm
Offices	300mm

All mounting heights shall be measured from finished floor level to the centre of the outlet box Socket outlet boxes shall comply with paragraph E09.9.4.

E09.11 PROVISION FOR TELEPHONE INSTALLATION

E09.11.1 General

This specification covers only the supply and installation of outlet points and wiring channels and/or conduits for telephones in buildings. The telephone installation will be carried out by Telkom personnel or Specialist Contractor.

E09.11.2 Regulations

All provisions for telephones in buildings shall comply with the latest issue of "FACILITIES FOR TELECOMMUNICATION SERVICES IN BUILDINGS" as issued by Telkom. In cases where the provision of this publication and the requirements of the Detail Technical Specification are in conflict, the latter shall take precedence.

E09.11.3 Sleeves for Main Cables

One or more asbestos-cement or PVC sleeves as specified, shall be installed from a point at the boundary of the stand, (position indicated by the Engineer), to the main telephone distribution board or the main telephone building duct , 600mm below ground level.

A manhole with steel cover (as specified in Part 2, Detail specification) shall be installed at each bend in the underground route or at intervals not exceeding 50m in straight sections.

The inner radius of bends shall not be less than 12 times the outside diameter of the sleeves.

All sleeves, manhole covers and accessories shall be supplied by the Contractor including the building work of the manhole, unless specified to the contrary.

E09.11.4 Separation of Services

Cables or conductors for telephone services shall be separated from all other services by:

(a) Installation in separate metal channels or conduits, or

(b) Installing the cables at a minimum distance of 300mm from all power cables, conductors and accessories, or

(c) An earthed metal barrier installed to ensure that the minimum distance through free air space between the telephone cables and other services is at least 300mm.

Conduits or wiring channels installed for telephone services may not be used for any other purpose. Where non-metallic channels are used, the separation as stated in (b) above shall be maintained through the installation.

E09.11.5 Main Telephone Distribution Board

The size and position of the Main Telephone Distribution Board where required, shall be installed according to the requirements of the Detailed Technical Specification.

The board shall consist of a metal tray, architrave frame and hinged doors and shall be flush mounted in the position shown on the drawings.

A 20mm thick wooden panel shall be installed in the main telephone distribution board and shall cover the entire back of the board.

The finish of the board shall comply with the requirements of paragraph E09.16.9.

All conduits to telephone outlets or sub-distribution boards in the building as well as the main incoming sleeves, shall terminate at the main distribution board as indicated on the drawing.

Where 100 x 100 x 50mm draw boxes are specified, the boxes shall be provided with a cover plate. A wooden panel need not be provided in these cases.

E09.11.6 Telephone Outlets

The Contractor shall make provision for outlets with blank cover plates only.

Telephone outlets in walls shall consist of flush mounted 100 x 50 x 50mm draw boxes with blank cover plates.

Telephone outlets in floors shall be of the same type as floor outlets for power sockets which may be specified in the Detailed Technical Specification.

These provisions also apply to underfloor ducting. If no floor outlets are specified, 100 x 100 x 50mm flush mounted draw boxes with blank cover plates shall be provided in the floor at the positions indicated on the drawings.

Where twin underfloor ducts are provided and where the one duct is intended for telephone cables, the separation between the ducts shall be maintained throughout the underfloor ducting installation, including power outlets and telephone outlets.

Where power skirting is specified for telephone installations, the Contractor need only install the skirting with covers since the telephone socket outlet will be fixed directly to the cover.

Where multiple power skirting is provided containing other services, no other cables may be installed in the section intended for telephone cables and the separation between the sections shall be maintained throughout the installation.

E09.11.7 Connection of Telephone Outlets

Telephone outlets shall be inter-connected and connected to the telephone distribution boards as shown on the drawings.

If the inter-connecting conduits are not specified, conduit sizes shall be 25mm diameter for a maximum of 10 outlets and 32mm diameter for 11 to a maximum of 20 outlets.

Metal channels or power skirting installed on the same floor level on opposite walls of the same area as well as parallel runs of underfloor ducting intended for the installation of telephone cables, shall be inter-connected at intervals of 8 metres. Conduits may be used for these inter-connections.

All conduit and all ducts or channels which do not have removable covers, shall be provided with galvanised steel draw wires.

Conduit connections to power skirting or surface mounted metal channels, shall be made by means of a 100 x 100 x 50mm draw box which is flush mounted immediately behind the duct or channel in which the telephone cables are to be installed. A hole shall be cut in the back of the duct or channel, immediately opposite the draw box. The edges of the hole shall be grommetted. The draw box shall be accessible from the front when the cover is removed.

Purpose-made accessories for the connection of conduits to underfloor ducts shall be used. Where these are not available a 100 x 100 x 50mm draw box shall be installed below the underfloor duct opposite a floor telephone outlet. A hole shall be cut in the back of the duct opposite the draw box. The draw box shall be accessible from the top via the floor outlet.

E09.12 SWITCHBOARDS AND DISTRIBUTION BOARDS

Please see Specification E04: Electrical Low Voltage Distribution Boards and Motor Control Centres.

E09.13 NOISE AND VIBRATION

If in the opinion of the Engineer, any equipment operates with, or transmits from it, objectionable noise or vibration, it will be necessary to rectify or replace such plant in order

that the system operates at conditions acceptable to the Engineer. Remedial measures taken to achieve satisfactory noise and vibration levels shall be at no additional cost to the Employer.

The following measures shall be taken where necessary, whether specifically stipulated in these documents or not, all to ensure quiet, vibration-free operation of the installations:

(a) Equipment shall be mounted on vibration isolators of the correct type and selection, dependent upon deflection requirements versus vibrating frequency.

(b) Pipework and ductwork shall be suspended or mounted using suitable supports with vibration isolators to prevent transmission of vibration from them to the structure to which they are attached.

E09.14 COMMISSIONING AND TESTING

The Contractor shall commission and test the entire installation at his own expense, including provision of all test equipment, such testing to be done in the presence of the Engineer, who shall have been notified of the dates and approximate duration of the tests sufficiently early to allow him to witness tests if necessary.

The Contractor shall properly test and call for inspection by the Engineer any work which is to be covered, concealed, built-in, otherwise closed up or rendered inaccessible, before such closing up takes place. The Engineer may require any work of this nature which he has not been called on to inspect before closing up, to be uncovered or made accessible to him entirely at the Contractor's expense, making good included.

It is in the interest of the Contractor to notify the Engineer when the installation reaches various stages of completion (e.g. before plastering, final finishes, before casting concrete, etc) in order that the Engineer may inspect the installation and point out discrepancies. These inspections shall be considered informal and under no circumstances will they, in part or in whole, invalidate the requirements of the document. Any costs incurred in correcting discrepancies shall be to the Contractor's account.

The Contractor shall keep full and proper written records of all tests conducted and commissioning information, such data to be properly indexed and submitted to the Engineer for his records.

The Contractor shall test electrical wiring for compliance with regulations and have the complete installation tested by the relevant authorities.

The Engineer reserves the right to inspect any item of equipment during manufacture or before delivery to site. The Contractor shall make available any item for such inspection. The Engineer shall also be furnished with manufacturer's test certificates whenever these are required by law or called for by the Engineer.

The Contractor shall commission the complete installation prior to inviting the Engineer to accept it, commissioning including inter alia the following services, as relevant:

(a) The Contractor shall record all motor running currents and set overload protection devices to correct values.

(b) The Contractor shall adjust and set all time clocks, time delay relays, automatic control devices and check their function for correctness and response.

(c) The Contractor shall remedy any defects apparent on the installation prior to calling upon the Engineer to accept the plants.

Thermal images of the panels and distribution board must be taken once the units are more than one week in operation. The images must be taken while in normal operating condition. The images should be reviewed and then presented as part of the Operations and maintenance manuals.

E09.15 LABELLING AND IDENTIFICATION

All equipment shall be labelled and identified using white trifoliate labels having black lettering engraved on them; where two similar items exist, they shall additionally be numbered for clarity in identification.

Labels shall be secured by means of white rivets, slotted label holders or screwed on. Self-tapping screws will not be allowed.

All other equipment including metres, instruments, indicator lights, switches, push-buttons, circuit breakers, fuses, etc., shall be identified. The function of the equipment and circuits shall be clearly identified. Flush mounted equipment within doors or front panels shall be identified with labels fixed to the doors or front panels respectively.

E09.16 OPERATING AND MAINTENANCE MANUALS; "AS BUILT" OR "AS INSTALLED" RECORD DRAWINGS

Provide three hard copies and one disk of all operating and maintenance manuals and record drawings.

Provide a MSWORD for WINDOWS disk copy for any word processed elements of the operating and maintenance manuals. Employ a specialist to prepare manuals for the form and content of the operating and maintenance manuals.

Agree format and contents with the Employer Operating and maintenance manuals must include, but are not limited to the following:

- Index of Contents
- A full description of each of the systems installed, written to ensure that the Employer's staff fully understand the scope and facilities provided. Description to include data on general design parameters, normal associated operating conditions and manufacturer's information concerning correct operation, etc., based on commissioning results.
- A description of the mode of operation of all systems.
- **Diagrammatic** drawings to each system (including distribution boards) indicating principal items of plant, equipment, valves, etc.
- A photo-reduction of all record drawings, together with an index.
  Size A4
  Size A3
- Legend for all colour-coded services.
- Schedules (system by system) of plant, equipment, valves, etc., stating their locations within the building, duties and performance figures. Ensure each item has a unique code number cross-referenced to the record and diagrammatic drawings and schedules.
- The name, address and telephone number of the manufacturer of every item of plant and equipment together with catalogue list and order acknowledgement numbers.
- Manufacturer's technical literature for all items of plant and equipment, assembled specifically for the project, excluding irrelevant matter and including detailed drawings, electrical circuit details and operating and maintenance instructions.
- A copy for all Test Certificates, Certificates of Compliance, Inspection and Test Records, Commissioning and Performance Test Records (including, but not limited to, electrical circuit tests, corrosion tests, type tests, start and commissioning tests) for the installations and plant, equipment, valves, etc., used in the installations.
- A copy of all manufacturers' guarantees or warranties.
- Copies of Insurance and Inspecting Authority Certificates and Reports.
- Starting up, operating and shutting down instructions for all equipment and systems installed.
- Details of procedures to maintain plant in safe working conditions.
- Control sequences for all systems installed.
- Schedule of all fixed and variable equipment settings established during commissioning.
- Back-up copies of any system software.
- Documentation of the procedures for updating and/or modifying software operating systems and control programs.

- Instructions for the creation of Control procedure routines and Graphic diagrams
- Details of the software revision for all programs provided.
- Two back-up copies of all software items, as commissioned.
- Details of lubrication systems and lubrication schedules for all lubricated items.
- A list of normal consumable items.
- A list of recommended maintenance spares to be kept in stock by the Employer, being those items subject to wear or deterioration and which may involve the Employer in extended deliveries when replacements are required at some future date.
- A list of any special tools needed for maintenance cross referenced to the particular item for which required.
- Procedures for fault finding.
- Emergency procedures, including telephone numbers for emergency services.
- Copies of all items incorporated in the plant room and switch room schedules and schematics.
- Encase the Manuals in A4 size, plastic-covered, loose leaf, four ring binders with hard covers, each indexed, divided and appropriately cover-titled. Fold drawings larger than A4 and include in the binder so that they may be unfolded without being detached from the rings.
- Provide record drawings. Include the provision of relevant framed plasticised drawings in all electrical rooms.
- Three copies of all “AS BUILT” or “AS INSTALLED” record drawings, in print form, are required to be handed to the Engineer before completion of the project. There shall have been previously submitted to the Electrical Engineer for comment and approval. The Electrical Engineer also requires 2 copies of all record drawings to be made available on disk on CAD format. All “AS BUILT” or “AS INSTALLED” record drawings are to be prepared by the Electrical contractor in CAD format.

E09.17 TESTING AND COMMISSIONING

The contractor shall supply factory test certificates for each drum of cable supplied under the Contract.

After the installation is complete, the contractor and the Engineer shall inspect the installation. The Engineer must be notified in advance of the inspection dates. The contractor will keep a snag list, reflecting all items not acceptable to the Engineer. The contractor will correct the snag items as required to the Engineers approval, updating the snag list as the items are completed and signed off by the Engineer.

The contractor shall carry out all the tests for the Main distribution board and will also conduct all tests and complete copies of the tests for each distribution board and for each supply (normal and alternative supplies), and attach as annexes to the completion report. The tests required will be the following as a minimum:

(a) Continuity of bonding
(b) Resistance of earth continuity conductor
(c) Continuity of ring circuits (if applicable)
(d) Earth loop impedance test
(e) Elevated voltage between incoming neutral and external earth (ground)
(f) Earth resistance at electrode (if required)
(g) Insulation resistance MΩ
(h) Voltage at main distribution board with no load for each phase to neutral
(i) Voltage at main distribution board with load (as calculated for full load) for each phase to neutral V
(j) Voltage at available load (worst condition as calculated for full load) for each phase to neutral
(k) Operation of all earth leakage units
(l) Operation of all earth leakage test buttons

(m) Polarity of points of consumption
(n) Phase rotation at points of consumption for three-phase systems
(o) All switching devices, make-and-break circuits

On completion of his work, the Contractor will issue an Electrical Certificate of Compliance (CoC). All tests deemed necessary to issue the CoC should be included. The Contractor shall make all arrangements, pay all fees and provide all equipment for these tests. The Contractor shall notify the Engineer timeously so that he may witness the tests.

Each installed cable shall be tested in accordance with:

(a) The Occupational Health and Safety Act (OHSA) 1994;

(b) The requirements of the Local and Supply Authorities.

E09.18 MAINTENANCE INSTRUCTIONS AND GUARANTEES

Retain copies of all maintenance instructions and guarantees delivered with components and equipment (failing which, obtain), register with manufacturer as necessary and handover to the Employer on or before Practical Completion. Notify the Employer of telephone numbers for emergency services by Specialist Contractors and Suppliers after Practical Completion.

E09.19 MEASUREMENT AND PAYMENT

Item ..... **Unit**

Supply and deliver distribution boards ..... No

The unit of measurement shall be the number of distribution boards supplied and installed. The tendered rate shall include full compensation for the supply and delivery of the distribution board as specified in the detail specification complete with all the electrical equipment specified.

Item ..... **Unit**

Install, test and commission the distribution boards..... No

The unit of measurement shall be the number of distribution boards installed, tested and commissioned. The tendered rate shall include full compensation for the installing, testing and commissioning of the distribution boards complete with all the specified electrical equipment in the distribution board. The tendered rate shall furthermore include for the wiring of the distribution board.

Item ..... **Unit**

Supply and deliver isolators..... No

The unit of measurement shall be the number of isolators supplied and delivered.

The tendered rate shall include full compensation for the supply and delivery of the isolators where the isolators are specified separately.

Item ..... **Unit**

Install isolators ..... No

The unit of measurement shall be the number of isolators installed.

The tendered rate shall include full compensation for the installing of the isolators where the isolators are specified separately.

Item ..... **Unit**

Supply and deliver circuit breakers ..... No

The unit of measurement shall be the number of circuit breakers supplied and delivered.

The tendered rate shall include full compensation for the supply and delivery of the circuit breakers where the circuit breakers are specified separately.

Item ..... **Unit**

Install circuit breakers ..... No

The unit of measurement shall be the number of circuit breakers installed.

The tendered rate shall include full compensation for the installing of the circuit breakers where the circuit breakers are specified separately.

Item ..... **Unit**

Supply and deliver fuse switches ..... No

The unit of measurement shall be the number of fuse switches supplied and delivered.

The tendered rate shall include full compensation for the supply and delivery of the fuse switches where the fuse switches are specified separately.

Item ..... **Unit**

Install fuse switches ..... No

The unit of measurement shall be the number of fuse switches installed.

The tendered rate shall include full compensation for the installing of the fuse switches where the fuse switches are specified separately.

Item ..... **Unit**

Supply and deliver earth leakage units ..... No

The unit of measurement shall be the number of earth leakage units supplied and delivered.

The tendered rate shall include full compensation for the supply and delivery of the circuit breaker earth leakage units where the earth leakage units are specified separately, e.g. (30 mA)

Item ..... **Unit**

Install earth leakage units ..... No

The unit of measurement shall be the number of earth leakage units installed.

The tendered rate shall include full compensation for the installing of the circuit breaker earth leakage units where the earth leakage units are specified separately, e.g. (30 mA)

Item ..... **Unit**

Supply and deliver contactors ..... No

The unit of measurement shall be the number of contactors supplied and delivered.

The tendered rate shall include full compensation for the supply and delivery of the contactors where the contactors are specified separately.

Item ..... **Unit**

Install contactors ..... No

The unit of measurement shall be the number of contactors installed.

The tendered rate shall include full compensation for the installing of the contactors where the contactors are specified separately.

Item ..... **Unit**

Supply and deliver light fittings ..... No

The tendered rate shall include full compensation for the supply and delivery to site of the specified light fitting, complete with lamp/s, wiring, control gear where applicable, diffusers, etc.

Separate items shall be scheduled for each type of light fitting required.

Item ..... **Unit**

Install light fittings ..... No

The tendered rate shall include full compensation for the handling, inspection, fastening, connecting and testing of the light fitting.

Separate items shall be scheduled for each type of light fitting. This rate shall furthermore include full compensation for the cost of providing and installing all hardware, timber backing, plugs, screws connector terminals and other materials required to install the light fitting in accordance with the specification.

Item ..... **Unit**

Supply and deliver switches ..... No

The tendered rate shall include full compensation for the supply and delivery to site of the specified switch complete with cover plate and fastening screws.

Separate items shall be scheduled for each type of switch.

Item ..... **Unit**

Install switches ..... No

The tendered rate shall include full compensation for the handling, inspection, fastening, connecting, fitting of cover plate and testing of the switch.

Separate items shall be scheduled for each type of switch.

This rate shall furthermore include full compensation for the cost of providing and installing all hardware screws and wall plugs in the case of surface mounted switches, required to install the switch in accordance with the specification.

Item ..... **Unit**

Supply and deliver photo-electric switch ..... No

The tendered rate shall include full compensation for the supply and delivery to site of the specified photo-electric daylight switch complete with mounting bracket and around bulkhead light enclosure.

Item ..... **Unit**

Install photo-electric switch ..... No

The tendered rate shall include full compensation for the handling, inspection, fastening of the bulkhead enclosure and photo electric switch, connecting and testing of the switch.

This rate shall furthermore include full compensation for the cost of providing and installing all hardware, screws, wall plugs and other material required to install the photo electric light switch in accordance with the specification.

Item ..... **Unit**

Supply lighting track ..... m

The unit of measurement shall be the linear metre of track supplied.

The tendered rate shall include the supply and delivery to site of the track as specified in the detail specification.

Item ..... **Unit**

Install lighting track ..... m

The unit of measurement shall be the linear metre of lighting track installed.

The tendered rate shall include full compensation for cutting to size and fixing to the ceiling or wall with appropriate fasteners of the lighting track and shall include the wiring connections of the supply circuit.

Item ..... **Unit**

Supply and install lighting track accessories ..... No

The unit of measurement shall be the number of splices, bends, elbows, connector units and end caps.

The tendered rate shall include full compensation for the supply, connecting, installation and fixing of accessories as detailed in the schedule of quantities.

Item ..... **Unit**

Supply consumer distribution kiosks ..... No

The unit of measurement shall be the number of distribution kiosk supplied.

The rate shall include full compensation for the supply of the distribution kiosks complete as specified.

Item ..... **Unit**

Install consumer distribution kiosks ..... No

The unit of measurement shall be the number of distribution kiosks installed.

The rate shall cover the cost of the sitting, handling, transporting, installing, painting, testing and commissioning of each kiosk.

Item ..... **Unit**

Supply and erect concrete plinths for consumer distribution kiosks ..... No

The unit of measurement shall be the number of plinths supplied and erected.

The rate shall include full compensation for the supply of precast plinths and bases and the erection thereof as specified.

Item ..... **Unit**

Supply consumer distribution pillars ..... No

The unit of measurement shall be the number of distribution pillars supplied.

The rate shall include full compensation for the supply of the distribution pillars fully equipped as specified.

Item ..... **Unit**

Install consumer distribution pillars ..... No

The unit of measurement shall be the number of distribution pillars installed.

The rate shall include full compensation for the installing of the distribution pillars and shall include for the excavation for the installing of the pillar and the backfilling, compacting and disposal of the surplus material once the pillar has been installed.

Item ..... **Unit**

Supply service connection cable ..... m

The unit of measurement shall be the length in metres of service connection cables supplied.

The tendered rate shall include full compensation for the supply and delivery of the cable to site.

Item ..... **Unit**

Lay service connection cable ..... m

The unit of measurement shall be the length in metres of service connection cable laid.

The tendered rate shall include full compensation for the handling, inspection, laying, cutting and testing the cable. Cables will be measured linearly over all lengths laid.

Item ..... **Unit**

Terminate service connection cable ..... No

The unit of measurement shall be the number of service connection cable terminated.

The tendered rate shall include full compensation for the termination cable including all material and labour to render complete terminations of the cables.

Item ..... **Unit**

Supply socket outlets..... No

The unit of measurement shall be the number of socket outlets supplied.

The tendered rate shall include full compensation for the supply and delivery of single or double single phase, three pin socket outlets.

Separate items shall be scheduled for the following:

(a) socket outlets flush mounted

(b) socket outlets surface mounted

(c) socket outlets to be installed in power skirting

(d) socket outlets to be installed in pedestals for floor ducting

(e) socket outlets to be installed in recessed service outlets for floor ducting.

Separate items shall be scheduled for standard and dedicated switched socket outlets. All socket outlets shall be supplied complete with cover plates and boxes where required. The tendered rate shall therefore include for the supply of the cover plates and fixing screws where applicable.

Item ..... **Unit**

Install socket outlets ..... No

The unit of measurement shall be the number of socket outlets installed.

The tendered rate shall include full compensation for the installing of the socket outlets. Separate items will be scheduled for the various type of socket outlets specified in item 6.6.8. The tendered rate shall furthermore include for the installing of the cover plates where applicable.

Item ..... **Unit**

Supply plug tops for dedicated socket outlets ..... No

The unit of measurement shall be the number of plug tops supplied.

The tendered rate shall include full compensation for the supply of plug tops for each of the dedicated socket outlets supplied and installed under this contract.

Item ..... **Unit**

Supply and deliver double pole isolator for geyser supply ..... No

The unit of measurement shall be the number of double pole isolators supplied.

The tendered rate shall include full compensation for the supply and delivery of double pole isolators for the geyser supplies.

Item ..... **Unit**

Install double pole isolator for geyser supply..... No

The unit of measurement shall be the number of double pole isolators installed.

The tendered rate shall include full compensation for the installing of double pole isolators for the geyser supplies.

Item ..... **Unit**

Supply and install connections to heaters, stoves, fans and air conditioners units ..... No

The unit of measurement shall be the number of connections made.

The tendered rate shall include full compensation for the installing of the connections to the heaters, stoves, fans and air conditioners and shall include for the supply and installing of the

double pole isolator or control unit which ever is applicable.

Separate items shall be scheduled for each type of connections.

Item ..... **Unit**

Supply double pole isolators for power skirting..... No

The unit of measurement shall be the number of double pole isolators supplied for the power skirting.

The tendered rate shall include full compensation for the supply and delivery to site of the double pole isolators.

Item ..... **Unit**

Install double pole isolators for power skirting ..... No

The unit of measurement shall be the number of double pole isolators installed.

The tendered rate shall include full compensation for the installation of the double pole isolators in the power skirting and shall include the connections of the conductors to the isolators.

Item ..... **Unit**

Supply junction boxes..... No

The unit of measurement shall be the number of junction boxes supplied.

The tendered rate shall include full compensation for the supply and delivery to site of the junction boxes.

Separate items shall be scheduled for each type of junction box.

Item ..... **Unit**

Install junction boxes ..... No

The unit of measurement shall be the number of junction boxes installed.

The tendered rate shall include full compensation for the installation of the junction boxes as specified.

Separate items shall be scheduled for each type of junction box.

Item ..... **Unit**

Supply and delivery of conduit .....m

The unit of measurement shall be the linear metre of conduit supplied and delivered.

The tendered rate shall include for full compensation for the supply and delivery of the specified conduit and shall include full compensation for the supply of the couplings to join the conducts. Separate items shall be scheduled for the different types of conduit specified.

Item ..... **Unit**

Installing of conduit.....m

The unit of measurement shall be the linear metre of conduit installed.

The tendered rate shall include for full compensation for the installing of the conduit including jointing and bending the conduit and fixing the conduit using saddles as specified. Separate items shall be scheduled for the different types of conduit and for installing the conduit in concrete, fixing the conduit in brick work, including the chasing thereof, fixing the conduit on the surface of structures or installing the conduit in ceiling voids.

Item ..... **Unit**

Terminate conduit..... No

The unit of measurement shall be the number of terminations made.

The tendered rate shall include full compensation for terminating the conduit in draw boxes and outlet boxes and shall include for all locknuts and bushes.

Item ..... **Unit**

Supply and install draw boxes ..... No

The unit of measurement shall be the number of draw boxes supplied and installed.

The tendered rate shall include full compensation for supplying and installing the draw boxes including the cover plates. Separate items shall be scheduled for installing the boxes in concrete, in brickwork including chasing, and on the surface of structures.

Item ..... **Unit**

Supply and install conduit outlet boxes ..... No

The unit of measurement shall be the number of conduit outlet boxes supplied and installed.

The tendered rate shall include full compensation for supplying and installing conduit outlet boxes and shall include blank cover plates where no equipment is installed in the boxes. Separate items shall be scheduled for 1, 2, 3 and 4 way outlet boxes and for installing the boxes in concrete, in brick walls, including the chasing thereof, and surface on structures.

Item ..... **Unit**

Supply power skirting .....m

The unit of measurement shall be the linear metre of power skirting supplied.

The tendered rate shall include full compensation for the specified power skirting including cover plates. Separate items shall be scheduled for one, two and three compartment power skirting.

Item ..... **Unit**

Install power skirting.....m

The unit of measurement shall be the linear metre of power skirting installed.

The tendered rate shall include full compensation for installing the power skirting including all material required to install the power skirting.

Item ..... **Unit**

Supply and install power skirting end caps, bends, conduit outlets & accessories ..... No

The unit of measurement shall be the number of power skirting end caps, bends and conduit outlets supplied and installed.

The tendered rate shall include full compensation for the supply and installing of the power skirting end caps, internal and external bends and outlets and shall include for the supply of all material required to complete the installing thereof.

Item ..... **Unit**

Supply under floor ducting.....m

The unit of measurement shall be the linear metre of under floor ducting supplied.

The tendered rate shall include full compensation for the supply of under floor ducting. Separate items shall be scheduled for the two and three compartment ducting.

Item ..... **Unit**

Supply under floor ducting accessories..... No

The unit of measurement shall be the number of accessories supplied.

The tendered rate shall include full compensation for the supply of the required accessories for the completion of the under floor installation. Separate rates shall be scheduled for cross-over, T-junction and right angle bend draw boxes and up-bends.

Item ..... **Unit**

Supply pedestal units ..... No

The unit of measurement shall be the number of pedestals supplied.

The tendered rate shall include full compensation for the supply of the specified pedestal units.

Item ..... **Unit**

Install under floor ducting..... m

The unit of measurement shall be the linear metre of ducting installed.

The tendered rate shall include full compensation for the installation of the under floor ducting.

Item ..... **Unit**

Install under floor ducting accessories ..... No

The unit of measurement shall be the number of accessories installed.

The tendered rate shall include full compensation for the installation of the accessories. Separate items shall be scheduled for the cross-over, T-junction and right angle bend draw boxes and up-bends.

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

E11 : ELECTRICAL EARTHING AND LIGHTING PROTECTION

Johannesburg Water

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City of Johannesburg
Johannesburg Water (SOC) Ltd

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Prepared	Senior Electrical Engineer	B Pieterse	August 2019	
Reviewed	Director	R Baard	August 2019	
Approved	Regional Maintenance Manager	T Thabeng	August 2019	

RECORD OF REVISIONS

Date	Revision	Author	Comments
5	2019-08-20	B Pieterse	Review of Electrical Standards, plus New Design Guidance
4	2014-06-03		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance
3	2012-05-30		Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance
2	2010-05-03		Review Electrical Standards
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PARTICULAR SPECIFICATION: VOLUME E11: GENERAL ELECTRICAL GENERAL EARTHING AND LIGHTNING PROTECTION

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E11.1 SCOPE

This specification covers the detail requirements of the general protection against lightning to be installed under the contract, including:

a) General notes on the lightning protection measures;

b) The risk management and definition of the risk to a structure due to lightning strikes;

c) A Lightning Protection System (LPS) describing principles to be followed for the protection against physical damage to a structure including the installations within the structure as well as injury to living beings due to touch and step voltages;

d) Surge Protection Measures (SPM) to reduce the risk of permanent failures of electrical and electronic installations within a structure due to a Lightning Electromagnetic Pulse (LEMP).

e) Information for the design, installation, inspection, maintenance and testing of the above.

E11.2 STATUATORY DOCUMENTS AND STANDARDS

E11.2.1 Standards

The latest edition, including all amendments up to date of tender of the following particular national and international specifications, publications and codes of practice which shall be read in conjunction with this specification and shall be deemed to form part thereof:

a)	SANS 10142-1	The wiring of premises Part 1: Low-voltage installations.
b)	SANS 10142-2	The wiring of premises Part 2: Medium-voltage installations above 1 kV ac not exceeding 22 kV ac. and up to and including 3 MVA installed capacity.
c)	SANS 62305-1	Protection against lightning Part 1: General principles
d)	SANS 62305-2	Protection against lightning Part 2: Risk management
e)	SANS 62305-3	Protection against lightning Part 3: Physical damage to structures and life hazard
f)	SANS 62305-4	Protection against lightning Part 4: Electrical and electronic systems within structures.
g)	SANS 62561	Lightning protection system components (LPSC).
h)	SANS 1063	Earth rods, couplers and connections.
i)	SANS 10199	The design and installation of earth electrodes.
j)	SANS 10313	Protection against lightning — Physical damage to structures and life hazard.
k)	SANS 10292	Earthing of low-voltage (LV) distribution systems.

E11.2.2 Particular Specifications to be read in conjunction with this Specification

The following particular specifications shall be read in conjunction with the Project Specification:

a) Automation and Control Design Standards, Volume 5: Clean Power and Surge Protection.

E11.3 CERTIFICATE OF COMPLIANCE

E11.3.1 New or modified installations

The Contractor shall appoint a competent and experienced lightning protection design engineer for the design, supply, installation, inspection and testing of the Lightning Protection System (LPS) as well as the Surge Protection Measures (SPM).

After installation and testing of the LPS and SPM, the lightning protection design engineer will issue a Lightning Protection System Installation Safety Report as prescribed in SANS 10313: Annex A as well as SANS10142-1, for each area of protection. The Engineer will witness the installation as well as all tests conducted.

Two copies of this report shall be submitted to the Engineer before handing over of any repair, modification or new installation involving LPS or SPM systems.

E11.3.2 Maintenance of installations

The Client shall appoint a competent and experienced lightning protection engineer to maintain and inspect the Lightning Protection System (LPS) as well as the Surge Protection Measures (SPM) on an annual basis. Tests and inspections should be done prior to the start of the lighting season.

The lightning protection engineer will issue a Lightning Protection System Maintenance Certificate as prescribed in SANS 10313: Annex B, for each area of protection.

E11.4 PROTECTION MEASURES

The following protective measures should be installed as far as possible. The most suitable protective measure shall be selected during the design phase, considering technical and economic aspects based on a risk assessment.

E11.4.1 Protection measures to reduce injury of living beings by electric shock

a) Adequate insulation of exposed lightning conductive parts;

b) Equipotential bonding of equipment and conductive parts and connection to a meshed earthing system;

c) Physical restrictions and warning notices where the above is not achievable.

E11.4.2 Lightning Protection System (LPS) to reduce physical damage

a) Air-termination system on high points;

b) Down-conductor system;

c) Earth-termination system;

d) Equipotential bonding;

E11.4.3 Surge Protection Measures (SPM) to reduce failure of electrical and electronic systems

a) Earthing and bonding measures;

b) Magnetic shielding;

c) Line routing;

d) Isolating interfaces;

e) Coordinated Surge Protection Device (SPD) system.

E11.5 RISK MANAGEMENT

Risk to a structure exposed to lightning flashes is managed by a process based on risk evaluation or assessment. Appropriate protection measures are selected to reduce the risk to or below the tolerable limit.

The following basic procedure must be followed during the risk assessment:

a) Identification of the structure to be protected;

b) Partitioning of the structure into zones;

c) Identification of all the types of loss in the structure;

d) The identification and calculation of the corresponding risk components for each type of loss;

e) Evaluation of need of protection;

f) Selection of protective measures (LPS, SPM or other protection measure);

g) Evaluate the cost-effectiveness of the protection measures;

h) Re-evaluation of the corresponding risk components and the need for further protection.

The risk assessment and the evaluation of loss and risks as well as protection selection must be done by a competent and experienced lightning protection design engineer. It is the responsibility of the contractor to appoint a lightning protection design engineer for this purpose.

E11.6 EXTERNAL LIGHTNING PROTECTION SYSTEM (LPS)

An external LPS is installed on a structure to intercept a direct lightning flash to the structure, conduct the lightning current safely towards earth and to disperse the lightning current into the earth. It consist out of an air-termination system, a down-conductor system and an earth-termination system.

E11.6.1 Design of the LPS

The design of the LPS must be done in accordance with SANS 62305-3 with specific reference to Annex E.

The LPS should be designed and installed by competent and experienced LPS design engineer and LPS installer (person who is competent to install, construct and test an LPS for compliance with this SANS 10313). It is the responsibility of the contractor to appoint a competent and experienced LPS design engineer and installer. The Contractor is responsible to manage consultation between the various parties involved in the project (client, local authorities, LPS design engineer, LPS installer, architect, civil contractor/builder and electrical engineer). In new structures, the LPS should be installed during the construction phase; proper timing for soil resistivity test and the design of the LPS is of utmost importance.

The LPS design engineer and installer will be responsible for the quality assurance on the project.

E11.6.2 Isolated LPS

On structures at risk of explosion and fire an isolated external LPS must be installed.

E11.6.3 Air-termination systems

Air-termination systems can be composed of any combination of the following elements:

a) Rods (including free-standing masts);

b) Catenary wires;

c) Meshed conductors.

Air terminals installed shall be located at corners, exposed points and edges on a structure. To determine the exact location one or more of the following methods should be followed:

a) Protection angle method;

b) Rolling sphere method;

c) Mesh method.

All types of air terminals shall comply in full with SANS 62305-3. The positioning of air termination system shall comply with SANS 62305-3 (Annexure A).

All air-termination components must be fixed and secured in such a way to withstand accidental external mechanical forces as well as electromechanical forces during a lightning strike.

E11.6.4 Down-conductor systems

If the air-termination system is supported by one or more non-conductive columns, at least one down-conductor is required for each column. Steel columns do not require additional down-conductors.

All down-conductor components must be fixed and secured in such a way to withstand accidental external mechanical forces as well as electromechanical forces during a lightning strike.

Down conductors may be placed on the surface of non-combustible walls. On structures at risk of explosion and fire, all down conductors must be isolated from the structure walls.

E11.6.5 Earth-termination system

For lightning protection, a single integrated structure earth-termination system is preferable and is suitable for all purposes (i.e. lightning protection, power systems and telecommunication systems).

An earthing resistance not exceeding 3Ω (measured at low frequency) is required for earth termination systems. Should it be impossible to achieve this earthing resistance value, the Engineer must approve the value obtained and deemed reasonable.

Type A earthing arrangement

Each down connector is connected to a horizontal or vertical earth electrode installed outside the protected structure. A minimum of two earth electrodes will be installed, buried at an upper end depth of minimum 0.5 m with a separation distance to minimize electrical coupling effects in the earth. The minimum length of the earth electrodes will be calculated during the design phase, based on the soil resistivity.

Type B earthing arrangement

A ring conductor is installed external to the protected structure, buried at an upper end depth of at least 0.5 m and at a distance of about 1 m away from the external walls. The radius of protection will be calculated during the design phase, based on the soil resistivity. Additional electrodes should be added to obtain the desirable protection radius. The number of electrodes shall not be less than the number of down conductors (with a minimum of two electrodes).

Test points

A test point must be installed at the connection between each down-conductor and earth termination electrodes. The joint will only be opened for testing and will remain closed at all times.

Conductor connections

Conductor connections shall be made secure by exothermic welding. Clamping or bolting of conductor connection points shall only be accepted with permission from the Engineer. All points of connection must be covered with a cold applied anti-corrosion and sealing tape based on a synthetic fabric, impregnated and coated with a neutral petrolatum compound.

E11.6.6 LPS Installation

Type B earthing will be installed as the preferred arrangement. Type A earthing will only be accepted with prior approval from the Engineer (in writing). The installation of the earth electrodes will be inspected and approved by the Engineer during the construction phase.

The LPS shall be bonded to the fixed electrical installation protective earthing in accordance with the requirements of SANS 10142-1. Where an installation may typically consist of a main building or plant and one or more satellite subsystems, the various earth networks shall be interconnected to form one earth system. Only in the rare instance of a subsystem being totally isolated, with no cables, pipes, fences or other conductive structures connecting it to the rest of the installation, may a system be provided with a separate earth network.

E11.6.7 Components

All material and components used in a LPS must conform to the requirements specified in SANS 62561.

Minimum cross-sectional area of conductors

a) Air-termination conductors, air-termination rods and down-conductors:

Configurations and minimum cross-sectional areas of air-termination conductors, air-termination rods and down-conductors are given in SANS 62305-3: Table 6 “Material, configuration and minimum cross-sectional area of air-termination conductors, air-termination rods, earth lead-in rods and down-conductors”.

The following material and dimensions will be specifically applicable. No copper conductors will be accepted.

Material	**Configuration**	**Cross-sectional area (sq. mm)**
Aluminium	Solid tape	70
	Solid round	50
Stainless steel	Solid tape	50
	Solid round	50

Table 1: *Specific configurations and minimum cross-sectional areas of air-termination conductors, air-termination rods and down-conductors.*

b) Earth conductors and electrodes:

Configurations and minimum dimensions of earth electrodes are given in SANS 62305-3: Table 7 “Material, configuration and minimum dimensions of earth electrodes”.

The following material and dimensions will be specifically applicable. No copper conductors will be accepted.

Material	**Configuration**	**Dimensions**	
		Earth rod diameter (mm)	**Earth conductor (sq. mm)**
Copper coated steel	Solid round	14	
Stainless steel	Solid round	15	78
	Solid tape		100

Table 2: *Specific configurations and minimum dimensions of earth conductors and electrodes*

E11.7 LPS FOR STRUCTURES WITH A RISK OF EXPLOSION

The design, construction, extension and modification of lightning protection systems for structures with a risk of explosion must comply with SANS 62305-3: Annex 3.

a) The LPS must be isolated from the structure. This includes the air termination conductors as well as all down conductors. Under no circumstances may any parts of the structure be used as part of the LPS

b) The distance between down conductors will not exceed 5m. The down conductor count and spacing will be determined during the design phase with a minimum of two down conductors installed.

c) The earth-termination system will be a type B arrangement

d) All installations/structures/equipment will be equipotential bonded to the lightning protection system. Junctions shall be provided for the joining of connection and earthing leads to containers, metal construction parts, drums and tanks

e) Aboveground metal piping shall be earthed at least every 30 m. Bonding conductors will

be connected to the piping at tap holes in the flanges for taking up screws. Where this is not possible, welded-on lugs or bolts will be used

f) Such devices shall be suitable for the environment in which they are installed.

The above will be applicable to aeration basins, bioreactors, HOW, digester (high risk areas)

E11.8 INTERNAL LIGHTNING PROTECTION SYSTEM (LPS)

An internal LPS is intended to prevent flashover between electrically conducting elements within the structure and the external LPS components using either equipotential bonding or an adequate separation distance.

E11.8.1 Equipotential bonding

All equipment likely to be subjected to surge currents shall be securely bonded together and to the earth network.

Bonding bar

A single bonding bar shall be installed for equipotential bonding. The bar shall be manufactured from electrical grade hard drawn aluminium 80sq mm complete with mounting insulators. The bar will be pre-drilled with ten M8 holes, fitted with stainless steel high tensile hex bolts with nuts and washers. The bar will be fitted with two removable test links, one on each end of the bar.

The bonding bar shall be connected to the earth-termination system at two connection points with two separate cables.

A ring bonding bar where more than one interconnected bonding bars are installed can be used for larger installations.

External conductive parts

External conductive parts shall be bonded to the bonding bar from a point as near as possible to the point of entry into the structure. This will include all electrical conductive pipes, cable ladder, fences and gates.

External electrical lines

Live conductors shall be bonded to the bonding bar via SPD's. (See Paragraph E11.1 Surge Protection Measures). All gland plates in electrical panels will be bonded to the earth network. Power cable armouring shall be bonded to the earth network at both ends of the cable via the cable glands on the gland plates.

Telecommunication and Instrumentation lines

Please refer to Automation and Control Design Standards, Volume 5: Clean Power and Surge Protection.

Internal systems

Screened cables installed in the internal system must be bonded to the bonding bar via the screen. Cables in metal conduits installed in the internal system must be bonded to the bonding bar via the conduits. Unscreened cables must be connected to the bonding bar via SPD's (See Paragraph E11.1 Surge Protection Measures).

Bonding conductors

Bonding conductors shall be short and shall run in straight or smoothly contoured routes. Material, dimensions and conditions of use shall comply with SANS 62305-3. The minimum cross-section for bonding components shall comply with SANS 62305-4 Table 1 "Minimum cross-sections for bonding components".

The following material and dimensions will be specifically applicable.

Bonding component	Material	Cross-section (sq. mm)
Bonding bars	Aluminium	80
Bonding to LPS	Aluminium	70
Connecting conductors from internal metal installations to bonding bars (carrying a partial lightning current)	Aluminium	70

Table 3: *Specific material and cross-section area for bonding components*

E11.9 INSPECTION AND MAINTENANCE OF LPS

E11.9.1 Inspection

Inspections should be conducted during the construction period as well as after completion of the installation. A Lightning Protection System Installation Safety Report as described in SANS 10313 Annex A (or similar) must be issued by the LPS installer after completion of the installation. All tests conducted during the commissioning of the LPS must be witness by the Engineer. Inspections must be conducted after any alteration or repair of the LPS.

Regular periodic inspections must be conducted on the LPS system of explosives facilities. A maintenance and inspection plan shall be developed for the installed protection systems. The system shall be tested every 12 months. A register shall be kept for this purpose. Only qualified personnel having the necessary training and expertise shall be permitted to maintain, inspect, test and sign off these facilities.

E11.9.2 Maintenance

Routine inspections should be conducted on a 12-monthly basis. Any observed faults must be repaired immediately.

E11.10 INJURY TO LIVING BEINGS DUE TO TOUCH AND STEP VOLTAGES

The area surrounding the down-conductor (within a 3-meter radius) may be hazardous despite measures described in this specification. Additional measure must be installed to reduce this risk to acceptable values:

E11.10.1 Touch voltage

a) The area is demarcated to prevent access and relevant notices are displayed (ISO 3864-1), or

b) The number of down-conductors are increased to above 10, which will reduce the current and induced voltages, or

c) Increasing the contact resistance of the soil to above 100kΩ, or

d) The down conductors are insulated against the lightning impulse (100 kV, 1, 2/50 µs impulse withstand voltage).

E11.10.2 Step voltage

a) The area is demarcated to prevent access and relevant notices are displayed (ISO 3864-1), or

b) The number of down-conductors are increased to above 10, which will reduce the current and induced voltages, or

c) Increasing the contact resistance of the soil to above 100kΩ, or

d) The down conductors are insulated against the lighting impulse (100 kV, 1,2/50 µs impulse withstand voltage), or

e) The installation of a meshed earth-termination system.

E11.11 SURGE PROTECTION MEASURES (SPM)

Surge Protection Measures (SPM) are implemented to reduce the risk of permanent failures of electrical and electronic installations within a structure due to a Lightning Electromagnetic Pulse (LEMP).

Equipment failure due to LEMP is caused by surges conducted by connected wiring or by radiated electromagnetic fields. The effect of line surges is reduced by the installation of Surge Protection Devices (SPD's). The effect of radiated electromagnetic fields is reduced by shielding of equipment and shielded lines. Equipment generally complies with EMC product standards, which is sufficient to protect such equipment against LEMP.

E11.11.1 Design and installation of SPM

The SPM should be designed, installed and signed off by a competent and experienced SPM design engineer and SPM installer (person who is competent to design, install, construct and test an SPM with a broad knowledge of Electromagnetic compatibility (EMC)). It is the responsibility of the contractor to appoint a competent and experienced SPM design engineer and installer.

The design of the Surge Protection Measures (SPM) must be done in accordance with SANS 62305-4 as well as the Risk Assessment study done as described in SANS 62305-2.

E11.11.2 Earthing and bonding

A meshed network with a 5m mesh width is installed around the structure. This mesh is connected to the Type B ring earth electrode as well as the structure's interconnected mesh reinforced concrete floor to form a meshed earth termination system. The earth-termination systems of all internal systems should be bonded together to prevent potential differences between the systems.

Bonding bars in a stand-alone or ring configuration should be used to bond all conductive parts and incoming services (metal pipes, power lines, signal lines) together. Incoming lines should be bonded with SPD's. The material and minimum cross-sections for bonding component must comply with SANS 62305.

E11.11.3 Magnetic shielding and line routing

Spatial shielding is used to define protections zones. It can be grid like and can use electrical conductive reinforcement in the building. Internal lines can comprise of shielded cables or metallic enclosures of cables. Cables must be routed close conductive parts in the shielding system (reinforced concrete) to minimise induction.

The requirement of SANS 62305 concerning the material and minimum cross-sections or thickness of air-termination and down conductors must be followed.

E11.11.4 Coordinated SPD system

Please read this section in conjunction with the document Automation and Control Design Standards, Volume 5: Clean Power and Surge Protection for system compatibility.

The principle of a coordinated SPM is based on the division of the protected area/s into Lighting Protection Zones (LPZ), where the first LPZn is the overall protection zone which borders the inner zone LPZ (LPZn+1). The effect of the LEMP is reduced with each zone employed. LPZ 0 is the unprotected outer zone where equipment will be exposed to full LEMP and lighting surge currents. LPZ 1…n is the inner zones where equipment is exposed to limited surge current and attenuated electromagnetic field. (Refer to SANS 62305-4 typical drawings.)

SPD's must be selected to reduce the surge overvoltage between the live conductors and earth to a value lower than the equipment's rated impulse withstand voltage U_W at its terminals (common mode withstand voltage). The type of SPD, the location of the SPD (as close as possible to the point of entrance of the line vs as close as possible to the equipment to be protected) as well as the connecting conductors must be considered.

Types of SPD's:

There are three types of SPD's:

a) Type 1 SPD

The Type 1 SPD is recommended in the specific case of service-sector and industrial buildings, protected by a lightning protection system or a meshed cage. It protects electrical installations against direct lightning strokes. It can discharge the back-current from lightning spreading from the earth conductor to the network conductors. Type 1 SPD is characterized by a 10/350 µs current wave.

b) Type 2 SPD

The Type 2 SPD is the main protection system for all low voltage electrical installations. Installed in each electrical switchboard, it prevents the spread of overvoltages in the electrical installations and protects the loads. Type 2 SPD is characterized by an 8/20 µs current wave.

c) Type 3 SPD

These SPDs have a low discharge capacity. They must therefore mandatorily be installed as a supplement to Type 2 SPD and in the vicinity of sensitive loads. Type 3 SPD is characterized by a combination of voltage waves (1.2/50 µs) and current waves (8/20 µs).

E11.11.5 SPM management

A Management Plan must be implemented by a competent and experienced SPM design engineer:

a) Risk analysis;

b) SPM planning;

c) SPM design;

d) Installation of the SPM;

e) Approval of the SPM;

f) Recurrent inspections (documented);

g) Maintenance (following defects noted during recurrent inspections).

E11.12 EARTHING OF THE LV DISTRIBUTION SYSTEM

E11.12.1 TN-S system earthing – Separate neutral and protective conductors

The protective conductor (PE) is a separate conductor connected to the transformer neutral (star point).The transformer neutral is connected to the structure earth-termination system.

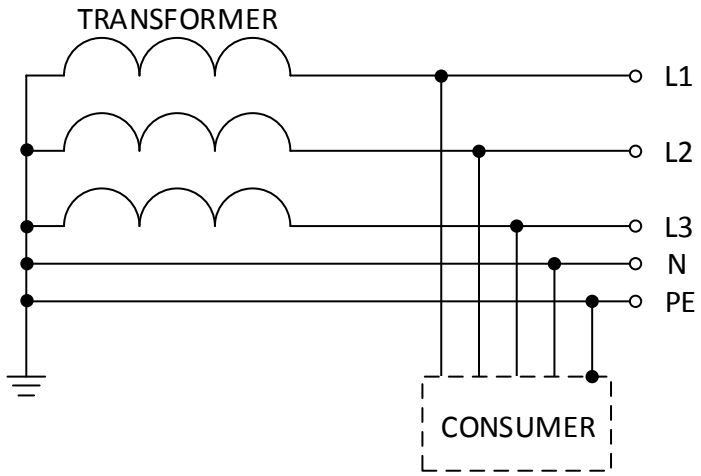

Figure 1. *TN-S System earthing*

E11.12.2 Requirements of the TN-S system earthing

a) In a single-phase TN-S system, the equivalent area of the neutral (N) conductor should be not less than the area of the phase conductor.

b) In a three-phase TN-S system, the equivalent area of the N conductor should be not less than half the area of one phase conductor.

c) In a three-phase TN-S system, all power cables will be four core, with the fourth (black) core used as the N conductor.

d) The protective earth (PE) conductor shall be able to carry the maximum fault current for the duration of the fault. This applies to any point in the distribution system.

e) The PE conductor should be of copper not less than $10mm^2$.

f) The minimum cross-sectional area of the PE conductor for phase conductors $16mm^2$ to $35mm^2$ is $16mm^2$.

g) The minimum cross-sectional area of the PE conductor for phase conductors above $35mm^2$ is at least 50% of the phase cross-sectional area.

h) No mechanism (circuit breaker, disconnector, fuse or removable link) which can separate the neutral conductor from the neutral point may be installed.

E11.12.3 Installation of the TN-S system earthing

a) The PE conductor will be installed next to the associated LV power cable.

b) Where the PE conductor is installed directly in the ground, bare copper earth wire will be used.

c) Where the PE conductor is installed in a covered cable trench or on a cable rack, black PVC insulated earth wire will be used. Both ends of the PE conductor will be identified with yellow/green crimp sleeves.

E11.14 LIGHTNING PROTECTION SYSTEM (LPS)

Figure 2 shows a typical LPS as implemented by Johannesburg Water

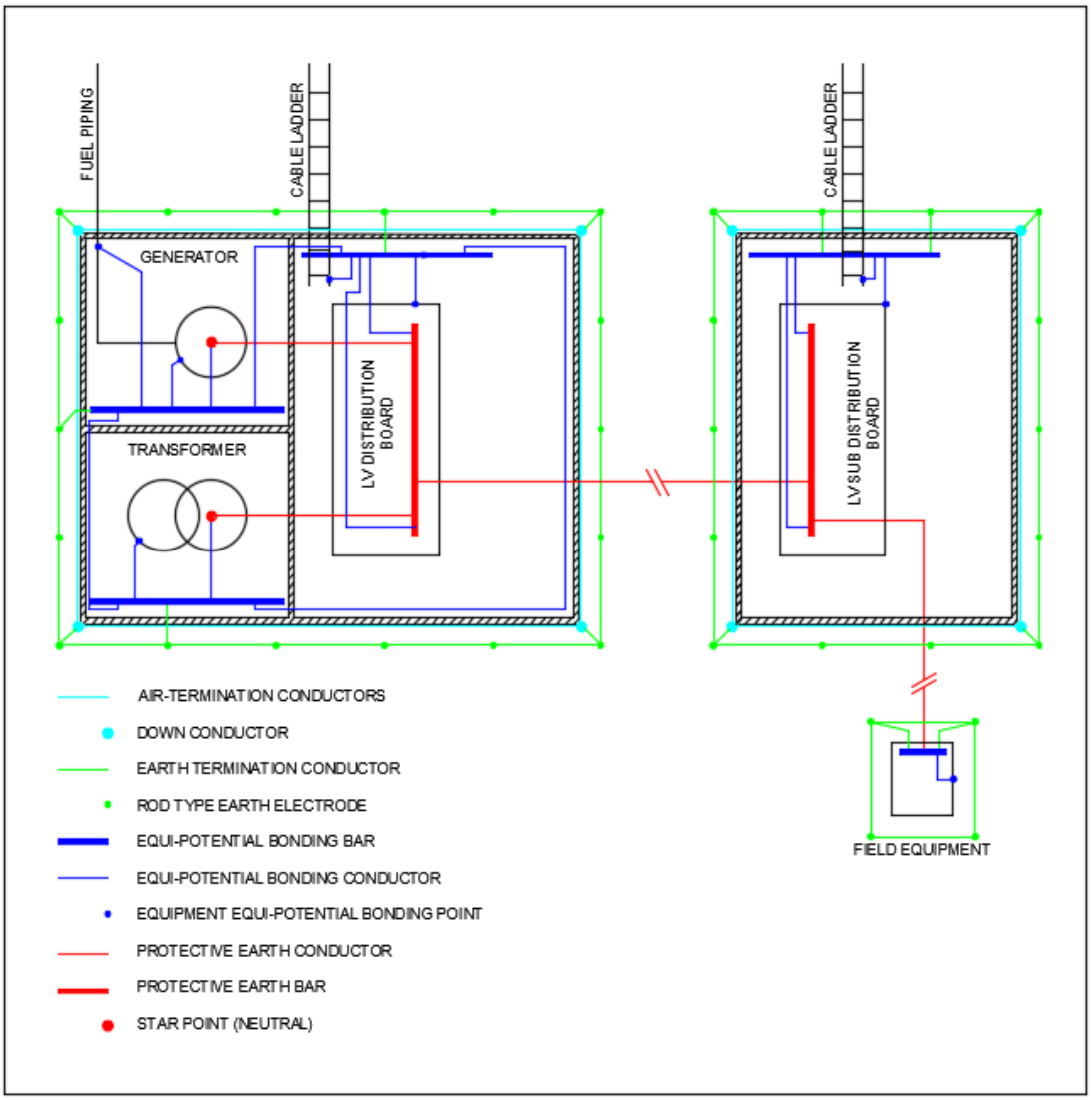

Figure 2. *Lighting Protection System (LPS)*

E11.16 MEASUREMENT AND PAYMENT

Item	Unit
Earth resistivity tests	No

The tendered rate shall include for the carrying out of the earth resistivity tests by a competent and experienced LPS engineer. The unit for measurement shall be per point where such tests have to be carried out.

Item	Unit
Design of a Lightning Protection System (LPS)	No

The tendered rate shall include for the design by a competent and experienced LPS engineer and must include the design of the Surge Protection Measures (SPM). The unit for measurement shall be an area of design.

Item	Unit
Installation of a structure LPS	Sum

The tendered rate shall include full compensation for the supply of all material required and the installation of the Lighting Protection system as per the design by a competent and experienced LPS engineer. It shall include for the testing of the LPS by a competent and experienced LPS engineer.

Item	Unit
Extra over for the supply and installation of additional rod type earth electrodes of specified length including welding/clamps for the connection of earth-termination conductors	No

The tendered rate shall include full compensation for the supplying and installation of the earth electrodes.

Item	Unit
Provision for additional earthing as required	Provisional sum

The provisional sum provided shall include for any additional earthing which may be specified by the Engineer after the acceptance of the contract.

The Contractor shall submit a written quotation to the Engineer when requested to by the Engineer and shall not commence with the installation of any additional earthing without the written instruction of the Engineer.

Item	Unit
Testing of a LPS	No

The unit of measurement shall be the number of tests undertaken by a competent and experienced LPS engineer, including the supply of the equipment required to do the test.

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PARTICULAR SPECIFICATION

M20: MECHANICAL VALVES: MANUFACTURE AND SUPPLY

Rev	Date	Description	Signature: JW Wastewater Partnership	Signature: Approval from Johannesburg Water
4	2013-10-23	Minor updates and re-issued	J Ritchie	
3	2012-07-30	General review	T Wellard	
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1	2009-05-12	Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance		

PARTICULAR SPECIFICATION M20: MECHANICAL VALVES: MANUFACTURE AND SUPPLY

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M20.1 SCOPE

This Specification covers the manufacture, testing and supply of sluice, butterfly, air, gate, reflux, diaphragm, flow limiter and pressure reducing valves for use in pressure pipelines for the conveyance of raw or potable water at ambient temperatures.

M20.2 INTERPRETATIONS

M20.2.1 Abbreviations

In this Specification the following abbreviations will apply:-

ANSI	:	American National Standards Institute
ASTM	:	American Society for Testing and Materials
BS	:	British Standards Institution
SANS	:	South African National Standards
SIS	:	Swedish Institute of Standards
DIN	:	Deutsch Industry Normen
ISO	:	International Organisation for Standardization
ASME	:	American Society of Mechanical Engineers
SAECC	:	South African Electrolytic Corrosion Committee

M20.2.2 Standards

For the purposes of this Specification the latest issues of the following standard specifications will apply:-

SANS 1700	:	Fasteners
SANS 135	:	Isometric Bold Screws and Nuts (Lexagon & square/coarse thread free fit series)
SANS 136	:	Isometric Precision Hexagon Head Bolts and Screws and Hexagon Nuts (coarse thread medium fit series)
SANS 144	:	Cast Iron Single-door Reflux Valves
SANS 191	:	Cast Steel Gate Valves
SANS 192	:	Cast Steel Single-door Reflux Valves
SANS 664	:	Cast Iron Gate Valves for Waterworks and heavy Industrial Purposes
SANS 936	:	Cast Iron Spheroidal Graphite Iron Castings
SANS 1431	:	Steel
BS 3100	:	Cast Steel
BS 4504	:	Flange Drilling
BS 5155	:	Cast Iron and Carbon Steel Butterfly Valves
SIS 05 59 00	:	Pictorial Surface Preparation Standards for Painting Steel Surfaces
ISO 2441	:	Pipe Line Flanges for General use - Shapes and Dimensions of Pressure Tight Surfaces
SANS 1123	:	Steel Pipe Flanges

M20.2.3 General Requirements

This specification must be read in conjunction with the following specifications:-

G01: Particular Specification for Colour Codes

G02: Particular Specification for Corrosion Protection

M20.3 GENERAL REQUIREMENTS

Satisfactory temporary end cover shall be provided to protect threads, flanges and prepared ends of valves from damage during transportation and handling on site.

Valves shall be so transported, stored and handled as to prevent damage. Valves damaged in any way shall be removed from the site.

The Contractor shall satisfy the Engineer as to the sufficiency of the place of manufacture regarding manufacturing, testing and inspection equipment to ensure that the production of valves is strictly in accordance with this Specification.

M20.3.1 Pressure Rating

The design pressure for the valve is specified in the Tender Document either in/or the Project Specification, Drawings and Schedule of Quantities. The minimum pressure rating for valves shall be 10 Bar. Valves shall be capable of withstanding the applicable test pressure as specified in SABS 664. Test pressure shall be maintained for 5 minutes and the valve bodies shall be watertight in all aspects.

M20.3.2 Wastewater Liquids and chemicals

Various different chemicals are used to treat wastewater. These include:-

- Ferric chloride
- Chlorine
- Polymer (Polyelectrolytes)
- Ammonium bromide

Valves used for the above mentioned chemicals shall be manufactured from highly non-reactive polymer such as Polyvinylidene Fluoride (PVDF) and PVC.

Valves which encounter raw wastewater, treated wastewater and sludge shall be manufactured from corrosive resistant material.

M20.3.3 Guarantee

All valves shall be guaranteed against faulty design, materials and workmanship until the end of the maintenance period on the Main Contract. During this period the Contractor shall be required to attend to and rectify any defects, which occur due to faulty design, materials or workmanship at his own cost.

M20.3.4 Operating and Maintenance Manuals

A copy of the Operating and Maintenance Manual for each valve type and different valve manufactures shall be bound in with the Operating and Maintenance Manual for the project. The manual shall be A4 size and properly bound. Drawings larger than A3 size shall be contained in separate plastic pockets.

M20.3.4.1 Contents

- A copy of the signed factory test certificate shall be bound in with the manual, while the original shall be handed to the Engineer.
- Operating instructions
- Maintenance instructions
- Lubrication instructions
- Spare parts list
- Drawings
- Brochures

M20.3.5 Jointing Material

Jointing material shall comply with SANS 1700. Valves shall be supplied complete with bolts, nuts, washers (2 per bolt) and gaskets for joining up to adjacent mating flanges.

Bolts shall be of stainless steel in all open applications (e.g. in valve chambers, reservoirs, etc.) and galvanised when buried provided the flanges are protected with DENSO mastic and tape. The bolt shall be long enough to allow at least two screw threads to protrude from the nut when the assembly is fully tightened. A washer must be provided both under the bolt head and the nut.

M20.3.6 Contact between Dissimilar Metals

When flanges of dissimilar metals are bolted together, the internal epoxy coating shall cover the contact area of the flange without any break.

Suitable insulation material shall be used between the contact faces of dissimilar metals of which the potential difference exceeds 0,3 V. Where corrodible metal is welded to a corrosion resistant metal, the protection coating specified shall overlap onto the latter by at least 5 mm.

M20.4 FABRICATION

M20.4.1 General

(a) Marking of Valves

The design pressure in Mpa shall be hard stamped on the edge of flanges to valves, to be visible from the top of valves.

(b) By-passes

Where indicated in the Project Specification or the Schedule of Quantities, valves shall be supplied with by-passes. Such by-passes shall be bolted on to the body of the valve and not to the adjoining pipework.

(c) Hand wheels and Direction of Closure

Where valves are required to be supplied with hand wheels, the rims of such hand wheels shall be machined to a smooth finish if specified. Arrows shall be cast on the hand wheels together with the wording "TO OPEN" or "TO CLOSE" - Closing being by the clockwise rotation of the spindle unless otherwise specified.

(d) For cap top valves an aluminium disc of at least 100 mm diameter with the same wording and arrows shall be slipped over the spindle and retained by the cap.

If specified in the Project Specification, valves shall be fitted with indicators representing

the valve status, showing fully open, fully closed and intermediate positions. Such indicators shall be corrosive proof and of robust design.

(e) Flanges

Unless otherwise indicated flanges shall conform, in all respects, to the requirements of SANS 1123 appropriate for the class of valve specified.

Should required sizes fall beyond the range of SANS 1123, flange dimensions shall confirm to the requirements as specified.

The Contractor shall obtain written confirmation of required flange drilling from the Engineer prior to the commencement of manufacture.

Sufficient clearance shall be allowed between the body of the valve and the flange to enable proper tightening of bolts. Tapped holes shall only be allowed in exceptional cases and with the Engineer's written consent.

(f) Information to be Supplied

Complete details of each valve offered must be provided at the time of tendering. This information will include at least the following:-

- Description
- Manufacturer's figure number
- Flange drilling
- Maximum working pressure (in kPa)
- Maximum unbalanced pressure (in kPa)
- Test pressure (in kPa)
- Material of components
- Gearing
- Accessories

M20.5 BUTTERFLY VALVES

Butterfly Valves shall be of the full-bore type and NOT reduced bore type with flanged ends. Valves larger than 200mm shall be fitted with gearboxes.

M20.5.1 Opening and Closing

All valves shall be capable of being opened or closed by hand under an unbalanced pressure equal to the design pressure without any difficulty. The disc shall close with a positive action with no possibility of slamming shut during any stage of the closing operation and the valve shall be capable of operating at any opening without variation of disc position or flutter of the disc.

The direction of the spindle rotation for valve closing shall be clockwise.

M20.5.2 Valve Body

Valve bodies shall be manufactured from cast iron or cast steel depending on test pressures and as specified.

The valve body shall have integral hubs for shaft bearing housings. Valves shall be provided with supporting feet and lifting rings where specified. A flow direction arrow shall either be cast into the body or shall be a brass plate screwed onto the body with brass screws.

M20.5.3 Discs

Discs shall be manufactured from cast iron or cast steel depending on test pressures and as specified. Discs shall be a single casting having a smooth streamlined design to minimize resistance to water flow.

The disc shall be off-set in the body to ensure simultaneous contact around its perimeter and shall have a positive non-slamming closing action.

M20.5.4 Seats and Seals

The profiles of the seats shall be smooth and continuous and shall provide adequate “lead in” for the resilient seal during closure of the disc to prevent excessive seating torque requirements. The seats shall be fixed to the valve body with stainless steel countersunk screws to facilitate replacement.

The seals shall be of the resilient type with non-weathering, non-sticking, long life properties. Seals shall be replaceable and shall be secured to the edge of the disc by means of a retaining ring. Sealing rings and seal retaining rings shall be manufactured from stainless steel.

The design of the seat and seal shall allow replacement thereof without removing the valve from the line.

M20.5.5 Shafts

Valve shafts shall be of high grade stainless steel. Valve shafts shall either be continuous through the disc or of a stub shaft design as described in the Project Specification and will be horizontal to the installed valve position. In the case of the sub-shaft type, each stub shaft shall extend into the disc hub for a distance of at least 1.5 times the shaft diameter.

All keys, dowel pins and taper pins used to attach the shaft to the disc shall be mechanically secured. The shaft shall be so sealed that the only two wetted parts shall be the disc and the seat.

M20.5.6 Bearings

Class 16 (1600 kPa) valves or valves with diameters of 350 mm or bigger shall be fitted with two-way adjustable bearings in order to permit precise disc-to-seat positioning at all times.

Positive bearing retention shall also be provided so that the bearing will not shift under operating conditions. The valve shall be capable of being installed and operated in any position.

The bearings shall be self-lubricating, long lasting sleeve-type bearings shall be fitted in the hubs of the valve body and at least one set of thrust bearings shall be provided.

M20.5.7 Gearboxes

Where it is necessary or where it is specified valves shall be operated via manually operated gearboxes

Gearboxes shall be self-locking and capable of holding the disc in a fixed position for any extended period of time.

Gearboxes shall be geared to be operated against the maximum unbalanced pressure with an effort not exceeding 200 N with each hand on the rim of a standard hand wheel. (Total effort = 400 N).

Gearboxes shall also be fitted with mechanical stops to prevent excessive turning and shall be

provided with replaceable shear pins. One spare shear pin shall be provided with each valve.

All gearboxes shall be equipped with position indicators, adjustable travel stops and indications of the "open" and "closed" positions.

The design of the gearbox shall readily allow for conversion to motorised drive at a later stage if required.

M20.6 AIR RELEASE VALVES

M20.6.1 Water works anti-shock and air release

Air valves shall be manufactured from cast iron or stainless steel depending on the test pressures and the project specification and of the single chamber design with cylindrical solid polymer control floats incorporating anti-shock design during high velocity air discharge.

The orifice plate, internals and body bolts shall be of stainless steel. All components of the valve shall be easily replaceable. All internals made of stainless steel that will be in contact with the fluid shall be lined or coated with a polyurethane paint to prevent cathodic action.

The design of the valve shall be such as to preclude the loss of water or the possibility of the float being blown shut by the passage of air when the accumulation of air in the pipeline is being released.

The valves shall be positive in the action to admit a free and full supply of air when the pipeline is being emptied or when the operating conditions demand.

Valves shall respond to the presence of accumulated air under normal working conditions by discharging it through a small orifice at any pressures within the specified design range.

Valves shall react immediately to pipeline drainage by full opening of the large orifice to allow unrestricted air intake. Valves shall not exhibit leaks or weeping past the large orifice seal at the maximum working pressure.

M20.6.2 Air Valves (Sewage)

Where air valves are required on sewage or industrial effluent pumping mains, they shall be specifically designed for such usage. Ordinary waterworks pattern air valves will not be acceptable.

Air valves shall be installed with an isolating valve on the inlet.

Full details of the air valves offered shall be provided at the time of tendering.

M20.6.3 Air Valves (Water Mains)

The following types of air valves as indicated on the Drawings and/or listed in the Schedule of Quantities are required.-

Type SO : Small orifice, single ball, lever type air valve which permits the escape of air from the pipe under working pressure.

Type LO : Large orifice, single ball air valve which allow air to enter the pipe when the pipe is being emptied and permit air to escape from the pipe when it is being filled.

Type DO : A combined small and large orifice air valve, the small orifice operating as the type SO and the large orifice as type LO above.

The size of the air valve shall be specified on the Drawings or in the Schedule of Quantities by the inlet diameter.

Air valves shall be suitable for the working pressure indicated on the Drawings or stated in the Schedule of Quantities.

All air valves shall be flanged and fitted with an isolating valve on the inlet pipe and a drain cock unless otherwise stated.

The air valves should be so designed that the balls are prevented from sticking.

Cover plates shall allow free discharge or intake of air, but shall prevent the ingress of foreign matter.

Valves shall be drop tight on shut-off and the design of the valve shall prevent balls from sticking.

When discharging large volumes of air at high rates the ball must not be caught up in the escaping air stream and close before all air has been released.

Tenderers shall submit full particulars of the air valves tendered on with the tender.

M20.6.4 Special Valves

All valves other than sluice and air valves shall be classified as special valves. The general requirements, pressure ratings, protective layers, flanges, markings, tests, etc. as specified in this Section will be applicable to the special valves. The particular valve will be further specified in the Project Specification.

M20.7 GATE VALVES

All gate valves shall comply with the requirements of SABS 664 and shall carry the SABS mark. Gate valves shall completely clear the bore of the valve in the fully open position. The direction of closing shall be clearly marked on the bonnet of the valve. Vales shall be drip-tight from zero to maximum working pressure under test conditions.

M20.7.1 Wedge Gate Valves

Valve seat and gate rings shall be manufactured from bronze to BS 1400 LG2.

Valves except flange faces shall be coated externally and internally with self-etching primer followed by one or more coats of fusion bonded epoxy material to give a total film thickness of at least 250 microns all applied in accordance with the manufacturer's specifications.

Valves where specified shall be supplied with fully enclosed, grease-packed, single-train spur gearboxes with a 3:1 or 4:1 ratio as specified.

Where required bronze gate guides and shoes shall be fitted as additional.

Integral mounted by-pass assemblies shall be fitted as additional where required.

M20.7.1.1 Auxiliary Fittings

Wedge gate valves of 300 mm diameter and larger shall be fitted with the following auxiliary fittings:-

- Drain Plugs

300 mm diameter valves and larger shall be supplied with gunmetal drain-plugs screwed into the lowest point of the valve and the valve body shall be suitably drilled and tapped to accept the drain-plug. The plug must be in position when the test pressure is applied.

- Ball Bearing thrust Collars

  300 mm diameter valves and larger shall be fitted with ball-races on the top and bottom of the thrust collars. The ball-races shall be totally enclosed in a grease-packed cover, which shall be sealed to prevent the egress of grease. Provision must be made for lubricating the ball-races and the lubrication arrangement shall allow for re-greasing while the valve is under pressure.

M20.7.2 Knife Gate Valves

The valve body shall be cast iron with soft rubber lining. Spindle and blade are to be manufactured from stainless steel. Valve seals are to be re-packable and reversible made from Nitrile rubber with PTFE scrapers, to withstand solid particles and grit associated with wastewater and sludge.

Hand wheels shall be rising spindle types. Knife gate valves shall be installed vertically at all times.

M20.7.3 Resilient Seal Valves

Resilient Seal valves ensure tight compression sealing without wear and shall be used as isolating valves. Valve bodies shall have unobstructed, pocket-free, bores i.e. no seating protrusions or gate well, with inclined seats and gate guides to eliminate deposits in the valve body.

The spindle seal shall have at least two Nitrile Butadine rubber to DIN 3770 O-rings located in a corrosion-resistant housing and a wiper ring to prevent ingress of dirt. A back seal shall permit replacement of spindle seats under pressure, with the gate in the fully open position.

The cast iron gate shall be fully covered with a Nitrile Butadine rubber sheath fully bonded to the gate by vulcanising.

Valves shall be smooth bore and shall operate without the use of any wedging action, which may scuff or damage the rubberised gate.

Valves shall be coated with a fusion bonded epoxy coating of minimum thickness 200 microns.

M20.8 NEEDLE VALVES

Type NLV1 needle valves of sizes 50 NB and under shall be used for flow control of dilution water. Needle valves shall be manufactured from stainless steel and shall adhere to ASTMA A 351.

The valve shall be hand operated and the ends of the body shall be screwed to BSP.

M20.9 SPECIAL VALVES

All valves used for special operations and conditions shall be carefully selected.

Tenderers are required to submit full details of the valves offered and the final selection shall be subjected to the approval of the Engineer. The valves offered shall not be accepted as substitutes for the standard valves specified.

M20.10 REFLUX/NON RETURN VALVES

Valves used for sewage effluent or sludge shall be self-cleansing at the base of the gate. The interior shall be smooth and free from any projections.

Valve bodies shall be of cast iron or cast steel depending on the test pressures and the project specification.

Valve doors shall be of cast steel or cast iron. Body rings, door rings and spindles shall be manufactured from stainless steel.

The following types of reflux valves as specified shall be supplied:-

(a) Single sloping swing door for sizes up to 400 mm.
(b) Double sloping swing door for sizes larger than 400 mm and up to 800 mm.
(c) Multiple sloping swing doors for sizes larger than 800 mm.

Valve bodies and seals shall be free of pockets that will allow dirt accumulation.

Valve doors shall be designed to prevent fluttering and shall allow rapid but non-slamming closure on reversal of flow. The gate shall swing free in the body and in fully open position shall not obstruct the flow.

Valves shall seal effectively under all operating conditions and the design shall be such that the gate rests against the seat in the absence of flow or of differential pressure without the aid of springs or external counterweights.

Where specified in the Project Specification, valve doors shall be balanced by attaching counterweights and levers, or hydraulic dampers to the extended valve spindle.

Where valves are fitted to buried pipe lines, only hydraulic dampers shall be used.

M20.11 DIAPHRAGM VALVES

The valve is to be able to handle sludge's, rags and grit as expected in waste treatment works. The valve body must be designed to minimise turbulence and give 100% leak tight closure.

The valve must have a smooth bore and minimise wear from abrasion and allow for rodding when sludge's set in the pipeline.

The valve operating mechanism must be sealed from service and atmosphere.

The diaphragm must be manufactured from tough, resilient type natural rubber of sufficient grade to handle abrasives, acids and alkalis as expected in sewage works.

The valve body is to be cast iron with sufficient corrosion and erosion protection to last the useful life of the valve.

M20.12 BALL VALVES

M20.12.1 Type BLV1

This type is used for general purposes for sizes of 50 NB and under. The ball and stem shall be manufactured from 316 SS and the body shall be 304 SS.

The seat and the gland shall be PTFE material. The valve body shall be of the reduced bore type with ends screwed to BSP. The valve shall be lever operated.

M20.12.2 Type BLV2

BLV2 type ball valves are used for sludge lines. The valve shall be short pattern reduced bore type, fully lined with a Polypropylene or fluorocarbon resin liner.

All interior surfaces including the ball, stem and collar shall be lined to ensure that there is no contact between the metallic components and the lined media. The liners shall be securely retained by means of dovetail grooves within the bore and shall extend over the flange faces.

M20.12.3 Valve Body

The body of the valves shall be manufactured from ductile iron and all external bolts, nuts and gland followers shall be grade 316 material.

M20.13 PRESSURE REDUCING VALVE ANGLE/GLOBE PATTERN TYPE

The pressure reducing valve shall maintain a constant downstream pressure regardless of changing flow rate and/or inlet pressure.

M20.13.1 Main Valve

The valve shall be hydraulically operated, pilot-actuated, single or double chamber globe or angle patter. The valve shall consist of three major components: the body, with seat installed; the cover, with bearings installed; and the diaphragm assembly.

The diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve, separating operating pressure form line pressure.

Packing glands and/or stuffing boxes are not permitted and there shall be no pistons operating the main valve or pilot controls.

M20.13.2 Main Valve Body

The valve body and cover shall be of cast material. Ductile iron is standard and other materials shall be available. No fabrication or welding shall be used in the manufacturing process.

The valve shall contain a resilient, synthetic rubber disc, with a rectangular cross-section contained on three and one-half sides by a disc retainer and forming a tight seal against a single removable seat inset. No O-ring type discs shall be permitted as the seating surface. The disc guide shall be of the contoured type to permit smooth transition of flow and shall hold the disc firmly in place. The disc retainer shall be of a sturdy one-piece design capable of withstanding opening and closing shocks. It must have straight edges and a radius at the top edge to prevent excessive diaphragm wear as the diaphragm flexes across its surface.

M20.13.2.1 Diaphragm

The diaphragm assembly containing a non-magnetic 304 stainless steel stem with sufficient diameter to withstand high hydraulic pressures shall be fully guided at both ends by a bearing in the valve cover an integral bearing in the valve seat. No centre guides shall be permitted. The stem shall be drilled and tapped in the cover and to receive and affix accessories as may be deemed necessary.

The diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve separating operating pressure from line pressure.

The diaphragm shall consist of nylon fabric bonded with synthetic rubber compatible with the operating fluid. The centre hole for the main valve stem must be sealed by the vulcanised

process or a rubber grommet sealing the centre stem hole from the operating pressure.

The diaphragm must withstand a Mullins Burst Test of a minimum of 4000 kPa per layer of nylon fabric and shall be cycle tested 100 000 times to insure longevity. The diaphragm shall not be used as the seating surface. The diaphragm shall be fully supported in the valve body and cover by machined surfaces which support no less than one-half of the total surface area of the diaphragm in either the fully opened or fully closed position.

M20.13.2.2 Valve Cover

The main valve seat and the stem bearing in the valve cover shall be removable. The cover bearing and seat in 15 mm and smaller size valves shall be threaded into the cover and body. The valve seat in 200 mm and larger size valves shall be retained by flat head machine screws for ease of maintenance. The lower bearing of the valve stem shall be contained concentrically within the seat and shall be exposed to the flow on all sides to avoid deposits.

To insure proper alignment of the valve stem, the valve body and cover shall be machined with a locating lip. No pinned" covers to the valve body shall be permitted. Cover bearing, disc retainer, and seat shall be made of the same material. All necessary repairs and/or modifications other than the replacement of the main valve body shall be possible without removing the valve from the pipeline. Packing glands and/or stuffing boxes shall not be permitted.

M20.13.2.3 Valve Manufacturer

The valve manufacturer shall warrant the valve to be free of defects in material and workmanship for a period of three year from date of shipment, provided the valve is installed and used in accordance with all applicable instructions. Electrical components shall have a one year warranty.

The valve manufacturer shall be able to supply a complete line of equipment from 32 mm through to 600 mm sizes and a complete selection of complementary equipment. The valve manufacturer shall also provide a cavitation chart which shall show flow rate, differential pressure, percentage of valve opening, Cv factor, system velocity and if there will be cavitation damage.

M20.13.3 Material Specification

Valve Size	:	50-300 mm
Main valve body and cover	:	Cast Iron
Main valve trim	:	Stainless steel
End detail	:	SABS 1123 table 1600/3 or 2500/3 as specified
Pressure rating	:	0-50°
Coating	:	Fusion bonded epoxy

Desired options:-

- X43 "y" strainer or equivalent on pilot piping
- Three ball valves on pilot piping, inlet, outlet and line to cover chamber
- 63 mm diameter pressure gauge, glycerine filled, fitted with 10 mm stainless steel ball valve on Tee-piece on inlet and outlet pilot piping.

M20.13.4 Pilot Control System

The pressure reducing pilot control shall be direct-acting, adjustable, spring-loaded, normally open, diaphragm valve designed to permit flow when controlled pressure is less than the spring setting. The pilot control is held open by the force of the compression on the spring above the diaphragm and it closes when the delivery pressure acting on the underside of the diaphragm exceeds the spring setting.

The pilot control system shall include a fixed orifice. No variable orifices shall be permitted. The pilot system shall include opening speed control on all valves 100 mm and smaller.

Three-way pilot controls will not be acceptable if the connection of TECHNOLOG “Autowat” or “Ecowat” controllers is specified.

The pilot control shall have a second downstream sensing port which can be utilised to install a pressure gauge.

A full range of spring settings shall be available in the range of 0 to 3000 kPa.

A direct factory representative shall be made available for the start-up service, inspection and necessary adjustments.

M20.13.5 Material Specification for Pilot Control

Pressure rating	:	1600 kPa or 2500 kPa as specified
Trim	:	Stainless Steel
Tubing and Fittings	:	Brass compression fittings with copper tubing
Adjustment range	:	200 to 2000 kPa or 100 to 500 kPa
Operating fluids	:	Water

M20.14 PRESSURE REDUCING VALVE (SINGLE DIAPHRAGM LINER-OPERATED TYPE)

M20.14.1 Function

The pressure reducing valve shall maintain a constant downstream pressure regardless of changing flow rate and/or inlet pressure.

M20.14.2 Main Valve

The valve shall be hydraulically operated, pilot activated automatic control valve for pressure reducing service. The valve shall consist of two parts: stainless steel body and an elastomeric liner. The valve shall be positioned in line and be controlled via an external pilot control valve.

M20.14.3 Material Specification

Valve Size		:50-300mm
Main valve Body	:	316 Stainless steel
End Detail (50 to 100 mm)	:	Wafer pattern
End Detail (150 to 300mm)	:	SABS 1123 Table 1600/3 or 2500/3 as specified
Pressure rating	:	1600 kPa or 2500 kPa as specified
Temperature range	:	0 to 70°
Liner Material	:	Natural Rubber

Liner retainer	:	316 Stainless Steel
Coating	:	Fusion bonded epoxy

Desired options:-

- X43 “y” strainer or equivalent on pilot piping
- Three ball valves on pilot piping, inlet, outlet and line to cover chamber
- 63 mm diameter pressure gauge, glycerine filled, fitted with 10 mm stainless steel ball valve on Tee-piece on inlet and outlet pilot piping.

M20.14.4 Pilot Control System

The pressure reducing pilot control shall be direct-acting, adjustable, spring-loaded, normally open, diaphragm valve designed to permit flow when controlled pressure is less than the spring setting. The pilot control is held open by the force of the compression on the spring above the diaphragm and it closes when the delivery pressure acting on the underside of the diaphragm exceeds the spring setting. The pilot control system shall include a fixed orifice. No variable orifices shall be permitted. The pilot system shall include opening speed control on all valves 100 mm and smaller.

Three-way pilot controls will not be acceptable if the connection of TECHNOLOG “Autowat” or “Ecowat” controllers is specified.

The pilot control shall have a second downstream sensing port which can be utilised to install a pressure gauge.

A full range of spring settings shall be available in the range of 0 to 3000 kPa.

A direct factory representative shall be made available for the start-up service, inspection and necessary adjustments.

M20.14.5 Material Specification for Pilot Control

Pressure rating	:	1600 kPa or 2500 kPa as specified
Trim	:	Stainless Steel
Tubing and Fittings	:	Brass compression fittings with copper tubing
Adjustment range	:	200 to 2000 kPa or 100 to 500 kPa
Operating fluids	:	Water
Desired Options	:	-

M20.15 FLOW LIMITER VALVES

M20.15.1 Screwed type limiter valves

The limiter valve shall consist of a screwed fitting with a rubber control ring orifice insert, which affects a consistent flow control within ± 10 % of the rated flow for a differential pressure across the valves over a range extending from 100 kPa to 1100 kPa.

The body of the limiter valve shall be made of uPVC plastic and shall female screwed at both ends to B.S.P.

The control rings shall be made of flexible nitrile elastomer rubber and must be able to move on a tapered seat in the body as the flow increases and be replaceable. The valve must be complete with control rings for the specified initial flow, which may be replaced in the future

(post-contract) for the final flow settings. The flow settings for the flow limiter valves are indicated in the Project Specification.

The screwed type limiter valve must be stamped with the flow in litres per minute and with an arrow to indicate the direction of flow.

A flow test must be conducted at the suppliers factory or test facilities, on one sample each of 20 mm, 25 mm and 32 mm flow limiter valve as prepared for use in the contract, over the following differential pressures:

Differential Pressure (kPa)	**Tolerance limit on rated flow**
50	± 50%
100	± 10%
150	± 10%
200	± 10%
300	± 101%
1000	± 10%

The measurement of flow rates must be to the satisfaction of the Engineer. If any one of the samples should fail to provide a flow rate within the tolerances specified, then all valves for installation on the contract must be tested for a selection of pressures on the contract must be tested for a selection of pressures up to the static pressures to be expected at installation sites, all to the satisfaction of the Engineer.

M20.15.2 Wafer type limiter valves

The limiter valves shall consist of a wafer pattern with a rubber control ring orifice insert, which affects a consistent flow control within ± 10% of the rated flow for a differential pressure across the valve over a range extending from the 100 kPa to 110 kPa.

The body of the limiter valve shall be made of uPVC plastic.

The control rings shall be made flexible nitrite elastomer rubber and shall be able to move on a tapered seat in body as the flow increases and be replaceable. The valve shall be complete with control rings for the specified initial flow, which may be replaced in the future (post-contract) for the final flow settings. The flow settings for the flow limiter valves are given in the Project Specification.

The limiter valve must be stamped with the flow in litres per minute and with an arrow to indicate the direction of flow.

A flow test must be conducted at the suppliers factory or test facilities, on one sample each of 50 mm and 80 mm flow limiter valve as prepared for use in the contract, over the following differential pressures:-

Differential Pressure (kPa)	**Tolerance limit on rated flow**
50	± 50%
100	± 10%
150	± 10%
200	± 10%
300	± 101%
1000	± 10%

The measurement of flow rates must be to the satisfaction of the Engineer. If any one of the samples should fail to provide a flow rate within the tolerances specified, then all valves for installation on the contract must be tested for a selection of pressures on the contract must be tested for a selection of pressures up to the static pressures to be expected at installation sites, all to the satisfaction of the Engineer.

M20.16 VALVE GEARBOXES

Gearboxes shall not be an integral part of the main body but shall be separate unit mounted to the body for easy removal. All gears shall be machine cut and fully enclosed and the lubrication shall be of the permanent type.

Positive stops shall be provided to prevent over opening or over closing of the units and visual indication of the point of travel at all positions in the open/close cycle shall be provided.

Torque limiting devices shall be fitted to prevent damage to gears and casings due to over tightening. Design of valves and gearboxes shall be such that leakage from the valve along the shaft cannot enter the gearbox.

M20.17 PROTECTION OF VALVES

M20.17.1.1 Internal Protection

Internal surfaces of valve bodies and discs shall be grit blasted to a Sa ½ of SIS 05 59 00 finish. Successive coats of an approved non-toxic epoxy resin paint suitable for spray application (Copon EP2300 or similar) shall then be applied to give a final dry film thickness of 300 µm. Drying times between successive layers will depend on environmental conditions and will be strictly in accordance with the requirements of the paint manufacturer.

As an alternative to the protection as specified above, the Contractor may be required to use either a solvent-less epoxy paint system or a fusion bonded epoxy powder coating. For fusion-bonded epoxy, a final dry film thickness of 250 µm is required.

Details of the protection required shall be given in the Project Specification.

M20.17.1.2 External Protection

External surfaces of valve bodies and discs shall be grit blasted to a Sa 2½ of SIS 05 59 00 finish. Successive coats of an approved non-toxic epoxy resin paint suitable for spray application (Copon EP2300 or similar) shall then be applied to give a final dry film thickness of 400 µm. Drying times between successive layers will depend on environmental conditions and will be strictly in accordance with the requirements of the paint manufacturer.

Where the specification does not call for an external surface consisting of an epoxy coating, the following shall apply:-

External surfaces of valve bodies shall be wire brushed to a Sa 3 of SIS 05 59 00 standard and painted with one layer zinc chromate primer to SANS 679 Type I (dried film thickness 50 µm). This shall be followed by two alkyd-based undercoats (each coat 25 µm thick) and one alkyd-based enamel finishing coat to SANS 630 Grade I (dried film thickness 25 µm). Final colour shall be as specified by the Engineer.

Machined flanges shall be painted with a protective coating of shellac or similar.

Refer to Particular Specification G02: Corrosion Protection

M20.18 TOLERANCES

The tolerances as specified in the appropriate SANS or BS standards shall apply to this Contract.

M20.19 COLOUR CODES

The standard final colour codes for equipment supplied under this Contract shall be in accordance with Particular Specification G01.

M20.20 TESTING AND INSPECTION

M20.20.1 Testing by Manufacturer

The Manufacturer shall carry out all tests to ensure that valve materials conform to the requirements of the relevant SANS or BS Specification. The Engineer shall not necessarily attend these tests but records must be kept and all test results and tests certificates must be provided to the Engineer.

M20.20.2 Testing by Independent Body

The Engineer may appoint an independent recognised body to conduct control tests. The Manufacturer shall provide samples required for such tests free of charge and the independent body in accordance with the relevant SANS or BS Specification shall do sampling.

The cost of such control tests shall be borne by the Employer.

M20.20.3 Inspection

Visual, operational and dimensional inspection of valves as well as inspection of protective coatings shall be carried out by the Engineer and/or the Manufacturer in the Manufacturer's workshop prior to the despatch of valves to site.

The Engineer's inspection will in no way relieve the manufacturer of any of his obligations to design, manufacture and supply valves strictly in accordance with the Specification.

M20.20.4 Hydrostatic Testing

The Engineer shall witness all hydrostatic tests and the Manufacturer shall give at least one week notification to the Engineer of the proposed dates for such tests.

Valve bodies shall be close ended tested to 2 x working pressure. Test pressures shall be maintained for at least 5 minutes and valve bodies shall be water tight in all respects.

Assembled valves shall be open-ended tested to 1.5 x working pressure for material strength and soundness. Valves shall be drop tight over the complete range of pressures from 0 to 1.5 x working pressure.

Each valve shall be supplied with a test certificate certifying that it complies in all respects with the requirements of this Specification.

M20.21 MEASUREMENT AND PAYMENT

Payment under scheduled items shall be made per complete installation as specified. Measurement and payment will distinguish between supply / delivery and installation / commissioning of the equipment.

The tendered rates or sums shall cover the cost of design, drawings, manufacture, supply, testing at the manufacturers works, delivery to site, off loading, installation, site testing, setting into operation, the supply of O & M manuals, commissioning and maintenance during the warranty period of all equipment specified and also for anything not specifically mentioned but obviously required, (e.g. all ancillaries, including all bolts, fastenings and brackets, safety guards and any work or material required for the proper installation of such equipment) to enable the equipment to be installed and/or function safely and correctly as specified. No claims whatsoever for extras will be allowed on the grounds that a necessary piece of equipment or a part thereof is not specifically mentioned.

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PARTICULAR SPECIFICATION

M21: MECHANICAL PRESSURE PIPEWORK

4	2013-10-23	Minor updates and re-issued	J Ritchie	
3	2012-07-30	General review	T Wellard	
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1	2009-05-12	Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance		
Rev	**Date**	**Description**	**Signature: JW Wastewater Partnership**	**Signature: Approval from Johannesburg Water**

PARTICULAR SPECIFICATION M21: MECHANICAL PRESSURE PIPEWORK

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M21.1 SCOPE

This specification covers the detailed design parameters, manufacture, supply, installation, test and commissioning of pipework, pipe items, protective coatings and describes methods for laying and jointing of pipes. The Particular Specification shall be read in conjunction with the Project Specification.

M21.2 INTERPRETATIONS

M21.2.1 Definitions

For the purposes of this Specification the following definitions shall apply:-

(a) Cut Lengths

Where this term is used in the Specifications, on the Drawings or in the Schedule of Quantities it shall be taken to mean a pipe of differing length from the standard length for pipes as supplied by the manufacturer.

Cut lengths are required as closure pieces between standard pipe lengths, between the ends of a pipe fitting or between pipe fittings.

(b) Plain End

This term refers to a pipe end that has been cut, machined or finished in a manner suitable for coupling to a pipe with a similar end as specified.

M21.2.2 Abbreviations

For the purpose of this Specification the following abbreviation shall apply:-

ASTM	:	American Society for Testing and Materials
API	:	American Petroleum Institute
BS	:	British Standard
SANS	:	South African National Standards
SIS	:	Swedish Institute of Standards
uPVC	:	Unplasticised Polyvinyl Chloride
ISO	:	International Standards Organsiation
DIN	:	Deutsches Institut für Normung
HDPE	:	High Density Polyethylene
MPVC	:	Modified Polyvinyl Chloride Pipes

M21.2.3 Standards

All design standards for the pressure pipework shall be subject to the latest amendments and editions of the following standard specifications:-

SANS 10400	:	National Building Regulations
SANS 9096-1: 1994	:	Testing of welders, where applicable to the type of welding required
SANS 10064	:	The preparation of steel surfaces for coating
SANS 10102-4	:	Selection of pipes for buried pipelines Part 1: General Provisions
SANS 10111-2-1	:	Engineering Drawing Part 1: General principles Engineering Drawing Part 2: Geometric Tolerancing Section 1
SANS 1700-5-9	:	Fasteners Part 5: General requirements & material properties Section 8: Corrosion resistant stainless steel fasteners-Bolts, Screws & Studs
SANS 1700-5-10	:	Fasteners Part 5: General requirements & material properties Section

8: Corrosion resistant stainless steel fasteners-Nuts

SANS 455 : Covered electrodes for the manual arc welding of carbon and carbon manganese steels

DWS 1110 : Construction of pipelines

M21.2.4 General Requirements

This specification must be read in conjunction with the following specifications:-

G01: Particular Specification for Colour Codes

G02: Particular Specification for Corrosion Protection

M21.3 CLASS DESIGNATION

Pipe classes indicated on Drawings and in the Specification should have the following meaning:-

Working Pressure (kPa)	Steel Pipes
300	
600	6
900	
1 000	10
1 200	
1 500	
1 600	16
1 800	
2 100	
2 400	
2 500	25

M21.4 MATERIALS

The type, ability and condition of the equipment and material are subject to the Engineer's approval.

Covered electrodes of mild steel or medium high tensile steel for hand welding must comply with SANS 455 and carry the SANS mark.

The Contractor must submit full particulars off all electrodes he intends using to the Engineer. All electrodes must be supplied by the Contractor and the consignment number submitted to the Engineer. Should a different consignment be used on the works, the Engineer may alter the welding procedure.

M21.4.1 Standards

M21.4.1.1 uPVC Pipes

Requirements:-

SANS 966 : uPVC Type I Pressure Pipes and Fittings for Cold Water Services
SANS 967 : Unplasticised poly(vinyl chloride) (PVC-U) soil, waste and vent pipes and pipe fittings
ISO 4422 : Pipes and fittings made of unplasticised poly (vinyl chloride) (PVC-U) for water supply – Specifications
SANS 1123 : Pipe flanges
SANS 791 : unplasticised poly(vinyl chloride) (PVC-U) sewer and drain pipes and pipe fittings
SANS ISO 4427 : Components of Unplasticised Polyvinyl Chloride (uPVC) Pressure

Pipe Systems for potable water

SABS 0112	:	The installation of polyethylene and unplasticised polyvinyl chloride pipes
BS 3505	:	Unplasticised polyvinyl chloride pressure pipes for cold potable water
DIN 8061	:	A1:1991 Unplasticised polyvinyl chloride pipes: General quality requirements and testing
ISO 1167	:	Plastic pipes for the transport of fluids: determination of the resistance to internal pressure.
ISO 1628	:	Plastics determination of viscosity number and limiting viscosity number. Part 2: PVC resins.
ISO 4422	:	Pipes and fittings made of unplasticised polyvinyl chloride for water supply specifications

125 & 140mm sizes are not recommended for uPVC pipes due to the lack of standard fitting.

M21.4.1.2 HDPE

Requirements:-

SANS ISO 4427	:	Black polyethylene pipes for the conveyance of liquids

M21.4.1.3 Mild Steel

Requirements:-

SANS 719 grade B	:	Electric welded low carbon steel pipes for aqueous fluids (large bore)
SANS 62	:	Steel pipe and pipe fittings up to 150 mm nominal bore

M21.4.1.4 Cast Iron

Requirements:-

BS 2035	:	Cast Iron flanged pipes and flanged fittings.
SANS 509	:	Malleable cast iron pipe fittings.
SANS 664	:	Cast Iron gate valves.
SANS 746	:	Cast-iron pipes and pipe fittings for use above ground in drainage installations

M21.4.1.5 Stainless Steel

Requirements:-

SANS 1044-3	:	Welding Part 3: The fusion of steel (including stainless steel): Tests for the approval of welding procedures
SANS 1044-4	:	Welding Part 4: The fusion welding of steel (including austenitic stainless steel): Tests for the approval of welders working where weld procedure approval is not required.
SANS 10162-4	:	Structural use of Steel Part 4: The design of cold-formed stainless steel structural

M21.4.1.6 Ductile Iron

Requirements:-

SANS 1835	:	Ductile iron pipes, fittings, accessories and their joints, for use in high and low pressure systems for potable and foul water
SANS 50545	:	Ductile iron pipes, fittings, accessories and their joints for water pipelines - Requirements and test methods
SANS 50598:1994	:	Ductile iron pipes, fittings, accessories and their joints for sewerage application - Requirements and test methods

M21.4.2 Steel (Other than Galvanised)

M21.4.2.1 Manufacturing Specifications

SANS 62	:	Steel pipe and pipe fittings up to 150 mm nominal bore
SANS 719	:	Electric welded low carbon steel pipes for aqueous fluids
SANS 1123	:	Standard Specification for steel pipe flanges
BS 4504	:	Flanges and bolting for pipes, valves and fittings

M21.4.2.2 Welding Specifications

BS 1965	:	Butt-welding pipe fittings.
BS 2633	:	Metal-arc welding of steel pipe lines and pipe assemblies for carrying fluids.
BS 4504	:	Flanges and bolting for pipes, valves and fittings.
API 5L	:	Specification for line pipe.
API 5LS	:	Specification for spiral-weld line pipe.
API 1104	:	Standard for welding pipe lines and related facilities.

M21.4.2.3 Protective Coatings

SANS 763	:	Hot-dipped (galvanised) zinc coatings.
SANS 0129	:	Code of Practise for plastic tape wrapping of steel pipe lines.
SANS 1117	:	Plastic wrapping for the protection of steel pipe lines.
SANS 1130	:	Glass fibre reinforcing material for pipe wrapping.
SANS 1136	:	Cold applied bitumen primer for steel pipe line protection.
SANS 1137	:	Hot applied bitumen for steel pipe line protection.
SANS 1138	:	Cold applied coal tar primer for steel pipe line protection.
SANS 1139	:	Hot applied coal tar enamel for steel pipe line protection.
SANS 1178	:	The production of lined and coated steel pipes using bitumen or coal tar enamel.
SIS 05 59 00	:	Pictorial surface preparation standards for painting steel surfaces.

M21.5 UPVC PIPES AND FITTINGS

All manufacturers of uPVC and MPVC pipes, fittings and couplings must be quality listed by the South African Bureau of Standards to comply with SABS ISO 9002.

All exposed uPVC piping shall be protected against ultra-violet degradation by the application of two coats of white PVA paint after degreasing.

Where flanged ends are required, the end of the pipe shall be prepared with a solvent welded stub adaptor to accommodate a galvanised steel backing flange.

All sludge and polyelectrolyte pipework shall be uPVC and rated 9 bar pressure and shall adequately supported to prevent sagging.

M21.5.1 Handling

Care shall be taken when handling uPVC pipes to ensure that pipes are not dropped or mishandled. Piping in transit shall be adequately secured using straps to prevent abrasion and surface damage.

During transport, handling and storage, the Contractor shall ensure that the pipes lie on a smooth surface and are not in contact with sharp objects and are not subjected to point or linear loads.

Yield (MPa) at 28° C	Tensile Modulus (GPa) 23°C	Max Temperature	Design Stress (MPa) at 20°C	Minimum Safety factor at 50 years

55	2.7-3.0	60	10,000	2.1

M21.6 HDPE PIPING

Flange couplings shall be kept to a minimum. Where the standard length of pipe is less than the required length, butt weld or flanged connections shall be used.

HDPE stub ends and loose flange connections may be butt welded and the bead formed inside the pipe shall be removed to avoid restrictions and product build-up. All flanges and bolts shall be galvanised.

Pipe work shall be adequately supported depending upon the size and class to prevent pipe sag. Where pipework is exposed directly to the environment, provision shall be made for suitable horizontal expansion joints.

M21.6.1 Handling

Care shall be taken when handling HDPE pipes to ensure that pipes are not dropped or mishandled. Piping in transit shall be adequately secured using straps to prevent abrasion and surface damage.

During transport, handling and storage, the Contractor shall ensure that the pipes lie on a smooth surface and are not in contact with sharp objects and are not subjected to point or linear loads.

The maximum stacking height for class 6-10 pipes shall not exceed 2m. All pipes exhibiting damage shall be rejected.

Yield (MPa) at 28° C	Tensile Modulus (GPa) 23°C	Max Temperature	Design Stress (MPa) at 20°C	Minimum Safety factor at 50 years
20	0.7-0.95	80	5,0	1.3

M21.7 MILD STEEL

All mild steel pipework and fittings other than steam tubing and screwed and socketed pipe, larger than 150 mm diameter shall comply with the requirements of SABS 719 grade B and shall have a minimum wall thickness as follows:

Normal Bore mm	**Min Wall Thickness mm**
Less than 400 mm	4
400-500	5
600-700	6
750-900	8
950-1100	10
1100-1500	12
1600-1800	14

Pipework other than screwed and socketed of sizes up to and including 150 mm nominal bore, shall comply with the requirements of SABS 62. These pipes shall be heavy class with flanged joints and suitable for a minimum working pressure of 1.6 MPa.

All screwed and socketed pipes shall comply with the requirements of SABS 62 Medium class and shall be “hot dip” galvanised. Unless otherwise specified screwed and socketed pipes shall not be used for the conveyance of steam, gas and compressed air. Compressed air pipelines of diameter 25 mm or less may be screwed and socketed.

Plain ends of pipes and fittings shall be protected against damage while being transported from the factory to the site. Details of the proposed protection system shall be submitted by the Engineer for approval.

M21.8 CAST IRON PIPES

All cast iron fittings shall be factory coated internally and externally with one coat bitumen paint to BS 3416 Type II leaving a dried film thickness of not less than 25 µm.

(a) All Exposed pipes and fittings except pipes installed in potable water retaining structures. Method of corrosion protection shall be specified in the project specification.

(b) After installation paint with one further coat as per factory coat.

M21.9 STAINLESS STEEL PIPES

Stainless steel shall be ANSI Type 304L or 316L as stated in the detailed specification. Where no welding is required Type 304 or 316 may be used. Manufacturers test certificates shall be provided for each material and each stainless steel item supplied shall be clearly and permanently marked with the grade of stainless steel and cross referenced to the applicable test certificate.

Welding of stainless steel shall be carried out using welding electrodes most suitable for the material and its applications by reference to the manufacturer's recommendations. Special precautions shall be taken to ensure that the strength and corrosion resistance of the material is not impaired by prolonged heating of the welds. All welds and adjacent areas shall be cleaned and pickled to remove the area of discolouration with a nitric and hydrofluoric acid formulation as recommended by the material suppliers.

After cleaning pickling all areas shall be thoroughly washed with clean water and re-passivated thereafter with a proprietary passivating solution of 10 per cent – 20 per cent nitric acid in aqueous solution recommended by the material suppliers.

M21.10 3CR12 PIPES

Test certificates and marking shall be used for 3CR12 as per stainless steel.

All 3CR12 shall be supplied "passivated" and upon completion of fabrication welds and other areas where the passivating layer has been removed or damaged and are contamination with mild steel or discoloured shall be cleaned and pickled using nitric acid and hydrofluoric acid formulation as recommended by the material suppliers. After cleaning/pickling all areas shall be thoroughly washed with a proprietary passivating solution of 10 per cent – 20 per cent nitric acid in aqueous solution recommended by the material suppliers.

Welding of 3CR12 steel shall be carried out under controlled conditions using stainless steel 309L welding rod or similar approved and recommended by the material suppliers. All welds shall be continuous and crevice free.

Where a fabricator has shops that deal with both carbon steel and stainless/ 3CR12 fabrications these shops are to be totally separated and no grinding wheels, etc., shall be interchanged between shops.

M21.11 DUCTILE IRON PIPES

Ductile iron pipes and fittings shall comply with ISO 2531. The nominal diameters of ductile iron are 80 to 2000mm.

The pressure rating of ductile iron is K9 range, with the nominal pressure of 3200 kPa. A safety factor of 4 times the working pressure shall be used for ductile iron pipes.

An integral rubber ring socket and spigot is used for the jointing. Ductile iron pipes shall have a inner lining of alumina cement mortar.

M21.12 STEEL PIPES, SPECIALS AND FITTINGS

M21.12.1 General

Protective coatings shall be either "factory" implying coating prior to delivery from the factory to Site, or "Site" implying coating on the Site after the item has been installed.

Undercoats shall be coloured differently to ensure complete coverage with each coat.

External protections other than specified in this clause e.g. coal, tar, enamel and proprietary types of tape wrapping shall when called for in the Schedule of Quantities be carried out as specified.

M21.12.2 Materials

Materials used for spun bitumen lining and bitumen fibre glass wrapping of pipes and the method to be followed shall comply with SANS 720.

Epoxy resin paint shall be approved by the Engineer and shall not break down chemically with time or affect the potability or cause discolouration of potable water in any way and the primer used with such paints shall be zinc rich epoxy type compatible with the paint. Bitumen based aluminium paint to be to SANS 802.

Undercoat for alkyd based enamel paint to be to SANS 681 Type II, and colour to match final decorative paint. Alkyd based enamel paint to be to SANS 630 Grade I.

Zinc chromate primer to be to SANS 679 Type I.

Bitumen paint to BS 3416 (Type II where specified).

M21.12.3 Types of Protection

Pipe work and fittings will be protected in accordance with the Particular Specification G02: Corrosion Protection.

M21.13 PIPE CONSTRUCTION

M21.13.1 General

Pipes shall be tested hydraulically in accordance with SABS 719 and test certificates shall be submitted to the Engineer before the pipes leave the manufacturers workshops.

M21.13.2 Marking of Pipes

The following markings shall be legibly and indelibly marked on each pipe and coupling:-

(a) The name, trade name or registered trade mark of the manufacturer.

(b) The nominal internal diameter.

(c) The class of pipe and colour code (marked at each end).

(d) The wall thickness (for steel pipes).

(e) Length of pipe (if different from the standard length)

(f) Pipe items, specials and valves shall be legibly and indelibly marked with the item number corresponding to the item number given in the Item Lists on the Drawings, or where Item Lists are not provided, the item number in the Schedule of Quantities.

M21.13.2.1 Information to be Supplied:-

The following information shall be made available to the Engineer prior to the award of the Contract:-

(a) Make and types of pipe offered.

(b) The friction loss formula applicable to the types of pipe offered.

(c) Standard pipe length.

(d) Thickness of pipe wall.

(e) Type of coupling and degree of maximum safe deflection permissible with the coupling.

Where the Contract calls for the supply, delivery and laying of the piping, the unit rate tendered for straight pipes shall include for one complete coupling (i.e. including rubber rings, insertion, bolts, etc.) per pipe length and shall include for the protection of the coupling.

Where the Contract calls for the supply and delivery only of the piping, the unit rate tendered for straight pipes shall include for one complete coupling per pipe length together with sufficient material for protecting the coupling.

Where the Contract calls for taking delivery of and laying the piping the unit rate tendered for straight pipes shall include for the labour necessary for protecting the couplings.

M21.14 WELDED STEEL PIPES

M21.14.1 General

Welders must be successfully tested in accordance with SANS 044 Part V by a certificate institution defined by SANS 044 Part V. The Contractor is responsible for the competency certificates of the welders. The Contractor must issue each welder with such equipment so that a welder can identify his joints. A list of identification marks must be kept by the Contractor and made available to the Engineer.

Should two joints of a particular welder not withstand the prescribed test, the welder may not undertake any more welds.

Pipes shall be manufactured by an approved welding process and shall not incorporate more than one longitudinal seam for pipes up to and including 1 000 mm diameter or two longitudinal seams for pipes bigger than 1 000 mm diameter.

Pipe specials shall be manufactured strictly as shown on the Drawings and described in the Documents. Plate thickness shall be such to ensure that the maximum stress shall not be higher than for an uncut pipe in the same pipeline.

The maximum angle between butt-ends of segments for gusseted bends shall be 22½E.

M21.14.2 Pipe Ends

Pipe ends must be thoroughly cleaned of all rust, grease and protection which may affect the quality of the weld. For cut lengths the ends must be bevelled to 30E with the end of the pipe and the roof surface prepared all at the Contractor's own cost. Should laminating, splitting of ends or any other defect occur during welding, the Contractor must cut the defective areas from the pipe.

M21.14.3 Handling

Pipes shall be brought in position in such a manner that damage to the pipes is avoided. Should the pipes have a longitudinal joint, the pipes must be placed so that this joint lies in the top third of the completed line. These longitudinal joints must be staggered at 20E from each other.

M21.14.4 Clamps

Internal clamps must be used to keep the pipes in position during the welding. The root opening must be between 1,5 and 3,0 mm and the pipes may not deviate more than 1,5 mm from the concentric.

Clamps may be removed only after 50 % of the root weld has been completed in equal sections around the perimeter of the pipes.

M21.14.5 Welding

Root welding may at no place be thicker than two thirds of the pipe wall and must be without defects.

Welding must be thoroughly cleared of slag, scale and oxide before the next weld is applied. Weld joints must consist of at least two welds to ensure the specified reinforcing.

Complete penetration must be ensured by letting the weld reinforcement protrude 1,5 mm on the inside of the pipe. No other protrusions will be allowed on the inside of the pipe.

Weld joints must be built up until the weld reinforcement protrudes between 0,8 mm to 1,6 mm above the pipe. The cover weld must be 3,2 mm wider than the original groove width.

In order to avoid cracks, the second or "warm" weld must be applied immediately after the root weld has been cleaned and prior to the cooling of the pipe at the joint.

The internal weld bead on welded seams shall protrude a maximum of 1,0 mm into the barrel of the pipe. For butt-welded pipelines the weld bead shall be ground flush with the pipe body at each pipe end.

The Contractor must submit with his tender a Qualification of Welding Procedures as set out in Section 2 of API Std 1104 including a procedure specification as set out in paragraphs 2.3a, d, e, f, g, h, I, j, k, l, m, n, p, q and r of above specification. The Contractor must demonstrate that this proposed procedure will produce an acceptable pipeline. Should tests reveal that an acceptable result cannot be obtained; the Contractor shall alter his procedure and qualification so that the desired result is obtained.

No welding may take place should inclement weather including rain, sand and wind result in bad joints. If practical, shelters may be erected. The Engineer's representative will decide if the weather is suitable for welding or not.

M21.15 BONDING OF PIPELINE

It may be necessary as a result of tests to be carried out by the Employer, for the pipeline to be

bonded across couplings for electrical continuity.

The bonds shall consist of lengths of 16 mm² PVC sheathed cable secured to the pipeline by thermal welding. Each and every flexible and flanged coupling will be bonded across except in the case of valve chambers where the bonding will take place in the form of a bypass around the outside of the chamber. At flexible couplings two fastenings to the pipe (one on either side of the coupling) and one to the barrel of the coupling shall be made. The external protection of the pipe shall be made good by filling the space cleared of wrapping for the connection with bitumen as used for wrapping the pipe, such that the depth of bitumen thus applied is equal to the depth of the wrapping.

The bonding shall be carried out as soon as possible after installation of the piping and before joints are protected and backfilled. The cables shall be installed in accordance with the requirements of the supplier and to the satisfaction of the Engineer.

Bonding of pipes shall be measured per joint unit. This price shall include for supplying of materials, transporting on Site and installing bonds and making good of pipe wrapping all as described in this Clause.

M21.16 BEDDING AND SUPPORTING OF PIPEWORK

In all cases buried pipes shall be laid on a 50 mm thick bedding layer, surrounded and covered to a height 150 mm above the pipe with selected fill material complying with the requirements of standardized specification unless otherwise indicated on the Drawings or ordered by the Engineer.

Bedding material shall be to the same Specification as selected fill.

Exposed pipework shall be adequately supported on concrete pads and fastened down with approved metal straps with rag-bolts cast into the concrete or with holder bats or as indicated on the Drawings or directed by the Engineer.

M21.17 LAYING OF PIPES

Only qualified workmen shall be employed for the laying and jointing of pipes and proper tools shall be used for the execution of the works. Care shall be taken during construction that the ends of pipes are not hit against each other and pipe ends are damaged in this way.

Once a sufficient length of trench has been excavated and trimmed to the required levels and grades, the pipes shall be lifted and carefully lowered into the trench and placed on the prepared bedding layer (where gravel bedding layers are called for).

Immediately prior to laying the pipe or fitting, it shall be carefully examined both externally and internally for any damage or defect, and all foreign matter shall be removed from inside of the pipe.

Pipes shall be laid evenly on the prepared bedding layer that shall be free of hollows, bumps or other irregularities. Where any such irregularities occurring in this layer prevent the pipe barrel from bearing on the bedding layer for its full length between joint holes, the pipe shall be lifted out of the trench or moved to one side while the bedding layer is trimmed in the specified manner, and where such filling or trimming is necessary as a result of any fault or omission on the part of the Contractor responsible for excavating the trenches, the additional handling of the pipe and trimming shall be to his own cost.

A guideline shall be strung parallel to the centre-line of the pipe and at the height of the centre-line of the pipe. Alternatively the Contractor may make use of a laser beam grade indicator.

All pipes and fittings shall be laid to the true lines and levels indicated on the drawings or as instructed by the Engineer. Pipes and fittings shall be positioned concentrically correct so as to obtain a thoroughly uniform joint. Where possible pipes shall be laid by commencing at the lower end of the grade and working uphill, and in the case of spigot and socket pipes, the socket end of the pipe shall face uphill.

In order to prevent foreign matter entering pipes already laid, a properly fitting wooden or other approved type plug or cap shall be used to cover the end of the last pipe laid whenever laying of pipes is interrupted.

Under no circumstances will the Contractor be permitted to use stones, corrugated iron or cement bags to cover the open end of closed pipes.

An approved pipe "cleaner" attached to a sturdy rope and left in the mouth of the pipe already laid and jointed, shall be pulled forward through the pipeline as each successive pipe is laid. The scraper and ropes used must be of soft material, which will not damage the inner surface of the pipes.

M21.18 DAMAGED PIPES

Damaged or defective pipes or fittings may not be used but shall be placed to one side for inspection by the Engineer who will determine and decide whether the damage is of such a nature that the pipe or fitting shall be rejected or whether it is so slight that it may be repaired on the Site. The decision of the Engineer with regard to the rejection of the damaged or defective pipes and fittings shall be final. Pipes and fittings shall be replaced or repairs undertaken by the Contractor at his own cost to the full satisfaction of the Engineer. In the case of pipes and fittings provided by the Employer, the responsibility of the Contractor for the repair and replacement of damaged pipes and fittings will commence once the Contractor has taken delivery of the material from the Employer. Before taking over any material from the Employer, he shall thoroughly inspect all material and immediately report any damage or defects therein to the Engineer.

The Engineer shall have the right to order the removal of any defective or damaged pipe or fitting that has not been repaired or approved as described above, from the pipe line, irrespective of whether such pipe or fitting has been laid and joined in the pipe line or not, and the Contractor must then undertake the removal and replacement of such pipe or fitting to the complete satisfaction of the Engineer, at his own cost.

M21.19 SIGHT RAILS

In all cases pipes are to be laid to definite lines and levels and sight rails shall be erected after setting out, at changes in direction and grade and at intermediate positions such that the distance between sight rails does not exceed 50 m or as the Engineer may require.

Sight rails for bulk excavation of trenches may be temporary to suit the Contractor's requirements but for purpose of final trimming and pipe laying sight rails shall be of sturdy construction, firmly planted and have the cross-arm neatly and clearly painted black and white.

Boning rods shall be well constructed with the cross-arm painted red or other colour contrasting with the sight rail. Sight rails and boning rods shall be maintained in a clean and sound condition and shall be subject to the approval of the Engineer at all times.

M21.20 STORAGE OF PIPES AND PREFABRICATED SECTIONS

Unless specifically stated to the contrary, the Contractor shall supply, deliver and install, as shown on the Drawings and in the Schedule of Quantities, all pipes, prefabricated sections and accessories required under each particular Section of the various Sections of the Contract.

Unless the pipes, prefabricated sections and accessories are off-loaded on the side of the excavated trench, the Contractor shall stack such pipes, prefabricated sections and accessories on an approved site. The cost involved in the transport from such storage place to the section of the trench where the drain or pipe line has to be built, shall be included in the construction cost.

During transport, handling, stacking and placing, the prefabricated units shall be protected against damage.

The Engineer reserves the right to restrict the height to which pipes may be stacked. Pipes larger than 300 mm diameter may not be stacked at all.

M21.21 JOINTING OF PIPES

Only suitably qualified workmen will be permitted to lay and join pipes and suitable equipment must be used for the execution of work.

Before they are joined together, the ends of pipes and all fittings and flanges shall be inspected and cleaned.

(a) Flanged Joints

Where flanged pipework, valves, etc., are to be connected, the insertion material shall be cut to the correct size and provided with bolt holes. The insertion material shall be positioned immediately prior to the two flanges being brought together and the whole joint must then be bolted together by tightening diametrically opposite bolts in sequence.

(b) Flexible Joints (Viking Johnson Type)

The flanges must be placed in position first; one over each end of the pipe, and the rubber rings must then be inserted by pulling them over the ends of the pipes or by using special pointed plugs, the point of which has been placed in the end of the pipe. Any twists in the rubber rings must be removed by rolling the rings along the outside of the pipe and they must then be brought into position so that the distance from the end of the pipe to the ring is equal to half the length of the detachable collar. The collar shall be placed over the end of one of the pipes and the two pipe ends shall be brought together in such a way that the collar is placed centrally over the joint. The bolts must then be placed through the flanges and carefully and evenly tightened to the required torque, thus ensuring a watertight joint.

(c) Flexible Joints (Loose Collar Type)

The pipe barrel shall be thoroughly cleaned over the area to be covered by the coupling. The coupling shall be installed strictly in accordance with the manufacturer's instructions - a copy of which shall be kept by the Contractor on Site.

(d) Screwed Joints

Screw threads on pipes and in sockets shall conform to the relevant standards. Threading on Site will be subject to the approval of the Engineer. PTFE tape only shall

be used for thread sealing. Sockets shall not be over tightened and the pipes shall be screwed the same distance into the socket on either side.

(e) Spigot and Socket Joints

For spigot and socket joints the ring shall be placed around the spigot end of the pipe, perpendicular to the centre-line and as near as possible to the end. The ring shall be clean, dry and not twisted. The joint is made by pushing the pivot in the socket by means of a crowbar or block and tackle. If the pipe is inclined to creep out of the joint, it is a sign that the ring is not rolled on evenly and it must be redone.

(f) Open Joints

For open joints the pipes shall be laid close together and any gap larger than 3 mm on the inside as well as outside shall be filled completely with 3:1 cement mortar and on the outside covered with one layer of jute material soaked in the same mortar. The jute material must overlap the joint by at least 75 mm on both sides.

M21.22 COUPLING DIFFERENT TYPES OF PIPING

The following methods shall be used for connecting different types of pipe together:-

Cast iron flange adaptors or steel flange and spigot pieces to suit the types of piping shall be coupled with a flexible coupling on one end and bolted to a flange on the other end which may, in the case of steel piping, be welded or screwed on.

Where a steel pipe is to be connected to an asbestos cement pipe with a larger outside diameter, without the use of a flange adaptor to the end of steel pipe shall be furnished with a steel ring welded on or, in the case of galvanised piping, a special galvanised steel socket shall be screwed on such that the outside diameters of the pipes match and the pipes may then be joined with a flexible coupling.

M21.22.1 Making of Openings

Where drains have to be joined to existing structures or existing drains or newly constructed prefabricated box culverts in such a way that it was not possible for the Contractor to leave openings for the joining or building in of prefabricated units, such openings shall be made according to the instructions of the Engineer.

The Contractor shall supply the necessary equipment and labour to make the openings according to the dimensions and/or requirements directed by the Engineer without damaging the rest of the structure or drain. If the openings are made too large or the rest of the structures or drain is damaged in any way, the Contractor shall repair it at his own expense to the satisfaction of the Engineer.

Blasting to make openings will only be permitted in exceptional circumstances.

Where necessary, parts of the existing structure or drain shall be propped until the junction of the new drain is completed.

The prefabricated units must be built into the openings or the other drains joined thereto as directed by the Engineer and the joint shall be finished neatly so that a minimum of obstruction is caused to the flow of water. The Contractor must provide all material, tools and labour to make the new junction.

M21.22.2 Positioning of Valves and Fittings

All valves and fittings shall be correctly positioned as indicated on the Drawings, and where necessary shall be supported by concrete pads. Spindle guides and anchors shall be fixed to the brickwork or concrete and carefully adjusted to ensure correct operation of the spindle.

M21.22.3 Thrust Blocks

Unless otherwise ordered by the Engineer, concrete Class 25/19 MPa thrust blocks shall be cast as a support for bends, tees and caps and at valves. The size of the thrust will depend on the strength of the soil, the pipe diameter, the working pressure and the type of item to be supported.

All thrust blocks shall be cast against undisturbed soil and in such a manner as to leave all couplings accessible and such that the bearing area is in accordance with the table given below, which table is based on the assumption that the safe bearing capacity of the soil is at least 100 kN/m². The Engineer will determine in each case the safe bearing capacity for the soil, and the bearing area of the thrust block may then be interpolated from the table. The areas are given in square metres.

Thrust blocks and pipework supports inside buildings shall be constructed to the dimensions given on the Drawings or as directed by the Engineer after the piping and fittings are installed in position.

Note: Bearing area of thrust blocks for pipe diameters, working pressures and bends not stated in the table below, shall be interpolated from the values given.

Nominal Pipe Diameter (mm)	Working Pressure KPa	Bends				End Caps and T-pieces
		11.25º	22.50º	45.00º	90.00º	
100	300	0.010	0.020	0.035	0.065	0.045
	900	0.025	0.050	0.100	0.185	0.130
	1 500	0.045	0.085	0.165	0.305	0.215
	2 100	0.060	0.120	0.230	0.425	0.300
200	300	0.035	0.070	0.135	0.245	0.175
	900	0.107	0.200	0.395	0.725	0.515
	1 500	0.170	0.335	0.655	1.210	0.855
	2 100	0.235	0.470	0.915	1.695	1.195
300	300	0.080	0.150	0.295	0.545	0.385
	900	0.230	0.450	0.885	1.630	1.150
	1 500	0.380	0.750	1.475	2.720	1.920
	2 100	0.530	1.050	2.060	3.805	2.685
400	300	0.135	0.265	0.515	0.950	0.670
	900	0.395	0.785	1.540	2.845	2.005
	1 500	0.660	1.310	2.565	4.740	3.340
	2 100	0.920	1.895	3.590	6.635	4.675
500	300	0.210	0.420	0.820	1.510	1.065
	900	0.630	1.250	2.455	4.530	3.195
	1 500	1.050	2.085	4.085	7.550	5.325
	2 100	1.465	2.915	5.720	10.565	7.450
600	300	0.305	0.600	1.180	2.175	1.535
	900	0.905	1.800	3.530	6.521	4.600
	1 500	1.510	3.000	5.885	10.870	7.665
	2 100	2.110	4.200	8.235	15.215	10.730
800	300	0.540	1.070	2.095	3.865	2.725

Nominal Pipe Diameter (mm)	Working Pressure KPa	Bends				End Caps and T-pieces
		11.25º	22.50º	45.00º	90.00º	
	900	1.610	3.200	6.275	11.595	8.175
	1 500	2.680	5.335	10.460	19.320	13.625
	2 100	3.750	7.465	14.640	27.050	19.070
1 000	300	0.840	1.670	3.270	6.040	4.260
	900	2.510	5.000	9.805	18.110	12.770
	1 500	4.185	8.050	16.340	30.185	21.285
	2 100	5.855	11.660	22.875	42.260	29.795

M21.23 CUT PIPES AND PREFABRICATED SECTIONS

Cut pipes may only be used with the Engineer's permission and the ends shall be cut square to the length of the pipe and finished smooth and evenly so that the cut ends is not inferior to that of an uncut pipe.

The Contractor shall measure the length required for a cut length, cut the pipe, prepare the end for the required coupling and install the cut length. The cutting and end-finishing operations shall be done with special tools available for the particular type of piping such that the cut end is not inferior to the factory made end. In the case of asbestos cement piping particularly, an end cutting machine as supplied by the pipe manufacturers only, shall be used for cutting and preparing the end.

In the case of steel pipes since the ends only are truly circular, it is necessary that cut lengths be factory made and prepared. The prices tendered for cut lengths for various types, classes and diameters of piping shall include for the cutting and end finishing operations but exclude the actual pipe length used as this will be measured and paid for under the item provided for supplying and/or laying of straight pipes. The price shall however, include for one coupling as required, and for any possible wastage.

In the case of sewer pipes, cut pipes may only be used at manholes and the cut end shall wherever possible be built into the manhole. Prefabricated units may only be trimmed or cut where they join structures or other drains.

Box culvert sections may only be trimmed or cut perpendicular to the direction of flow to obtain the correct length and units of the correct skew shall be obtained from the manufacturer where the box culvert drain joins at a skew and in such cases the second last unit shall be trimmed or cut to obtain the correct length.

The ends of pipes to be built in shall be trimmed or cut to the correct skew to be finished smoothly on the inside face of the wall into which it is built.

Units shall be cut in such a way that the edges are not shattered or cracks are not caused in the concrete where the structural strength of the unit causes it to break. When it is trimmed it shall be cut or sawn to obtain the correct length and skew end.

The necessary openings for junctions shall be left when structures or drains are constructed. If the Contractor neglects to leave such openings, he shall, at his own expense, make such openings afterwards or remove the building work and reconstruct it with openings, all according to the Engineer's directions.

Units must fit neatly into the openings provided for them and must be firmly concreted or built in without any obstruction to the flow of water.

M21.23.1 Sterilizing of Pipelines

Pipelines that are to be used for potable water shall be sterilized over its complete length before it is taken into use.

The pipe shall be filled with potable water chlorinated to a concentration of 10 mg of chlorine per litre of water which shall remain with the inner surface of the pipe line for a period of not less than 24 hours. The pipeline is to be filled for sterilizing in such a manner that no shock is created or air trapped in the pipeline.

The Contractor shall at least 14 days prior to the commencement of sterilizing, submit full details of the proposed method of sterilizing the pipe line to the Engineer for his approval.

The Contractor shall provide all necessary tools, equipment and labour necessary to sterilize the pipeline. After sterilizing the pipe line the Contractor shall, at no extra cost empty the pipe lines and dispose of the water in a manner approved by the Engineer.

The Contractor may use the following products as a source of chlorine:-

(a) Chloride of Lime to SANS 295 yielding one third by weight free chlorine.

(b) Calcium Hyper Chloride to SANS 295 yielding 70% by weight free chlorine.

(c) Chlorine gas applied by chlorinator.

The unit rates tendered under the items in the Schedule of Quantities for sterilizing pipe lines shall include for all materials (including water) and labour necessary and shall also include for all arrangements the Contractor may have to make in order to obtain water and fill the pipe line.

M21.23.2 Route Markers

In certain instances concrete pipe route markers may be required. Such markers shall be detailed fully in the Project Specification.

M21.23.3 Protective Layers on Pipes and Fittings

Unless otherwise indicated on the Drawings or stated in the Schedule of Quantities, pipes, specials and fittings shall be protected as shown here-under. Note that preparation of metal surfaces shall be done as specified for steel and other metal work.

PVC, Polythene, galvanised and Chromed Piping

Pipes and fittings manufactured from the above materials shall receive no treatment except as follows:-

(a) Exposed galvanised steel piping shall be thoroughly cleaned and coated with one layer of etching primer, one coat zinc chromate primer and finishing coats as for exposed steel piping when called for in the Schedule of Quantities.

(b) The exposed threads and where galvanising has been damaged shall be thoroughly cleaned and all traces of oil removed with an appropriate solvent. One coat of zinc chromate primer to SANS 679 Type 1 followed by one undercoat to SANS 681 Type II to a total dried film thickness of 50 µm shall be brush applied to all surfaces.

(c) Buried galvanised steel piping shall, when called for in the Schedule of Quantities, be protected by wrapping with pressure sensitive tape or butyl rubber laminated tape.

(d) Identification bands shall be painted on exposed PVC, Polythene and chromed piping in accordance with instructions of the Engineer.

M21.23.4 Flexible and Flanged Couplings

The couplings shall first be cleaned by removing all loose scale, rust, extraneous matter such as mud, by means of wire brushing and removing possible excess water by wiping with a dry cloth.

After cleaning, the whole of the coupling shall be well primed with a paste of saturated petroleum hydrocarbons (petrolatum), insert fillers and passivating agents, leaving a thin film on flanges and sleeves and a liberal amount around the bolt heads, narrow cavities, etc. A mastic plats of petrolatum, insert fillers and mineral fibres shall then be applied to cover all the bolt heads on the outside of the flanges (also between flanges to give approximate 5 mm cover over the sleeve). The mastic shall then be moulded up to, but not to completely cover the bolts and flanges.

A glass fibre, felt coated tape saturated with petrolatum with insert siliceous fillers shall then be applied circumferentially, starting and finishing on top of the coupling, care being taken to form the tape well into the angle between the flange and the pipe. Care shall be taken to smooth the tape down and ensure conformability to the underlying mastic. The tape should be "fed" onto the coupling and not stretched.

Two complete turns of 0,15 mm thick polyethylene sheeting shall be applied over the coupling. The sheeting shall be wide enough to cover the entire coupling and overlap by 150 mm on top of the coupling. The sheeting shall be secured onto the pipe barrel each side of the coupling by means of self adhesive tape overlapping 25 mm on the pipe barrel and 75 mm on itself.

The tendered unit rate for wrapped couplings shall include all materials, labour, transport, etc. to complete the protection of the coupling in any position along the pipeline.

M21.24 COLOUR CODES

The standard final colour codes for equipment supplied under this Contract shall be in accordance with Particular Specification G01.

M21.25 TOLERANCES

Pipes shall be laid to the lines, grades and levels as specified on the Drawings

(a) Vertical deviation from the straight line between two consecutive levels shall not be more than the value of "d" as calculated from the following formula :-

$$d = 5 + \frac{L^{1/2}\ D^{1/2}\ S^{1/2}}{60}$$

Where : d = tolerance in millimetre
L = length of pipe between control point in millimetre
D = nominal pipe diameter in millimetre
S = slope of pipe taken as the difference in level of control points in millimetre divided by L

(b) The horizontal deviation from the specified direction and line between two consecutive control points shall not be more than the maximum vertical deviation as calculated under (a) above.

Pipe items and specials shall be manufactured to the dimensions as specified in the pipe lists or shown on the Drawings

Maximum allowable deviation from the specified dimensions shall be as follows:-

(a) Straight pipes and tapers :-

Length (mm)	Tolerance (face to face) (mm)
Up to 1 800	± 16
1 800 to 2 700	± 24
2 700 to 3 600	± 32
Longer than 3 600	± 40

(b) Bends and Tees :-

Diameter (mm)	Tolerance (centre to face) (mm)
Up to 300	16
300 to 600	24
600 to 1 200	40

M21.26 TESTING

M21.26.1 Steel Pipes and Pipe Fittings

M21.26.1.1 *Testing and Inspection at Manufacturer's Works*

Where factory inspection and supervision of tests are required by the Engineer, such tests and inspections shall be carried out at the manufacturer's works at the expense of the Contractor who shall provide free of charge all necessary testing facilities, labour, instruments, etc. that may be required.

An independent inspector such as the SABS may be appointed to act on behalf of the Engineer. Fees payable to such an inspector, however, will not be to the account of the Contractor.

M21.26.2 Non-Destructive Tests

(a) Visual Inspection

All pipes and pipe specials shall be visually examined, shall be free of defects, such as cracks, laminations and arc burns and shall comply fully with the dimensions as specified.

A penetrant dye shall be used for the visual inspection of welding.

(b) Ultrasonic Inspection

All longitudinal or spiral welds on straight steel pipes shall be checked ultrasonically with approved equipment capable of continuous and uninterrupted inspection of weld seam - all in accordance with API 5L.

(c) Radiographic Inspection

As an alternative to (b) above, 20% of all longitudinal or spiral welds on straight pipe, and up to 100% of all butt-welds on straight pipes and up to 100% of all welds for pipe specials shall be checked radio graphically in accordance with API 5L.

(d) Hydrostatic Testing

All pipes and pipe specials shall be subjected to hydrostatic testing at a test pressure determined from the following formula:-

$$P = \frac{1500\ Yt}{D}$$

Where P = Hydrostatic test pressure in kPa
Y = Minimum Yield stress of material in Mpa
t = Nominal wall thickness in mm
D = Nominal outside diameter in mm

All leaks on sweating shall be considered as defects.

(e) Visual Inspection of Linings and Coatings

Linings shall have a smooth glossy finish, free from ripples, runs, pinholes, bubbles, laminations, disbanding, fraying or other blemishes.

Coatings shall be free of crazing, laminations, disbanding, pinholes, craters, bridging across and weld beads, or any sign of physical damage and shall have an acceptable smooth finish.

(f) Holiday Testing of Linings and Coatings

The entire lining and coating of each pipe shall be tested by the Contractor to the Engineer's satisfaction with an approved holiday detector fitted with the following heads:

(i) For epoxy linings and coatings - with a wet sponge detector head.
(ii) For bitumen or coal tar linings and coatings - with a copper bristle search head.
(iii) For wrapped coatings - with a rolling ring detector around the pipe.

(g) Thickness of Linings and Coatings

The thickness of linings and coatings shall be measured by means of a magnetic or eddy current instrument suitable for measuring non-metallic films on curved magnetic surfaces.

(h) Delamination Test and Disbonded Areas

Refer to SANS 1178 Clauses 7.2.3 and 7.2.4.

M21.26.3 Destructive Tests

Destructive tests on steel pipes and specials shall be carried out in accordance with SANS 719 and SANS 1178.

M21.26.4 Testing and Inspection on Site

M21.26.4.1 Site Welding

The Contractor must appoint an inspector from a certified institution in accordance with SANS 044 Part V at his own cost. An incompetent inspector must be replaced by a competent person. A copy of all inspection reports must be provided at no cost to the Engineer.

Inspection and test of welds must be carried out in accordance with API Std 1104 chapter 5 and the standard required must be according to chapter 6. All results must be tabulated.

Radio graphical tests in accordance with chapter 8 of above specification must be carried out. The numbers of welds of each welder that must be tested are: the first three joints, then every third joint to a total of 6 joints and then one out of every 10 joints. Should one joint fail the prescribed tests, the above procedure must be repeated starting from the before last joint.

The Contractor must keep a complete record of the position of every radio graphical tested joint and provide a copy at no cost to the Engineer.

All joints, which fail the prescribed test of API Std 1104, must be repaired in accordance with chapter 7 of above specification.

M21.26.4.2 Linings and Coatings

Linings and coatings shall be visually inspected on Site prior and after installation for any sign of physical damage.

All repairs to linings and coatings undertaken on Site shall be to the Engineer's approval who also reserves the right to order pipes and pipe specials to be returned to the factory for repairs to linings and coatings.

For bitumen linings and coatings the following procedure shall be followed:-

Weld spatters must be removed and steel surfaces must be wire brushed to ST 3 of SIS 0559 and all dust must be removed. Damaged bitumen primers, bitumen and lime layers must be scraped and/or brushed until steel or good bitumen is reached to a point at least 100 mm from the point of repair.

Bitumen primer must be cold applied to steel and exposed bitumen surfaces and left to dry for at least 4 hours but not more than 4 days.

For the repair of linings bitumen applied hot in an acceptable manner shall be used.

One layer of warm bitumen to a thickness of 1.5 mm followed by two layers bitumen saturated glass fibre cloth applied by means of a warm iron to ensure complete affixion and bitumen saturation must be applied as wrapping. Above must be followed by one layer of 1 mm thick warm applied bitumen on one layer of white lime over the joint area. The thickness of the wrapping must be at least a thick as the original and edges must fit to the original protection.

Bitumen must be heated in closed kettles to a maximum of 235EC. Local overheating must be prevented by stirring.

M21.26.4.3 Hydrostatic Testing of Pipe Line

Pipe joints shall in general be left exposed until the pipeline has been successfully tested and passed by the Engineer. All open excavations at joints shall be adequately and safely protected. Should the Engineer order any joints to be backfilled prior to testing, the responsibility for re-exposing the joints for the purpose of repair of leaks after testing shall be entirely the Contractor's own and he shall not be entitled to extra payment for such work.

The Contractor shall provide and maintain in good condition the equipment necessary to carry out the test. Where temporary pumping equipment is used for testing, the equipment shall consist of a force pump with the suction end in a suitable container of water, and connected to the pipe line by means of high pressure hosing in good condition and/or piping and all the necessary flanges, connections, couplings, etc. and a pressure gauge suitably calibrated and in good condition. The equipment and method of assembly for testing shall be subject to the approval of the Engineer.

The entire pipe line or portion of the pipe line between closed valves and/or blank flanges mat be tested at any one time provided that no section of the pipe line is subject to a higher pressure than one and a half times the working pressure for the particular class of pipe and fitting.

Prior to commencing the test the Contractor may, if he so desires, keep the pipeline full of water for as long a period as he considers necessary. The Contractor shall, at least 14 days prior to the first test being carried out, submit full details of the procedure he intends to follow, to the Engineer for approval.

For the purpose of the test the pipeline shall be filled with water in such a manner that no shock

is created or air trapped in the portion to be tested.

Once the pipe line is completely full of water, the pressure shall be brought up to one and a half times the maximum working pressure for all parts of the portion of pipe line under test as the water level in the container at the suction end of the pump noted. The initial application of the test pressure shall be done in the presence of the Engineer.

The pressure shall be maintained at the test level for 4 hours.

The quantity of water which has to be added to the container at the suction end of the pump during the 4 hours that the pipe line is under test in order to bring the water level back to the initial level at the start of the test, shall be carefully recorded. No water may be added to the container except in the presence of the Engineer.

Should the quantity of water thus added not exceed the following limit, the pipeline shall be deemed to be successfully tested.

Limit of leakage permitted over 4 hours:-

(a) For pipeline with flexible joints

50 ml per 10 mm of pipe diameter per 1 000 m of pipe length per 10 m maximum test head for the portion of pipeline tested. All joints must be inspected while the test is in progress to ensure that there are no visible leaks.

(b) For pipeline with welded joints

10 ml per 10 mm pipe diameter per 1 000 m of pipe length per 10 m maximum test head for the portion of pipeline tested. Should the leakage be more than 3 l/km of pipe tested, the Contractor must prove that no single leak exceeds 0,2 l in 4 hours.

M21.26.5 Other Pipe Materials

Visual inspections and hydrostatic tests shall be carried out on Site as described for steel pipes. Factory inspections and tests shall be as specified in the relevant SANS Specification for the pipe material concerned.

M21.27 MEASUREMENT AND PAYMENT

Payment under scheduled items shall be made per complete pipework system installation as specified. Measurement and payment will distinguish between supply / delivery and installation / commissioning of the equipment.

The tendered rates or sums shall cover the cost of drawings and instructions for anything not specifically mentioned but obviously required for the proper installation to enable the system as described to be installed and/or function safely and correctly as specified. No claims whatsoever for extras will be allowed on the grounds that a necessary piece of equipment or a part thereof is not specifically mentioned

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PARTICULAR SPECIFICATION

G01 : COLOUR CODING OF EQUIPMENT

2	2013-10-23	Minor updates and re-issued	J Ritchie	
1	2009-05-12	Review of Mechanical / Electrical and Control / Instrumentation Standards, plus New Design Guidance		
Rev	**Date**	**Description**	**Signature: JW Wastewater Partnership**	**Signature: Approval from Johannesburg Water**

City of Johannesburg
Johannesburg Water (SOC) Ltd

PARTICULAR SPECIFICATION: VOLUME G01 : COLOUR CODING OF EQUIPMENT

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G01.1 SCOPE

This Specification has been adopted by Johannesburg Water to ensure the colour coding of electrical equipment, mechanical plant and pipework located on Johannesburg Water's Wastewater Treatment Works shall conform to the ruling Occupational Health and Safety Act.

The Specification comprises of **three** parts, namely:

(a) SANS Code of Practice 10140-3, Identification colour marking – Part 3 : Contents of pipelines: 2003

(b) A table (Table 1) which supplements SANS 10140-3, above, in order to provide greater detail or clarity on the colour marking of pipelines conveying fluids commonly found on the treatment works

(c) A table (Table 2) which gives the colours adopted for certain electrical equipment and mechanical plant.

Throughout the Specification the colours used shall match the corresponding colours given in SANS Specification 1091, National Colour Standards for Paint: 2004 (as amended).

Where a colour code is not covered by this Specification, the matter shall be referred in writing to the Divisional Manager: Investment Delivery for ratification.

Table 1 : Colour Coding of Pipework on Johannesburg Water's Wastewater Treatment Works

Contents of Pipeline	Basic Colour	Colour Coding Indicator	
		Single Band	Second Band
Water, non-drinkable			
Cooling water	Brilliant Green		
Final treated effluent		White	
Recycled effluent		Black	Dark Violet
Air saturated effluent		Black	Dar Violet
Filtrate		Black	Aquamarine
Wash Water		Black	
Scum water		Black	Dark violet
Dewatering Liquors		Black	Dark Violet
Overflow from P.S.T's		Black	Crimson
Overflow from Clarifier		Black	Dark Violet
D.A.F Underflow		Black	Crimson
Supernatant Liquor		Black	Avocado
Overflow Gravity Thickener		Black	Crimson
Fire Fighting			
Boiler feed		Cornflower	
Hydraulic power		Salmon Pink	-
Poly-electrolyte		Light Grey	-
Raw sewage		Middle Brown	-
Settled sewage		Mid-grey	-
Thickener overflow from:			
Primary sludge		Crimson	-
Activated sludge		Canary Yellow	-
Digested sludge		Maroon	-
DAF liquors		Canary Yellow	Turquoise Blue
Filtrate		Ultramarine	-
Washwater		Black	-
Scum water		Dark Violet	Crimson
Treated effluent		Dark Violet	-
Dewatering liquors		Black	Ultramarine
Acids	Jacaranda		
Ferric chloride		Crimson	
Ferric sulphuric		Artic Blue	

Contents of Pipeline	Basic Colour	Colour Coding Indicator	
		Single Band	Second Band
Alkalis			
Lime Slurry	Dove Grey		
Gases			
Sludge gas	Light Stone	Jacaranda	
Steam	Pastel grey	Aluminium	Clad/lagging
Nitrogen	Light Stone	Black	Light Grey
Hydrogen	Light Stone	Black	Signal Red
Methane (digested)	Light Stone	Turquoise Blue	
Carbon dioxide	Light Stone	Light Grey	
Chlorine/Hypochloride	Canary Yellow		
Oxygen	White		
Compressed Air	Artic Blue		
Ventilated Air	Artic Blue		
Vacuum Air	Artic Blue		
Instrument Air	Artic Blue		
Sludges			
Anaerobically digested	Middle Brown	Maroon	
Anaerobically digested: thickened		Maroon	Light Grey
Raw Sludge	Dark Violet		
Lime treated	Dark Brown	Dove grey	
Primary	Dark Brown	Crimson	
Primary thickened	Dark Brown	Crimson	
Digester supernatant liquor	Middle Brown	Salmon Pink	
Activated : mixed liquor	Royal Blue	Canary Yellow	
Activated : gravity thickened	Royal Blue	Canary Yellow	Dark Violet
Activated : return sludge	Royal Blue	Canary Yellow	Middle Brown
Activated : DAF overflow/float	Royal Blue	Canary Yellow	Turquoise Blue
Activated : primary	Royal Blue	Canary Yellow	Crimson
Activated : digested	Royal Blue	Canary Yellow	Maroon
Activated : waste	Royal Blue	Canary yellow	
Pasteurised	Light Brown		
Oil			
Diesel oil	Black	White	
Hydraulic oil	Golden brown	Salmon Pink	
Lubricating	Golden brown	Brilliant Green	
Transformer	Golden brown	Crimson	
Other Liquids			
Polyelectrolyte	Golden Yellow	Jacaranda	
Cooling liquid	White		

Notes: This table supplements SANS 10140-3: 2003

All codes are in relation to SANS 1091: 1975

Table 2: Colour Coding of Electrical Equipment and Mechanical Plant

Item	Colour	Remarks	Code to SANS 1091
Electrical panels : (external)	Light Orange	NOSA	B.26
Electrical panels : (external) emergency power on	Signal Red		A.11
Electrical panels : (Internal)	White		G.80
Coupling guards and motor guards	Golden Yellow	SANS 10140-2	B.4
Motor cowls	Light Orange	Historical	B.26
Electrical motors, pumps and compressors	Deep Pastel Green		H.28
Gearboxes	Navy Light Grey	NOSA: See also "Small Gearboxes"	G.35
Blower	Deep Pastel Green	NOSA	H.28
Baseplates	Olive Drab		
Cranes	Golden Yellow		B.4
Valve bodies		See SANS 10104-3, Clause 4.2	
Valve hand-wheels			
Small gearboxes	To be same colour as prime mover		

G01.1.1 Machined Components

All machined components shall be protected by "Tectyl" or similar proprietary coating after manufacture. The coating shall be sufficiently durable to prevent corrosion during storage and installation and shall be removed using the manufacturers recommended solvent after final adjustment of the equipment. Final paining shall be carried out in accordance with the system specified.

G01.1.2 Records

The contractor and sub-contractors shall maintain records of the application environment, dates of applications, conditions of surfaces before preparation, blast profiles, wet and dry film thicknesses, overcoating times, paint types and batch number, method of application, tests and type of instruments used, which shall be incorporated into the Component Quality Plan and be available to the Engineer or his Representative for review and surveillance. Two copies of the completed Component Quality Plan shall be provided within 2 weeks of completion of the corrosion protection system.

G01.2 MEASUREMENT AND PAYMENT

For the purpose of this Contract the electro-mechanical items shall be supplied and installed conforming to this specification. The cosmetic panting application shall be included for and the surface preparation, transporting of equipment to and fore from the applicator shall be included for. No separate measurement item shall be included for the application of these coatings.

STANDARD SPECIFICATION

CITWIF

CORROSION IN THE WATER INDUSTRY FORUM

CORROSION PROTECTION FOR WATER INFRASTRUCTURE AND SUPPLY SERVICES

STANDARD SPECIFICATION

CORROSION PROTECTION - COATING AND LINING

FOR WATER INFRASTRUCTURE AND SUPPLY SERVICES

FOREWORD

The purpose of this document is to Upgrade the Skills and Standardisation of Corrosion Protection Procedures and Specification to achieve improved levels of quality and reliability of water infrastructure and supply services.

The document is also a proposed revision of SANS 1217 Ed.2. There are parts of the SANS 1217 incorporated into this document.

Historical experience related to coating and lining to provide amendments and enhancements is also incorporated.

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1. SCOPE

The purpose of this document is to Upgrade the Skills and Standardisation of Corrosion Protection Procedures and Specification to achieve improved levels of quality and reliability of water infrastructure and supply services.

The document incorporates the previous SANS 1217 Ed. 2 standard and DWS 9900 specification.

This specification covers the corrosion protection of steel pipes, specials and other water related infrastructure to be used for the conveyance and storage of raw and potable water at ambient temperature, which may be buried or subjected to environments with variable corrosive tendencies.

Cathodic Protection of buried infrastructure is covered by SANS15589-1, SANS 50162, SANS 53509 and associated.

2. INTERPRETATIONS

2.1. PROJECT SPECIFICATION

Pipes and specials shall be manufactured, and corrosion protected in accordance with the requirements specified in the Project Specification. No deviation from specification will be allowed without the written consent of the Project Engineer.

In the case of there being conflict between specifications, the Project Specification will take preference.

2.2. APPLICATION

This specification contains clauses that are generally applicable to the corrosion protection of steel pipes and specials.

2.3. DEFINITIONS

Acronyms and abbreviations

Acronyms and abbreviations are listed in ANNEX A: ACRONYMS

Acceptable

Acceptable to the authority administering this specification, the appointed Corrosion Engineer or to the asset owner concluding the purchase contract

Approval

Approval shall indicate Acceptance of the quality, material, and process by the appointed Corrosion Engineer

Breakdown voltage

A voltage that is high enough to exceed the electrical insulating properties of a coating or lining and is sufficient to cause current to break through and damage the coating or lining and flow through to the metal substrate.

Coating and lining

A coating shall be a homogenous material applied to the external surface of a steel pipe to prevent corrosion of the surface but may also refer to a corrosion protection material for other steel structures.

A lining shall be a homogenous material applied to the internal surface of a steel pipe to prevent corrosion of the surface.

Coating material

Material used to form a coating or a lining (or both)

Corrosion Engineer

The Corrosion Engineer's qualification, skills and experience shall meet the same requirements as the professionally registered person defined in Section 4.10.1 (DESIGN ENGINEERS, PROJECT MANAGERS AND CONSULTING COMPANIES).

The Corrosion Engineer shall be appointed by the Asset Owner and shall have discretion and authority are the following:

- Specify and select corrosion protection systems in accordance with this specification.
- Draw up detailed specification(s) as and when required.
- Approval of specific materials for construction.
- Approval of specific materials for corrosion protection.
- Approval of corrosion protection application procedures.
- Approval and management of quality control requirements.
- Approval of required qualifications of staff working on the project.
- The authority to reject/stop work that does not meet the requirements of this specification.
- Any such authority as delegated to the Corrosion Engineer by the Asset Owner.

Defective area

Area of the coating or lining on a pipe that fails in one or more respects to comply with the appropriate requirements of this specification

Dielectric strength

Dielectric strength is a measure of the electrical insulating properties of a coating or lining determining spark test voltages to find electrical insulation defects.

Voltage gradient at which dielectric failure of the coating or lining occurs under specific test conditions

Dis-bonding

Dis-bonding refers to a loss of adhesion and subsequent separation of a coating or a lining from the substrate, as a result of mechanical, chemical, or other action.

A Dis-bonded area is an area of lining or coating where dis-bonding occurs.

Holiday

A Holiday, also known as an Electrical Insulation Defect (EID), is a discontinuity in the coating or lining such as a void, crack, thin spot, holiday, pinhole, embedded conductive particles, foreign inclusion, or contamination in a coating or lining that significantly lowers the dielectric strength of the coating or lining.

Inspection and Testing Plan (ITP) / Quality Control Plans (QCPs)

It is the quality control documentation that defines the fail/pass criteria and inspection points.

Inspector

Suitably qualified person authorised by the Asset Owner, Engineer/Corrosion Engineer and or Contractor to act as his representative in examining the work and materials and in drawing such samples and carrying out such tests or quality assessments as might be necessary to ensure compliance with this specification.

Maintenance

A diversified job function to locate, identify and repair or rehabilitate defects.

Perm inch or Perm cm

Water vapor permeability is a measure of the passage of water vapor through a membrane. It is the rate of water vapor transmission per unit of area of vapor pressure differential under test conditions. Refer to ASTM D 1653 for the test method.

Rehabilitation

All measures for restoring or upgrading the performance of an existing pipeline and water infrastructure systems.

Renovation

Work incorporating all or part of the original pipeline and water infrastructure system by means of which its current performance is reinstated and/or improved.

Repair

The process of restoring the structure that is locally damaged or deteriorated or broken to good condition

Replacement

Rehabilitation of an existing pipeline or water infrastructure system by the installation of a new system, without incorporating the original structure

Solvent

One of the following:

a) That part of a liquid coating material that volatilizes from the film during the drying process, or

b) Volatile liquid compatible with a coating material and used for the purpose of cleaning equipment used in the application of a coating material.

c) Any flammable or potentially flammable liquid as defined by applicable safety regulations.

Standard Test Conditions

Temperature of 23°C ± 2°C and the relative humidity of 50% ± 5% in accordance with SANS 3270.

Suitable

Capable of fulfilling or having fulfilled the intended function or fit for its intended purpose

Tainting

Imparting or having an objectionable odour or taste (or both).

Toxicity

Ability of a coating or lining to potentially cause harm as defined in SANS 241.

Relevant Surface Area

Part of an article covered or to be covered by the coating and for which the coating is essential for serviceability and /or appearance.

Test Area

Representative part of the relevant surface area within which an agreed number of single

measurements are made as a spot-check

Measurement Area

Area over which a single measurement is made

3. APPROVAL REQUIREMENTS

3.1. APPROVALS BEFORE AWARD OF CONTRACT

The Corrosion Protection System specified in the Project Specification, shall be agreed upon between the Corrosion Engineer, Cathodic Protection Engineer and Project Engineers.

a) Approval of the corrosion protection system, procedures and specific materials offered in the Tender. Manufacturer's data sheets or legible copies thereof shall be submitted for each product.
b) Acceptance of the Quality Control Plan for Corrosion Protection - refer to Annex F: QUALITY CONTROL PLAN TEMPLATES.
c) Approval of the corrosion protection application procedures for both internal and external field joints and site repairs dependent on pipe design, trench conditions and corrosion protection.

3.2. PRE-QUALIFICATION REQUIREMENT

Due to the specialised nature and importance of corrosion protection, pre-qualification is generally required for products, service providers and skills in corrosion protection. Users of the specification would typically be Water Service Providers / Authorities who shall stipulate detailed pre-qualification requirements.

3.3. APPLICATION APPROVALS

a) Qualification of personnel
b) Quality of equipment
c) Pre-preparation
d) Surface preparation
e) Application
f) Final Acceptance

3.4. MATERIAL SUBSTITUTION

The compliance of the specific commercial products proposed by the Contractor for the selected field coating systems shall be identified at tender stage. The coating manufacturer name and product number, certified test reports and data sheets shall be provided. All repair coatings proposed shall have an established history of use on pipelines.

The substitution of corrosion protection materials after contract award may only be approved if the following criteria are met:

- equivalent or superior performance criteria as required in Chapter 9 and 10, and
- Approval in writing by both the Corrosion Engineer and the Project Manager.

4. QUALITY REQUIREMENTS AND TESTING PROCEDURES

To be read in conjunction with the relevant Sections of Chapters 6 (MANUFACTURE AND PRE-PREPARATION), 7 (SURFACE PREPARATION), 8 (APPLICATION AND QUALITY CONTROL) and ANNEX F: (QUALITY CONTROL PLAN TEMPLATES)

4.1. PHILOSOPHY OF INSPECTION

The philosophy for undertaking quality control and testing procedures is to ensure that the applied corrosion protection systems meet the project design life requirements.

The inspection philosophy and QCP template(s) submitted at the time of tender need to be site specific to reflect the actual project conditions during execution and thereafter the Corrosion Engineer shall approve the final QCPs.

In the event that the main contractor or corrosion protection sub-contractor is subject to time penalties, then the Asset Owner shall make a provision for costs associated with continuous inspection so as to ensure that inspection activities do not result in unnecessary delays to the work progress.

Frequency and philosophy of inspection will be determined by the nature of the project (workshops, site, small or large projects)

4.2. THIRD-PARTY INSPECTION

Inspections shall be undertaken by the Employer or an Independent third-party or his nominated representative. The Employer or Independent third-party or his nominated representative inspectors shall be separate and additional to the main contractor and coating application contractors' in-house inspectors.

The finalisation, agreement and acceptance of the project quality control plan will have a huge bearing on the cost and frequency of inspections.

The Corrosion Engineer shall have the authority to change hold points and inspection intervals on the quality control plan in order to manage the project risk.

The Corrosion Engineer in consultation with the Asset Owners and Project Managers shall select one of the four inspection philosophies below during the preliminary design stage and again review the selection prior to project commencement or at the kick-off meeting.

- Continuous inspection/Permanent inspectors:
  Priced monthly with the working hours to be the same as the main contractor.

- Hold point inspection only:
  Priced daily for each time a hold point needs to be released.

- Random inspection/Surveillance/Witness:
  Priced hourly but limited to a predetermined total for the project.

- Final release inspections:
  Priced daily for each section of work final release

The inspector's rates shall be inclusive of generating the reports and supplying inspection instrumentation and Professional Indemnity (PI) insurance to 5% of the contract value. The inspector shall submit copies of his PI insurance together with his rates.

The selection of the cost format and or frequency of inspection shall have a significant

price implication and needs to be considered with respect to the coating material selected, skill of the application contractors, access difficulties associated with site conditions and the corrosion life expectancy required for the project.

4.3. QUALITY ASSURANCE AND PROCEDURES

The Contractor shall ensure that he is fully conversant with the requirements of this specification and the relevant Corrosion Protection systems.

Contractors shall be obliged to ensure that skilled workers/staff with qualifications and experience as defined in Section 4.10 (QUALIFICATIONS AND EXPERIENCE OF STAFF) shall be used.

Corrosion protection materials shall be manufactured in accordance with SANS 9000 and the relevant South African Bureau of Standards (SABS) or South African National Standards (SANS) specifications, or equivalent, as specified in contract documents.

4.3.1. SAMPLING

The quality assurance procedures and plan shall define the quantity and type of samples that the Corrosion Engineer requires for material testing. The samples shall be subject to first non-destructive testing and thereafter at the Corrosion Engineers discretion destructive testing. Sampling may be requested to be done on the mainline pipe or steel structures, or where specified on separate smaller representative coupons or test plates.

The number of samples for testing and the age of samples at test shall be specified by the Corrosion Engineer in the contract documents. Refer to the generic coatings and lining sections for specific requirements as they may differ.

4.3.2. TEST AND CONTROL SPECIMENS FOR DESTRUCTIVE TESTING

When so agreed in writing between the purchaser and the supplier for the purpose of carrying out destructive tests, prepare suitable specimens and line them or coat them (or both), as appropriate, in a manner identical to that employed on the pipes in the consignment.

If required a sufficient length of production pipe shall be cold cut to provide the required number of samples for conducting the coating destructive tests.

For the purposes of monitoring the process, use the test methods in accordance with Chapter 8 (APPLICATION AND QUALITY CONTROL).

4.4. QUALITY PLAN AND DOCUMENTATION

The Contractor shall submit documentation that meets the minimum requirements and format of the Quality templates attached in the Annex F: QUALITY CONTROL PLAN TEMPLATES.

4.4.1. INSPECTION AND TESTING PLAN (ITP) / QUALITY CONTROL PLANS (QCP)

(a) An ITP or hold points QCP is a master Quality Control Plan or document which shall include acceptance criteria for inspections and must be agreed between Asset Owners' Corrosion Engineer or Representatives and Project Managers by means of pre-approval of quality control documentation generated and submitted by the contractors for Approval. The master quality control plan shall contain hold points agreed to by the Corrosion Engineer.

(b) After Approval of the master Quality Control Plan, the documentation shall be reproduced to be used on a daily basis or per section of work completed or per batch to record all measurements and requirements. These QCP records must include at least surface preparation standards and profile measurement, salt tests, temperature, humidity and dew point measurement, Dry Film Thickness (DFT) measurements, Electrical Insulation Defects (EIDs), adhesion testing, all in accordance with the relevant standards and specifications.

4.4.2. METHOD STATEMENT

The Contractor shall submit method statements, programme and a process flowchart detailing a trial application of the field coating systems.

(a) The Method statement is the document describing the procedures, methods, equipment, and tools to be used for surface preparation, coating, and lining application.

The Application schedule shall state the time and place when the following will be conducted:

- Inspection of material.
- Hydrostatic testing of uncoated castings, pipes, and fittings.
- Manufacture of components.
- Fettling or dressing.
- Degreasing.
- Water soluble salts test.
- Blast cleaning and application of the first coat.
- Application of intermediate and final coats.
- The commencement of site repairs.

(b) Coating and lining products.

(c) Pickling and passivating products (where applicable).

4.4.3. PROCEDURE QUALIFICATION TRIAL (PQT)

The PQT is required for new coating or lining materials or for field joints where new combinations of coating and lining materials are proposed to be used and subsequent inspection and testing of its properties to confirm that the procedure is able to achieve a coating or lining of specified properties carried out at the premises of the applicator or any other agreed location.

In addition, pre-qualification testing may be required by Asset Owners to set and approve an initial benchmark before Project Managers allow work to continue on the project.

The Contractor shall undertake a procedure qualification test program at least one month prior to commencement of field coating work to satisfactorily demonstrate that the proposed repair procedures will meet the requirements of this Specification when applied to pipe.

Prior to commencement of the field coating operations the Contractor shall submit to the Corrosion Engineer all necessary details of the proposed coating materials and procedures for Approval and evidence of its experience of applying the selected field coating materials. The testing shall verify the properties of the applied coatings as detailed in the relevant sections of this specification.

The test program shall be proposed by the Contractor and witnessed by the Corrosion Engineer. It shall be based on the consistent successful application of the coating to three or more repairs for each pipe diameter and coating type of each type to be used, to confirm the properties of the applied coatings. Approval of the material and procedures shall be based on the application procedure the Contractor proposes to use for the repairs. The

results shall be recorded by the Contractor and submitted to the Corrosion Engineer for Approval.

4.4.4. PRE-PRODUCTION TRIAL (PPT)

The PPT is the application of a coating or lining systems and subsequent inspection and testing of its properties to confirm that the method statement is able to produce coating or lining of specified properties carried out in the factory or field immediately prior to start of production.

The PPT shall be performed on site to demonstrate that the repair coatings can be correctly applied in accordance with the written procedures before production coating commences. The PPT shall be performed immediately prior to production using the same written procedures and personnel involved in the repair coating application during production. PPT shall repeat the test programme required by PQT.

Only individuals who have successfully completed the PQT and PPT shall be used for repair coating application. The minimum tests to be undertaken during PPT shall be as required in the relevant coating specifications.

A PPT plan detailing all aspects of the application and destructive testing shall be submitted to the Corrosion Engineer 30 days before the test date for review and comments. A PPT report will be issued within 10 days of the testing providing numerical values of test results.

4.4.5. MATERIAL TESTS

The Manufacturer's material test data certification and the Contractor's quality records shall be subject to examination by the Corrosion Engineer or his representative. Reasonable samples of the cleaning and coating materials to be used may be removed for testing.

Rejection of the samples shall place a hold on the use of materials of the same batch number and any components that have already been cleaned or coated with the rejected material shall be reworked.

At the sole discretion of the Corrosion Engineer, he may require that for each batch of coating materials, the Contractor shall, in the presence of the Corrosion Engineer, take a one-kilogram/one-litre sample of each material and batch, sealed in suitable containers and identified by their batch number. These batch samples shall be stored by the Supplier or Manufacturer, as per Section 8.1 (MATERIAL) below or as per the Manufacturers data sheet, whichever is the more stringent.

These samples shall be maintained for a minimum period of two years following completion of production. The Corrosion Engineer may take up to one half of each of these samples for testing at any time during that period.

4.5. INSPECTION BY THE CORROSION ENGINEER

Inspection of items to be corrosion protected shall be carried out by the Corrosion Engineer, his appointed representative or a nominated inspection authority as per the approved Quality documentation and inspection procedures at the steel fabricator’s works, corrosion applicator’s works or on site.

The Corrosion Engineer's inspection shall in no way relieve the Contractor or Sub-contractors of any of their obligations to design, manufacture and supply equipment of superior quality and workmanship in accordance with the specification.

4.5.1. FIELD AND SITE INSPECTIONS

For new pipelines, the frequency of inspection shall be continuous during bedding, laying, field joint, backfill and testing.

For field jointing maintenance work, the frequency of inspection shall be continuous.

4.6. FREQUENCY OF TESTING AND INSPECTION ON AUTOMATED SYSTEMS

Testing and inspection of automated blasting and coating operations shall be such that the specified parameters are obtained consistently throughout the operation. Frequency of grit additions to maintain blast profile shall be established during pre-production testing, applicable to all coating and lining systems.

Blast profile on automated blasting systems deteriorates during the shift due to wear and breakdown of the abrasive particles.

The spray pattern and thickness can change due to wear. Atomisation pressures can change due to progressive blockage of spray lines which results to changes to the coating consistency and film thickness.

Checking must be carried out at least every two hours by the in-house inspector and records must be available for the third-party inspector.

4.7. INDEPENDENT INSPECTION AND SURVEILLANCE

An independent, technically qualified organisation or individual as described in Section 4.10 (QUALIFICATIONS AND EXPERIENCE OF STAFF) shall be employed by the client to carry out quality surveillance of the work on his behalf.

The inspection authority has the right to inspect any item covered in the Contract at any stage of execution of the Contract and shall be granted safe access to the works as required.

Where imported supplies are to be inspected before shipment, the Contractor shall notify his suppliers abroad of the conditions applicable to inspections and, also request them to notify the representative abroad when consignments are ready so that arrangements for inspection may be made.

Testing shall be verified by an acceptable independent organisation.

4.8. QUALITY CONTROL AND MEASURING INSTRUMENTS

The frequency and method of both non-destructive and destructive testing shall be pre-agreed in the master quality control documentation.

The Contractor shall have the following measuring instruments, at his shop or site, at all times:

1. Climatic condition testing and measuring instruments:
   - Ambient air temperature gauge.
   - Steel surface temperature gauge.
   - Relative humidity gauge.
   - Dew point measurement gauge.
2. Pre-preparation:
   - Radius gauge.
   - Weld finish comparator.
   - Weld height measurement gauge.

- UV light.

3. Surface preparation:
   - Blast surface profile gauge.
   - Cleanliness comparator.
   - Soluble salt test equipment.
   - Dust and debris test tape.
4. Application:
   - Wet film thickness gauge.
   - Dry film thickness gauge.
   - Electrical insulation defects tester (spark and sponge).
   - Adhesion tester (hydraulic pull-off).
   - Curing test (MEK and/or Barcol hardness test).
5. Calibration of test and measuring instruments:
   - All test instruments shall have current calibration certification.
   - All instruments shall be calibrated daily, except where otherwise specified by manufacturers, to achieve the required accuracy.
   - Dry film thickness gauges shall be calibrated on a flat surface, provided that the surface profile is in accordance with the specification.

4.9. DESTRUCTIVE TESTING

Non-destructive and agreed destructive testing shall be done in accordance with ITP/QCP to meet requirements.

Should the non-destructive testing results be cause for concern, the Corrosion Engineer or his representative may carry out additional destructive tests to ascertain compliance with the Specification. Areas damaged shall be repaired by the Contractor to the satisfaction of the Corrosion Engineer at no additional cost.

4.10. QUALIFICATIONS AND EXPERIENCE OF STAFF

To facilitate Skills Development in South Africa various Director Generals of the Water Service Providers and Water Asset Owners authorized skills requirements associated with corrosion protection in their organisation.

Corrosion Engineer shall conform to the same requirements as the professional registered person in Section 4.10.1 below.

To ensure skills, quality and reliability of water infrastructure and supply services, the following minimum qualifications and experience are required:

4.10.1. DESIGN ENGINEERS, PROJECT MANAGERS AND CONSULTING COMPANIES

- Design Engineering companies, Project Management companies, and Consulting companies shall employ and involve in the project at least one staff member who is a professionally registered engineer or technologist with the appropriate corrosion awareness qualifications, skills and experience that are acceptable to the employer.

  This team member shall have passed any two of the following corrosion courses:

  - Corrosion Engineering Course *
  - CITWI Corrosion in the Water Industry Course *
  - Corrosion Management Course*
  - SAQCC Paint Supervisors Course *
  - SAQA approved equivalent courses,
  - Other International approved courses, such as but not limited to ICorr (UK), Corrodere, ACA, AMPP (NACE CIP, CP and SSPC).

  NOTE: * Courses examined by SAQCC (Corrosion Protection).

Experience: The individual described above shall have a minimum of 15 years relevant experience in corrosion protection which shall include both protective coatings and cathodic protection.

4.10.2. MAIN CONTRACTOR, CORROSION PROTECTION INSPECTORS AND APPLICATORS

A senior member of the construction team (main Contractor and, if applicable, the Sub-Contractor companies for Corrosion Protection Inspection and Application) shall have the minimum appropriate corrosion awareness qualifications comprising passing any two of the following:

- Corrosion Engineering Course *
- CITWI Corrosion in the Water Industry Course *
- Corrosion Management Course*
- SAQCC Paint Supervisors Course *
- SAQA approved equivalent courses,
- Other International approved courses, such as but not limited to ICorr (UK), Corrodere, ACA, AMPP (NACE CIP, CP and SSPC).

NOTE: * Courses examined by SAQCC (Corrosion Protection).

The minimum skills requirements necessary for manufacture, installation (internal and external field joints and specials) and any other corrosion protection defect repair of steel pipes and other steel infrastructure are specified below:

4.10.2.1. CORROSION PROTECTION INSPECTOR:

Inspectors are responsible for performing tests in accordance with the QCPs and documenting inspection results and submitting reports to their supervisor for onward transmission to the Corrosion Engineer.

- Unsupervised individuals inspecting items exposed to atmospheric corrosion shall have a minimum SAQCC Level 1 Paint Inspectors Certification or a minimum NACE CIP Level 1 qualification or SAQA approved equivalent qualification and at least 3 years documented inspection experience. A Level 1 Inspector may also inspect items exposed to different corrosion environments under the supervision of a Level 2 or Level 3 Inspector. The inspector's qualification and experience shall be approved at the discretion of the Corrosion Engineer.

- Individuals inspecting items such as pipelines, field joints etc. shall have a minimum SAQCC Level 2 Paint Inspectors Certification or a minimum NACE CIP Level 2 qualification (NACE CIP Level 1 under the supervision of a NACE CIP Level 2) or SAQA approved equivalent qualification and at least 7 years documented inspection experience. The inspector's qualification and experience shall be approved at the discretion of the Corrosion Engineer.

- Supervision of inspection teams and unsupervised non-destructive and destructive inspections of liquid and non-liquid coatings applied to any substrate, where technical knowledge and problem-solving ability may be required, shall only be performed by individuals having a NACE CIP Level 3 qualification or SAQA approved equivalent qualification with at least 10 years documented inspection experience. The inspector's qualification and experience shall be approved at the discretion of the Corrosion Engineer.

4.10.2.2. CORROSION PROTECTION SUPERVISORS:

Individuals shall have a minimum SAQCC examined Paint Supervisors Certification, ICorr (UK) or equivalent formal qualification and at least 3 years relevant involvement and documented experience at the discretion of the Corrosion Engineer.

4.10.2.3. CORROSION PROTECTION APPLICATORS:

Individuals shall have a minimum SAQCC Paint Applicators Certification or equivalent formal qualification at the discretion of the Corrosion Engineer.

4.10.2.4. IN ADDITION TO THE ABOVE, IT IS MANDATORY THAT:

- Applicators and Supervisors shall be trained and certified in their individual capacity and to have a product specific qualification from the brand name supplier once a contract is entered into with a successful bidder.
- The brand name suppliers of linings, coatings, shrink sleeves, or tape products shall ensure that Applicators and Supervisors are appropriately trained and certified in their individual capacity, as competent and approved Applicators of their products, at the time of receiving training by the supplier.
- This product specific training and certification shall be supervised and monitored by an approved independent authority.

The product suppliers' representative who gives the product specific training shall also have passed any two of the following courses:

- Corrosion Engineering Course *
- CITWI Corrosion in the Water Industry Course *
- Corrosion Management Course*
- SAQCC Paint Supervisors Course *
- SAQA approved equivalent courses,
- SAQCC Corrosion Protection Course PA1*
- Other International approved courses, such as but not limited to ICorr (UK), Corrodere, ACA, AMPP (NACE CIP, CP and SSPC).

NOTE: * Courses examined by SAQCC (Corrosion Protection)

5. GENERAL REQUIREMENTS

5.1. DESIGN PRECAUTIONS

All items to suppress corrosion shall be designed in accordance with SANS 12944-3.

5.1.1. COMPATIBILITY OF MATERIALS

The Contractor shall ensure that metals or alloys are compatible or are adequately protected if, in the galvanic series, there is a 0,3-volt difference in the galvanic potential.

5.1.1.1. ACCESSIBILITY

Easy access for protection and maintenance shall be provided. The use of back-to-back angles, partially open box sections or inaccessible stiffeners to be avoided.

Corrosion protection of areas that are unavoidably inaccessible shall be specifically specified or approved by the Corrosion Engineer.

5.1.1.2. WATER RETENTION AREAS

Pockets, recesses and crevices in which water and dirt may collect shall be avoided. Water retention areas shall be properly drained by holes as large as possible i.e. 150 mm diameter – minimum 50 mm diameter.

Surfaces of corrodible metals, such as the inside of tanks or hollow sections that cannot be protected by any method (e.g. painting or dipping), shall be avoided, or where not possible, be fully sealed against ingress of air and moisture.

5.1.1.3. PERMANENT INSTALLATIONS IN CONCRETE

Permanent installations in concrete shall be manufactured from stainless steel, coated and lined as specified in Section 9.3.4 (ENCASED IN CONCRETE).

Reinforcing steel shall not be welded to puddle flanges, pipes, pump bases or any steel structure encased in concrete.

5.1.2. CORROSION PREVENTION

The Contractor shall ensure that the following steps are taken to minimise corrosion:

(a) If dissimilar metals are used:

Coat all surfaces of the whole assembly including the more noble member of the galvanic series.

(b) If the noble member of the assembly cannot be entirely covered:

(i) Keep the anode/cathode ratio as large as possible in the particular component.

(ii) Use electrical insulators between two metals. Insulation must be completed; a bolt requires a sleeve as well as washers of an insulating material.

(c) Joints and crevices between metals shall be sealed.

(d) Where fastening is unavoidable, the fasteners shall be more noble (cathodic) than the base material. Fasteners shall be coated where possible and/or adequately electrically insulated between fasteners and the base material.

5.2. PIPE JOINTING SYSTEMS

The following pipe jointing systems are generally used:
Refer to the diagrams attached in ANNEX B: DRAWINGS.

Mechanical couplings
Flanged joints
Insulating joints
Spigot and socket
Butt welded joints for large pipes
Butt welded joints for small pipes

The type of jointing system will influence the choice of corrosion protection for both the mainline pipe and the field joint. Consideration must be given to the method of application as a separate issue to the selection of the corrosion protection material.

Fully welded pipe connections, as opposed to flanged / mechanically coupled pipe, are preferred where at all possible and especially on joints of pipes of 800mm diameter and larger.

Internal lining access limitations must be considered in the choice of corrosion protection of the field joints, especially for pipes smaller than 800mm diameter. In such cases the field joints systems must be appropriate and compatible with the lining and coating system to allow for successful application.

Buried flanged joints / mechanically coupled connections must be avoided. If possible flanged and coupling joints must be located in chambers. If not possible, needs to be properly protected with a mastic and wrap.

More flanges may be required for small bore piping to achieve suitable internal corrosion protection. Alternatively, remote lining application methods for the internals of small bore welded pipes or pigging repair method should be considered.

Refer Section 9.7 (CORROSION PROTECTION OF DIFFERENT JOINT SYSTEMS).

5.3. INSTALLATION REQUIREMENTS

5.3.1. SUPPORTS

When pipes are installed or mounted on concrete supports, rubber insertion shall be used to insulate the pipe from the support. The thickness of the rubber insertion shall not be less than10 mm and protrude not less than 20 mm all round.

5.3.2. ANCHORS IN CONCRETE

All permanent anchors in concrete shall be stainless steel to ASTM A240 grade 316.

Special care shall be taken to ensure that anchors be installed to the correct level and depth. Anchors shall not be cut after installation without prior inspection and Approval of the Corrosion Engineer.

To avoid a galvanic reaction (stainless steel/galvanizing) under wet conditions, the nut and washer shall be FBE coated. Where necessary, caps shall be specified by the Corrosion Engineer.

5.3.3. SEALING

Pipes that enter or exit concrete shall be sealed on their circumference with a continuous polyurethane or polysulphide flexible sealer, in a 25 mm square recess, approved by the Corrosion Engineer.

5.3.4. ARMORING

Armoured or special protection shall be applied to surfaces at all road and rail crossings, through sleeves and culverts, and as requested by the Corrosion Engineer.

5.4. HANDLING AND TRANSPORT

5.4.1. PHYSICAL PROTECTION

Adequate provision shall be made for the protection of the pipe coating, between the completion of manufacture and installation.

The coated items shall not be handled within the drying time, relevant to the ambient temperature, recommended by the coating manufacturer.

5.4.2. END COVERS

After inspection, testing and final Acceptance, all ends (including branch ends), shall be sealed as follows:

All plain ends shall be sealed with plastic or other approved sheeting secured to the pipe circumference with double flat steel binding strips and all flanged ends shall be closed off with sturdy timber flanges.

All plastic covers and timber flanges to be clearly marked: “NOT TO BE REMOVED BEFORE INSTALLATION”.

Plastic covers and timber flanges shall remain in place during handling, transport, storage, and only removed immediately prior to / during laying.

5.4.3. BRACING

Temporary bracing to prevent excessive flexing and oval deformation of thin wall pipes during lifting and transportation shall be designed, manufactured, and installed to avoid damage to coatings and linings.

5.4.4. LIFTING

All coated items shall only be lifted by means of broad band slings that will not damage the coating. Slings shall not be less than 500 mm wide for pipes up to 500 mm nominal bore and 1 000 mm wide for larger pipes or as approved by the Engineer.

5.4.5. MARKING OF PIPES, CRATES AND BAGS

(a) Each pipe and special shall be legibly, indelibly, and durably marked, (stencilled and hard stamped in such a manner that the coating is not damaged), with the following information:
- Contract number.
- Scheme name.
- Serial and or item number of the pipe or special.
- Nominal diameter.
- Grade and thickness of steel.
- Hydrostatic test pressure.

(b) The bags and crates shall be tagged using metallic tags and shall indicate the following information:

- Contract number.
- Scheme name.
- Part numbers.
- Description.
- Sizes.
- Quantities.

Each bag or crate shall have the delivery address listed on a separate metallic tag.

5.4.6. TRANSPORT

Coated items shall be handled with due regard to the relatively soft nature of organic coatings and appropriate precautions shall be taken.

The Contractor is responsible for the safe delivery of all the items and small parts to site without damage. All items shall be securely packed to prevent damage while in transit.

If transported by a third party, the Contractor is responsible for ensuring protection of items as specified.

Precaution shall be taken to support and chock the pipes on padded cradles and/or saw-dust filled bags to prevent movement when loading onto vehicles.

Where stacked pipes are transported, the packing shall be of a thickness and positioned to ensure that pipes do not touch when they flex.

Items shall be firmly lashed or chained with padded lashing. The area of padded surfaces shall be adequate to prevent damage to coatings.

Bolts in bags and other small components shall be labelled and crated. The bags and crates shall be tagged using metallic tags and shall be marked in accordance with Section 5.4.5 (MARKING OF PIPES, CRATES AND BAGS) (b) above.

Each bag or crate shall have the delivery address listed on a separate metallic tag.

The Site Engineer shall be notified of the delivery date and of any requirements regarding off-loading and storage at site.

5.4.7. OFF-LOADING AT SITE

The pipe supplier shall be responsible for the transportation and supervision during off-loading of the pipes and other small components at the delivery site.

Under no circumstances shall coated pipes be allowed to rest directly on the ground.

The final delivery inspection and Acceptance of equipment supplied shall be undertaken on site after off-loading has been completed.

5.4.8. STACKING AND STORAGE

The Contractor shall provide all the necessary balks of timber or saw-dust filled bags used to support the items on soil, concrete or other hard surface and to separate them from each other both at his works, on site and when stringing along the trench.

Pipes shall be stacked to a safe height on level ground not exceeding two pipes high.

Grass or other vegetation shall not be allowed to grow in the storage area within three metres of the equipment.

5.4.9. DAMAGE

Any damage that occurs during the handling and storage of items at the Manufacturer/Contractor's works, including transportation to site, shall be repaired by the Manufacturer/Contractor at his own cost, in accordance with the specification and to the Approval of the Engineer.

5.4.10. REJECTION

The Engineer has the right to reject any damaged items and materials which have been delivered and off-loaded at site.

5.5. SPARE PIPES

Corrosion protection of spare pipe spools is described in Section 9.10 (SPARE PIPES - LONG TERM STORAGE OF PIPES).

5.6. MEASUREMENT AND PAYMENT

The lining and coating of straight pipes shall be measured per linear metre of pipe, lined, and coated.

The lining and coating of specials, whether lined by hand or otherwise, shall be measured per unit of completed specials, except where such specials are lined and coated in a single in-situ operation by mechanical means. In this case the lining and coating of the same shall be included, measured per linear metre of completed pipeline.

Payment for factory applied linings and coatings shall be included in the payment for pipes delivered to site.

Payment for in situ applied linings and coatings shall be for completed linings and coatings at the rates scheduled.

6. MANUFACTURE AND PRE-PREPARATION

STANDARDS

SANS	1344	Medium duty solvent detergent.
SANS	5770	Preparation of steel substrate before the application of paints and related products – Test for the assessment of cleanliness of blast-cleaned steel surfaces for painting - Freedom from certain soluble salts.
SANS	5772	Preparation of steel substrate before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces - Profile of blast-cleaned steel surfaces by a micrometre profile gauge.
SANS	5502-3	Preparation of steel substrate before the application of paints and related products – Test for the assessment of surface cleanliness – Part 3: Assessment of dust of steel surfaces prepared for painting (pressure sensitive tape method).
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after overall removal of previous coatings.
SANS	8501-3	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 3: preparation grades of welds, edges, and other areas with Surface imperfections.
SANS	8504-2	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast cleaning.
SANS	10064	The preparation of surfaces for coating.
SANS	14713-2	Zinc coatings – Guidelines and recommendations for the protection against corrosion of iron and steel in structures. Part 2: Hot dip galvanizing.
SANS	12944-3	Paints and varnishes – Corrosion protection of steel structures by protective paint systems. Part 3: Design considerations.
ISO	11125	Preparation of steel substrates before application of paints – Metallic blast-cleaning abrasives.
ISO	11127	Preparation of steel substrates before application of paints – Non- metallic blast–cleaning abrasives.
NACE	SP0178	Fabrication details, surface finish requirements, and proper design considerations for tanks and vessels to be lined for immersion service. Appendix C - Visual comparator for acceptable weld contours.

6.1. RESPONSIBILITY

The Manufacturer or refurbishment Contractor shall be responsible for all the pre-preparation prior to surface preparation. Pre-preparation shall be carried out to the Approval of the Corrosion Engineer and the Corrosion Protection Contractor.

6.1.1. PERSONNEL

Pre-preparation shall be carried out by competent personnel, under the supervision of an experienced supervisor.

6.1.2. MARKING

All items shall be permanently and indelibly marked to identify each individual item as specified by the Corrosion Engineer.

6.2. FABRICATION REQUIREMENTS

There are always two separate requirements for the degree of steel finishing and smoothing.

- The manufacturing and fabrication requirements.
- The steel finishing requires smoothness to meet the corrosion protection specifications in accordance with SANS 8501-3 and the requirements of Sections 6.2.1 (SURFACE DEFECTS) up to 6.2.4 (SHAPE IMPERFECTIONS), below, whichever is more stringent.

6.2.1. SURFACE DEFECTS

All extrusions, rolled steel, and castings shall be clean and free of score marks, pits, protrusions, blisters, porosity, blowholes, cracks or any other flaws which may be detrimental to structural performance.

Laminations, scabs, or occluded scale shall be ground out. If such grinding penetrates deeper than 7% of the metal thickness, the area shall be repaired by welding or the metal shall be rejected at the discretion of the Corrosion Engineer.

6.2.2. SURFACE IMPERFECTION

An imperfection is a discontinuity or irregularity in the outer or inner surface of a steel pipe, i.e. a scab, lamination, flat area, sharp indentation, deep scratch and gouge mark. At the discretion of the Corrosion Engineer, such marks that have a depth greater than 7% of the actual wall thickness shall be classed as structural defects, as well as being unsuitable for coating or lining. Imperfections 7% or less can be smoothed out by grinding alternatively repaired by welding at the discretion of the Corrosion Engineer, provided that the repair is compatible with the coating or lining system to be applied. The maximum size of an imperfection to be repaired shall not exceed 0.01m^2.

Wall Thickness - After extensive grinding, which must be approved, the remaining wall thickness shall be measured by ultrasonic inspection and shall not be less than the specified minimum wall thickness. Items formed from pipe with thickness less than the specified minimum wall thickness shall be rejected. Ground areas shall merge smoothly with the surrounding pipe surface.

Prior to the coating application for pipes, the exterior surface shall be thoroughly inspected under adequate lighting. Any damage such as surface imperfections, slivers, scabs, burrs, gouges, or sharp-edged defects, shall be repaired in accordance with this specification. Pipes that have damage repaired by grinding shall be re-blasted to meet the requirements of the clauses above.

6.2.3. SURFACE UNDERCUTS, CAVITIES AND PITS

Weld undercuts and cavities as well as pits in metal surfaces are not permitted.

All undercuts, cavities and pits shall be ground out, re-welded and ground to a smooth contour. For maintenance of different surface imperfections refer to Chapter 11 (**REHABILITATION / RENOVATION**).

6.2.4. SHAPE IMPERFECTIONS

6.2.4.1. OUT OF ROUNDNESS

Shape imperfections are dents in the pipe body or out of roundness on pipe ends.

When the mean pipe diameter to wall thickness ratio exceeds 120, shape imperfections shall be checked using templates and straight edges with tolerances to be agreed between

the purchaser and the supplier.

The corrosion risk is that the sagging of the pipe together with a rigid coating or lining can result in annular disbondment and an interstitial space between the steel substrate and coating where steel degradation can take place without being visible on Cathodic Protection surveys.

6.2.4.2. DENTS

A pipe shall not contain dents greater the 6,4 mm measured as the gap between the lowest point of the dent and the projection of the original contour of the pipe.
The length of the dent in any direction shall not exceed one-half of the diameter of the pipe.

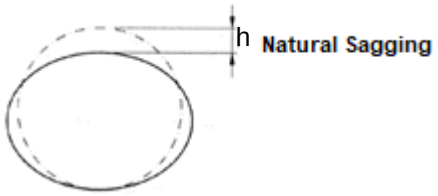
All cold formed dents deeper than 3,2 mm with a sharp bottom gouge shall be considered defects. The gouge may be removed by grinding**.**

6.2.4.3. PIPE ENDS OVALITY

Out of roundness (ovality) on pipes should not be more than ± 1% of the outside diameter of the pipe or, alternatively, as agreed between purchaser and the supplier. Natural sagging of the pipe is not included in the 1%.

The out of roundness limitation for pipes with rigid coatings or linings is necessary to prevent damage to coating or lining when completing a field joint.

The difference between the nominal pipe circumference and the pipe end circumference shall not be greater than the pipe wall thickness.



Natural sagging of un-stiffened pipes shall be calculated as follows:

$$h = \frac{D^4}{t^2} \times 1{,}312 \times 10^{-10}$$

Where

h is the natural diameter sag, in millimetres (mm);

D is the mean pipe diameter (pipe outside diameter – pipe wall thickness), in millimetres (mm);

t is the pipe wall thickness, in millimetres (mm);

$1{,}312 \times 10^{-10}$ is a conversion factor that allows for the density and Young's Modules of steel and the acceleration due to gravity, in millimetres (mm).

EXAMPLE

Pipe outside diameter	= D = 1 820mm
D^4	= 10 685 471 850 496
Wall thickness	= t = 12 mm
t^2	= 144
Mean diameter	= 1 820 – 12 = 1 808
10^{-10}	= 0.000 000 000 1

$$h = \frac{10\ 685\ 471\ 850\ 496}{144} \times 1{,}312 \times 0.000\ 000\ 000\ 1$$

= 9.7 mm

6.2.4.4. LIFTING LUGS, STIFFENERS, COMPENSATION PLATES AND CROSS BRACING

Where required, lifting lugs, stiffeners, compensation plates and cross bracing shall be fitted by the manufacturer to the requirements of the Corrosion Protection Contractor, Inspector, and the Approval of the Engineer.

6.2.4.5. TEMPORARY LIFTING LUGS TO BE REMOVED

After removal, the damaged coating area shall be repaired in accordance with the original Specification.

6.2.4.6. PERMANENT LIFTING LUGS

Permanent Lifting Lugs shall have a doubler (load spreading) plate. These plates are required to have a vent hole for the release of welding gases. After completion of fabrication welds, the vent holes on the load spreading plates shall be closed by welding. Lifting lugs not intended to be removed, shall be manufactured of equal or more noble grade than the base material in accordance with the Specification.

6.2.4.7. COMPENSATION PLATES

Where compensation plates, such as used for reinforcement at pipe branches, these plates (collars, wraps) are required to have a vent hole for the release of welding gases. After completion of fabrication welds, the vent holes shall be closed by welding.

6.2.4.8. STIFFENERS

External stiffeners must be attached with continuous fillet welds to avoid corrosion crevices before the application of external coating or internal lining. Stitch welding is not acceptable.

6.2.4.9. BRACING

Large diameter pipes may become out of round under their own weight and bracing shall be installed by the pipe manufacturer to prevent the oval deformation. Precautions may need to be taken that the bracing does not hinder boom spray access or other corrosion protection application methods. The Corrosion Engineer shall take into consideration that certain coating and lining types do not accommodate flexing and oval deformation of steel pipes.

6.2.5. WELD FINISH

The weld finish requirement shall be applicable to all types of corrosion protection systems and read in conjunction with the weld finish subheadings hereunder.

All welds shall be continuous and shall have a smooth contour. Undercuts, sharp protrusions, steep angles, blowholes, and discontinuity of reinforcement are not permitted. The weld finish shall be suitable and appropriate to the type of corrosion protection.

Welding processes used shall limit heat input to a minimum to restrict the heat affected zone. Welds shall be free from slag, slag inclusions, cracks, surface cavities and under-cuts. Irregular projections shall be ground to a smooth contour. Areas adjacent to welds shall be free from weld spatter. Such spatter shall be removed by grinding or scraping.

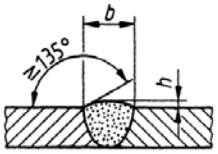
Stitch welding or staggered welds substantially increases the risk of corrosion and is prohibited unless permitted with prior written Approval of the Corrosion Engineer together with the submission of remedial corrosion protection procedures.

Some special corrosion protection materials such as cement mortar, and fibre glass may require different weld finish requirements which shall be specified by the Corrosion Engineer.

6.2.5.1. WELD FINISH FOR LIQUID OR POWDER APPLIED SYSTEMS

The weld finish requirements for proper corrosion protection shall be in accordance with NACE SP0178 grade C (ground smooth and blended) for liquid or powder applied systems.

The shape of welds shall be gently convex, and the height of the weld bead shall not exceed 1mm internally and 3mm externally. The angle of interface between substrate and weld shall be ≥ 135°.



The Approval of the weld resides with the Corrosion Engineer or appointed inspector. The Corrosion Engineer may in his sole discretion impose alternative requirements for weld bead height as well as the angle that the weld bead makes to the surface.

6.2.5.2. WELD FOR TAPE WRAP AND SHRINK SLEEVES

The weld finish requirements for proper corrosion protection shall be in accordance with NACE SP0178 grade B (ground flush) for tape and shrink sleeve systems.

For tape wrap and shrink sleeves, the weld bead height is critical, and welds shall be ground flush (reduced to zero mm).

- Weld Bead Height with respect to shrink sleeves and tape wrap is more critical than the requirements for liquid or powder applied systems.

- The requirement for the weld ground flush is applicable to corrosion protection materials applied under tension as a sheet, a film or tape wrap.

- This requirement for a flush ground weld bead is applicable to factory manufactured steel pipe for longitudinal, circumferential and spiral welds, as well as circumferential field welded joints. Failure to adhere to these weld finish requirements will result in tape wrap or shrink sleeves being prohibited for use.

6.2.5.3. WELD FINISH FOR RUBBER LINING

The steel finish shall meet the requirements of EN 14879 Part 1:2005 Table 5 – Weld imperfections – Class A4 - For a nominal lining thickness (natural or synthetic rubber sheeting) over 1 mm. Refer to pictorial diagrams in Annex H: WELD IMPERFECTIONS - EN 14879

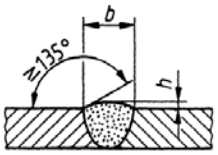
Selected extract from Table 5 – Weld imperfections – Class A4:

- Excess weld metal and overlap: Weld bead permitted where b/h ≥ 10. Where b is the bead width and h is the bead height. Not permitted for tubes with a nominal size of DN 500 or lower.
- Incompletely filled groove: Permitted where b/h ≥ 10. Not permitted for tubes with a nominal size of DN 500 or lower.
- Undercuts: Permitted where h is not greater than 0,1 mm if edges can be smoothed by blast cleaning.

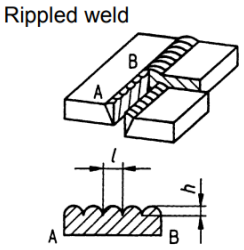
No ripple allowed on weld bead for rubber lining.

6.2.5.4. WELD FINISH FOR SINTERED POLYETHYLENE COATING

The shape of welds shall be gently convex, and the height of the weld bead shall not exceed 1mm internally and 3mm externally. The angle of interface between substrate and weld shall be ≥ 135°.



The steel finish for rippled welds is only allowable where h ≤ 0,3 mm and l/h ≥ 30.
(Where h is rippled height superimposed on the weld bead height)



The Approval of the weld resides with the Corrosion Engineer or appointed inspector.

6.3. PRE-PREPARATION

6.3.1. GENERAL REQUIREMENTS

6.3.1.1. PROTRUSIONS

Protrusions shall be removed by grinding and dressing to a smooth contour.

6.3.1.2. SHARP EDGES

Burrs and rough faces caused by guillotining, flame cutting, drilling, machining, or punching shall be removed by grinding.

All sharp edges shall be radiused to a minimum of 2 mm.

6.3.2. MATERIALS

6.3.2.1. CASTINGS

Castings shall be structurally acceptable to the Engineer and may be rejected at the Engineers discretion.

The use of grey cast iron is generally not accepted.

The surface finish on casting with respect to joint lines, blowholes and roughness shall be acceptable to the Corrosion Engineer.

Grinding is permissible to achieve an acceptable surface finish.

Castings with defects exceeding the restrictions given in the tables below shall be rejected.

It is **not** acceptable for new castings to have metal stitching.

In the case of blowholes occurring opposite each other, the combined depth shall be taken into account.

Blowholes and cavities not exceeding 2 mm depth shall be smoothed out by grinding. Small and repaired blowholes shall be ground level and smooth.

- For cast steel (carbon content <2%) components only:

  In addition to passing the pressure test criteria for the cast steel component the Acceptance criteria for the repair of blowholes and cavities shall be:

SURFACE	DEPTH OF BLOWHOLES	DIAMETER OF BLOWHOLES	REPAIR METHOD
Internal	Maximum 10% of material thickness	20% maximum of material thickness	Welding only*
External	Maximum 5% of material thickness	20% maximum of material thickness	Solvent free epoxy or welding
External	5% to 10% maximum of material thickness	20% maximum of material thickness	Welding only*

- For brass, bronze, ductile iron, spheroidal graphite iron (SG iron) and other cast materials:

  In addition to passing the pressure test criteria for the cast component the acceptance criteria for the repair of blowholes and cavities shall be:

SURFACE	DEPTH OF BLOWHOLES	DIAMETER OF BLOWHOLES	REPAIR METHOD
External	Maximum 5% of material thickness	20% maximum of material	Solvent free epoxy or brazing

NOTE: Welding is not generally permitted on castings.
*Welding on castings is only permitted under the authority of a Metallurgist.

Castings shall, after inspection by the Corrosion Engineer, be ground smooth and have a surface finish appropriate for the specified corrosion protection system.

6.3.2.2. HOT-DIP GALVANIZED ITEMS

The design and manufacture of all items to be hot-dip galvanized shall conform to SANS 14713-2.

Vent holes shall be drilled by the manufacturer, in accordance with the above standard, to the Approval of the Engineer and Galvanizer.

The Silicon and Phosphorus contents of materials to be galvanized shall comply with the standard below. If no material certificates are available, samples of the materials shall be analysed for their Silicon and Phosphorus contents.
The following materials shall be used:

(a) For aesthetic appearance
- Aluminium killed steel or
- Silicon killed steel with a Silicon content not exceeding 0,04% and a Phosphorus content not exceeding 0,02%.

NOTE: Material certification shall be supplied.

(b) For general corrosion protection
- Aluminium killed steel or
- Silicon killed steel with a Silicon content not exceeding 0,25% and a Phosphorus content not exceeding 0,02%.

6.3.2.3. CORROSION RESISTANT STEELS

Fabrication shall take place in dedicated areas separate from carbon steel.

All equipment used in the forming and manipulation of stainless-steel items during fabrication shall be clean and free of materials that may contaminate the metal with carbon steel.

The manufacture of items from corrosion resistant steels shall be in accordance with the SASSDA's Information Series and the guidelines of the material supplier.

Discoloration caused by welding or cutting shall be mechanically cleaned by buffing followed by pickling and passivation in accordance with the SASSDA's Information Series and the guidelines of the material supplier.

Organic contamination shall be removed by degreasing in accordance with Section 7.2.3 (DEGREASING).

Iron contamination shall be removed by pickling and passivation, by the dipping process, after degreasing.

All surfaces shall be tested for free iron contamination by the water or the ferroxyl test method.

6.4. PRIMARY CLEANING

The Manufacturer or Refurbisher shall remove oil, grease, or other surface contaminants with a water-soluble solvent degreaser followed by rinsing with clean, soft water before the items are despatched to the Corrosion Protection Contractor. Carry out a reliable and suitable test to ensure oil and grease is removed.

6.4.1. HYDROSTATIC WATER QUALITY

Water used for Hydrostatic testing shall be free of contamination of oil, grease, and other deleterious matter. Particular care needs to be taken when the Hydrostatic test water is recycled. If Hydrostatic test water is recycled then a daily evaluation shall be done to ensure compliance that there is no contamination.

6.4.2. WELD SPATTER RELEASE AGENTS

The use of weld spatter release agents is not acceptable as the typical formulations contain silicone which is difficult to identify and remove. Such weld spatter release agents may result in poor adhesion of coatings and linings.

7. SURFACE PREPARATION

The best possible degree of surface cleanliness is always preferred before the application of corrosion protection materials. Should any doubt arise a cleaner surface and more stringent specification shall be required.

STANDARDS

SANS	1344	Medium duty solvent detergent.
SANS	5770	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness of blast-cleaned steel surfaces for painting - Freedom from certain soluble salts.
SANS	5772	Preparation of steel substrate before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces - Profile of blast-cleaned steel surfaces by a micrometre profile gauge.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after overall removal of previous coatings.
SANS	8502-2	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 2: - Laboratory determination of chloride on clean surfaces.
SANS	8502-3	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 3: - Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method).
SANS	8502-5	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 5: - Measurement of chloride on steel surfaces prepared for painting – ion detector tube method.
SANS	8504-2	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast cleaning.
SANS	10064	The preparation of surfaces for coating.
SANS	12944-4	Paints and varnishes – Corrosion Protection of steel structures by protective paint systems. Part 4: Types of surface and surface preparation.
ISO	11125	Preparation of steel substrates before application of paints – Metallic blast-cleaning abrasives.
ISO	11127	Preparation of steel substrates before application of paints – Non- metallic blast–cleaning abrasives.
NACE	SP0178	Fabrication details, surface finish requirements, and proper design considerations for tanks and vessels to be lined for immersion service. Appendix C - Visual comparator for acceptable weld contours.

The default surface preparation requirement shall be Sa3 as described in SANS 8501-1 and in addition shall be subject to time limitation between obtaining the degree of surface cleanliness and application of corrosion protection as described in the section that deals with quality control of coatings and linings.

In addition to this default requirement there may also be project specific surface preparation standards that will take precedence.

7.1. RESPONSIBILITY

The weld finish and the manufacturing finish is the responsibility of the steel fabricator and shall be subject to pre-inspection and Acceptance by the Corrosion Engineer before such items are released for corrosion protection.

Any corrective action such as grinding that may be required to meet surface finish requirements for corrosion protection shall be undertaken by the manufacturer and/or welding contractor.

7.1.1. SURFACE PREPARATION

Surface preparation shall be generally in accordance with SANS 12944-4.

Surface preparation of pipes shall be divided into four parts:

- Mainline coatings and linings
- Field Joint application
- Specials
- Renovation

The Corrosion Protection Applicator shall be responsible for activities such as degreasing, salt decontamination and blasting of all surfaces to be corrosion protected.

7.1.2. PERSONNEL

The Contractor carrying out the surface preparation shall have competent personnel with the necessary technical knowledge of the processes involved. All work shall be carried out under the supervision of an experienced and qualified supervisor.

To ensure skills, quality and reliability of water infrastructure and supply services, minimum qualifications and experience are required.

The competence of the personnel is more clearly defined under Section 4.10 (QUALIFICATIONS AND EXPERIENCE OF STAFF) as detailed in this document.

7.1.3. EQUIPMENT

Plant and equipment shall, to achieve the specified surface preparation, comply with the following:

(a) Compressed air supply shall be free of oil and moisture.

(b) Compressors shall have a capacity and pressure output to achieve the required nozzle pressures. (Worn nozzles shall be replaced).

(c) All plant, equipment and temporary structures shall at all times be maintained in good and safe working order.

If the correct surface preparation is not achieved due to inadequate plant and equipment, the Engineer may order the Contractor to obtain such plant and equipment as may be necessary to achieve the specified results.

7.1.4. WORKING CONDITIONS

Surface preparation shall not take place when atmospheric conditions are likely to affect the corrosion protection processes adversely.

The Contractor shall provide screens, covers, trestles or any other equipment (e.g. environment) necessary to avoid contamination of surfaces and to minimise time delays caused by inclement weather.

7.1.5. ACCESS FOR FIELD JOINTS

The Pipe Laying Contractor shall provide method statements of how he intends to lay the pipeline while still allowing safe access to both internal and external field joint surfaces to ensure proper application of corrosion protection.

7.1.5.1. TRENCHES AND FOX HOLES

The Pipe Laying Contactor shall be responsible for providing suitable access for the Corrosion Protection Contractor so as to allow proper application of corrosion protection to the field joints. The clearance between the outside diameter of the steel pipe and the trench excavation shall be such that it allows for the method of corrosion protection e.g. stand-off distance for spraying or clearance for a wrapping machine. Fox holes must be aligned with pipe joints.

7.1.5.2. INTERNAL FIELD JOINT SURFACES

The Pipe Laying Contractor shall provide safe access into pipes with diameters that are large enough to allow man entry in accordance with health and safety regulations.

For pipe diameters too small for safe man entry the Pipe Laying Contractor shall provide a method statement for Approval by the Engineer for internal field joint surface preparation and subsequent application of corrosion protection.

The method statement for internal application of field joint corrosion protection shall define the interaction between the Pipe Laying Contractor and the Corrosion Protection Contractor such that there is a limitation on number of pipe lengths to be laid in advance of application of internal corrosion protection.

Visual inspection shall be done of all internal field joints by video, DVD or similar recording.

7.1.6. HEALTH AND SAFETY

The Contractor shall, at all times, enforce health and safety measures necessary to comply with the latest version of the Occupational Health and Safety Act and the corrosion protection manufacturer's safety requirements.

7.2. PROCEDURE

7.2.1. APPROVAL OF WORKS AND PROGRAMME

The Contractor's programme, plant and equipment and works shall be approved by the Corrosion Engineer prior to commencement of surface preparation.

When the pipe diameter is relatively small such that man access is restricted the corrosion protection of the internal field joints must be done progressively as the pipeline is laid.

For all pipelines, the programme and procedure must detail how access will be dealt with to properly and safely perform internal field joint repairs in accordance with the specifications.

7.2.2. INITIAL INSPECTION

Before accepting items from the fabricator, the Corrosion Protection Applicator and/or Corrosion Protection Inspector shall check the initial condition of the surface for:

(a) Visible surface defects.
(b) Contamination.
(c) Any required metal dressing.

(d) Elimination of burrs and radiusing of edges.
(e) Removing of weld spatter and weld imperfections such as blowholes.
(f) Suitable lifting lugs.

and shall bring any concerns relating to the above to the attention of the Corrosion Engineer. The Corrosion Engineer shall issue instructions for the correction thereof.

Areas subjected to chemical attack, salt spray, fungus or bacteria shall be neutralised, rinsed with clean potable water before abrasive blast-cleaning.

7.2.3. DEGREASING

All surfaces to be coated shall be tested for oil and grease contamination by the water break free test or ultra-violet light or any other method agreed to by the Corrosion Engineer.

Oil and grease contamination shall be removed by:

- Steam-cleaning.
- An emulsifiable or aqueous detergent applied in accordance with SANS 1344.
- An alkaline cleaning solution.

Allow to react, then rinse off with clean, potable water to remove all residues prior to surface preparation, all in accordance with clauses 4.3 and 4.4 of SANS 10064.

The surfaces shall be tested after degreasing and show no oil, grease, or chemical contamination after degreasing.

Care shall be taken to avoid entrapment of cleaning agents in recesses or other retention areas.

Volatile solvent degreasers, such as thinners, are to be avoided as the solvent spreads the grease around and then evaporates leaving a thin residual film of grease over a larger surface area.

7.2.4. ROUGH / PRE-BLASTING

On new steel rough blasting and pre blasting is not normally required.

All rust, mill scale, weld primer or marking paint on the cutbacks of the pipe ends shall be removed by rough/pre-blasting.

Renovation:
For maintenance type work the standard procedure is to rough blast and pre-blast for inspection for mechanical repairs if necessary and final blast.

The Engineer shall be advised when blast-cleaning of the appropriate section will be completed so that an inspection can be carried out to determine if repairs are required.

Blast-cleaning shall be done in accordance with the code of practice SANS 10064 to achieve a cleanliness of Sa2. (SANS 8501-1)

7.2.5. AUTOMATED PRODUCTION LINE BLASTING

Automated blasting using a wheel abrader or similar may be done on a pipe production line or larger structural steel beams as follows.

Twin head abrasive blasting machines shall be used. The abrasive shall be a G18 to G50 steel grit to provide the specified surface profile; all abrasives shall be in accordance with ISO 11124-2, ISO 11124-3, or ISO 11124-4. The use of sand is not permitted.

Grit blasting may be preceded by shot blasting to remove mill scale. Mixing of shot and grit in the same blasting machine is not acceptable unless there are two blasters. In this case, the first may contain a 50/50 mix (or an agreed mix) of shot and grit. The final blast shall use grit only.
Blasting and other dust producing areas shall be screened, or kept separate, from coating application areas using positive segregation or approved air management techniques.

Automated blasting machines often recycle their abrasive and therefore the metallic abrasive shall be continually sieved to remove ‘fines’ and 'contaminants' and the quality shall be checked, including for soluble salts, at a frequency approved in the Quality Control Plan (QCP).

In addition to the parameters of Section 7.2.7.1 (Humidity And Temperature), no blast cleaning shall take place when the prevailing relative humidity is greater than 85%, unless pipe is preheated to at least 5°C above the dew point.

Twice per shift, samples of the abrasive mixture shall be removed from the hopper and checked for hydrocarbon contamination. The sample shall be placed in a beaker to which de-ionised water is added. The beaker shall then be sealed and shaken vigorously. Once the grit has settled the surface of the water shall be examined for signs of hydrocarbon contamination. If any signs are found, all the abrasive in the hopper shall be rejected and not re-used.

Additionally, abrasive materials shall be checked at least once per shift to ensure that only uncontaminated angular grit with an acceptable size distribution is used. As a minimum the following shall be carried out.

Size distribution of the abrasive shall be carried out by sieve analysis. Dust and fines shall not be more than 15%. A risk of recycling abrasive is that the blast profile progressively reduces as more grit particles break down to fines.

Absence of moisture shall be verified by placing a sample of abrasive on a clean, dry sheet of absorbent paper.

The surfaces of the pipes shall be blasted until a finish of Grade Sa3 to SANS 8501-Part 1 (steel condition A or B) is attained. The surface profile (anchor pattern) shall be between 50 and 100 microns measured in accordance with SANS 8503-Part 5. Profile measurements shall be made with Testex Press-O-Film or other approved method suitable for the abrasive being used.

Following abrasive blasting, the surface shall not be contaminated with dirt, dust, metal particles, hydrocarbons, water, chlorides, sulphates, or any other foreign matter which would be detrimental to the coating, and within the stated limits of this specification.

If pipe was delivered with a temporary coating such as varnish, the pipe surface shall be checked with magnification to confirm no residues of varnish remain in the anchor pattern valleys.

Any dust or loose residue that has accumulated during blasting and/or grinding operations shall be removed by the use of clean compressed air or by vacuum extraction. Alternative methods for removing dust and lint shall require Approval of the Engineer. For an automated blasting process, the surface of the cutback area shall be checked for dust contamination with transparent adhesive tape at least twice per shift. The dust contamination shall not be in excess of dust Quantity Rating 2 and a size Class 2 in accordance with SANS 8502-3.

7.2.6. WATER SOLUBLE SALTS LIMITS

The blast cleaned surfaces to be coated shall be tested for water soluble salts. The maximum level of salts allowable on the surfaces shall not exceed the values given below.

Should these values be exceeded, the surfaces shall be cleaned by: -
(a) A liquid soluble salt remover approved by the Coating Manufacturer or
(b) Washing with a high-pressure jet of clean potable water or
(c) Water injected blast-cleaning or
(d) Re-blast or flash blast-cleaning

Water soluble salt decontamination may require repeated washing and re-blasting cycles until the soluble salts are within the specified limits.

Prepared surfaces shall be in accordance with the table below.

WATER SOLUBLE SALTS	FOR DRY/ABOVE GROUND	FOR IMMERSED OR BURIED CONDITIONS
Maximum at any point using test method described in Section 7.6.2 (WATER SOLUBLE SALT TEST METHODS)	A max of 150 mg/m^2 of chloride	Chloride – Max of 70 mg/m^2 Soluble ferrous ion contaminants - Max of 100 mg/m^2 Sulphate contaminants - Max of 170 mg/m^2

NOTE: The conversion factor for salt concentration on a steel surface to change between milligrams per square metre and micro grams per square centimetre is 10 mg/m^2 to 1 microgram/cm^2

When so required by the Corrosion Engineer, the surface should be assessed for chloride contamination in accordance with SANS 8502-2 or SANS 8502-5, as agreed by the manufacturer.

For water soluble salt test methods on steel surfaces, refer Section 7.6.2 (WATER SOLUBLE SALT TEST METHODS).

7.2.7. FINAL-BLAST

7.2.7.1. HUMIDITY AND TEMPERATURE

Final-blasting and corrosion protection shall not be carried out if the steel temperature is less than 3°C above dew point.

For new steel in a workshop or fabrication facility, all blast-cleaned surfaces shall be coated within four (4) hours when relative humidity is below 70% or two (2) hours when relative humidity is between 70% and 85%.

At the discretion of the Corrosion Engineer in the event that the relative humidity is consistently between 80% and 90% blast-cleaning may only take place if the steel is at least 5°C above the condensation temperature (dew point) of the air and if the steel is coated within one hour after blasting, provided that the paint or coating systems that are used under conditions of high humidity are **not moisture sensitive**.

For maintenance and refurbishment work of old corroded steel on a site such as internals of a buried pipeline, the Corrosion Engineer shall have the discretion to issue a written concession that relaxes the time limitation after grit blasting and substitutes this with a hold

point inspection of the blast cleanliness standard to ensure that no deterioration has occurred due to the elapse of time. Any dispute relating to cleanliness of blasted steel that has aged shall be settled by blasting test patches to ensure that there is no colour variation between the old blasted steel and the freshly blasted steel.

7.2.7.2. BLASTING-MATERIAL

Final blast-cleaning shall be carried out using clean, uncontaminated blast-medium in accordance with Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

7.2.7.3. CLEANLINESS

All surfaces for "wet/submerged**/**buried conditions" and for "dry conditions" shall be blast-cleaned to Sa3 and Sa2½ respectively.

7.2.7.4. PROFILE

The required surface profile specified in the table in Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL) shall be achieved by final-blasting in accordance with SANS 10064 and/or SANS 8504-2.

7.2.7.5. RESIDUAL DUST AND DEBRIS

Prior to coating, dust and debris shall be removed by vacuum-cleaning. A dust and debris test shall be done in accordance with SANS 8502-3 as per Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

Only with prior Approval by the Corrosion Engineer may dust and debris be removed by blowing with clean uncontaminated compressed air.

For the internal field joint as well as internal patch repairs of pipelines, all blasting grit must be removed from the pipeline before application of the protective lining.

7.2.7.6. CONTAMINATION

After final-blasting, the un-coated steel shall not be touched with bare hands. All applicators shall wear white gloves and shoe covers where applicable.

7.2.7.7. SWEEP-BLASTING

Sweep blast-cleaning is used to create a fine, even profile on soft materials and to remove portions of a coating. This method may be used to tie existing mainline coating by means of "feathering" to field joint coating or may be used as a method of surface preparation of galvanizing for application of duplex coating. Sweep blasting is also used to restore the specified blast cleanliness standard on steel when the blast quality has deteriorated due to the passage of time or rain/humidity.

The sweep blasting must not create an excessive blast profile (≤ 50 microns) in the soft material of mainline coating.

The guideline for sweep blast-cleaning is as follows:

Equipment and air supply	Free of oil and moisture
Nozzle pressure	Typical pressure 300 kPa for soft material
Nozzle pressure	Minimum pressure 600 kPa
Nozzle angle to the surface being cleaned	30° to 60°
Sweeping distance	Minimum of 600 mm or more
Abrasive – ultra fine non-metallic grit	Minimum 0,2 mm – maximum 0,8 mm
Grit	Only new grit shall be used

7.3. FIELD JOINT SURFACE PREPARATION

Field Joints are dealt with in two different diameter classes based on man access to pipe internals.

The ends of coated steel pipes shall not be coated for a minimum distance of 100 mm from the welding edge. The pipe ends/cut-backs shall be pre-blasted in the pipe manufacturers works.

NOTE: The weldable primer has poor corrosion resistance and is difficult to remove under field conditions after the pipe ends have been welded together. Therefore, the cut-back pipe ends are NOT to be coated with a weldable primer but left as bare steel. It is easier to remove surface rust than it is to remove a weldable primer.

In the event that the pipes are not installed for an extended period, under corrosive conditions, the unlined strip (cut-back) surface shall be temporarily protected with a coat of weldable primer (red or a different colour to the lining/coating) whilst awaiting installation.

If the pipe is going to be used as a stock item and stored for an extended period of time under corrosive conditions, the Corrosion Engineer shall decide whether to coat the pipe to the end with the full system or a weldable primer.

NOTE: The pipelay crew shall not proceed more than one shift / day ahead of the internal field joint protection crew. Should a concession be required it shall be accompanied by a detailed method statement, with due consideration to access for field joint corrosion protection relative to pipe diameter.

Refer to Section 7.4.6 (BRISTLE BLASTING), The use of bristle blasting may be an acceptable alternative method of surface preparation for field joints for certain field joint coating systems.

Refer to Section 8.2 (e) (SPECIAL COATING AREAS) for the requirements of providing a method statement relating to performing the corrosion protection.

Refer to Section 9.6 (FIELD JOINT CORROSION PROTECTION) for the field joint corrosion protection information.

7.3.1. PIPES 800MM AND LARGER IN DIAMETER

After two pipe ends are welded together the welds are dressed to the maximum weld bead height allowed in this specification and all weld splatter removed. Cut-back ends (internally and externally) shall then be final blasted and comply with all other requirements as per Section 7.2 (PROCEDURE) above. Once the surface preparation meets the required standards then the coating or lining shall be applied before the blast quality deteriorates.

The existing mainline coating and lining shall be protected against excessive blast damage. The existing coating and lining shall be roughened minimum of 50mm to allow good adhesion of the field joint corrosion protection material.

7.3.2. PIPES SMALLER THAN 800MM IN DIAMETER

Shortly before two pipe ends are welded together the cut-back ends shall be pre-blasted or final blasting and the blast type shall be determined by the time interval in which the coating or lining can be applied with consideration for access restriction with respect to pipe diameter for internal man access.

The existing mainline coating and lining shall be protected against excessive blast damage where the existing coating and lining is roughened minimum of 50mm to allow good adhesion of the field joint corrosion protection material.

7.4. SURFACE PREPARATION REQUIREMENTS

The surface preparation requirements in the table below in Sections 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL) and 7.4.2 (BLAST PROFILES FOR CORRODED STEEL) are general requirements. In addition to these general requirements there will also be detail project specific surface preparation standards that will take precedence.

Refer to the notes below the table in Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL) for more information.

7.4.1. SURFACE PREPARATION PARAMETERS FOR NEW STEEL

Prepared surfaces shall be in accordance with the table below:

PROPERTY	FOR DRY/ABOVE GROUND CONDITIONS	FOR WET AND OR BURIED CONDITIONS
Cleanliness to SANS 8501-1 (min)	Sa 2½	Sa 3
Residual dust and debris SANS 8502-3 maximum particle size	Class 3	Class 3
Residual dust and debris SANS 8502-3 maximum quantity	Rating 2	Rating 1 *(refer note)
Oil, grease, and perspiration	Nil	Nil
Surface Profile (min) Coats up to 400 µm (max)	40 µm 80 µm	40 µm 80 µm
Surface Profile (min) Coats >400 µm (max)	50 µm 100 µm	50 µm 100 µm
Surface Profile (min) Solvent Free Coats	50 µm No maximum	50 µm No maximum
Water soluble salts at any point (refer note)	A max of 150 mg/m^2 of chloride	Chloride - Max of 70 mg/m^2
	-	Soluble ferrous ion contaminants - Max of 100 mg/m^2
	-	Sulphate contaminants - Max of 170 mg/m^2

NOTES:

- Surface profile shall not exceed 25% of the coating thickness for thin film solvent-based paints such as MIO and IOZ in dry atmospheric conditions.
- For solvent free coatings, the upper maximum limit for blast profile shall be in accordance with the manufacture data sheets.
- To reduce the risk of inadequate wetting out, the *maximum* surface profile for hot applied plural component sprayed rigid polyurethane shall not exceed 80 microns.
- To reduce the risk of inadequate wetting out, the *average* surface profile for hot applied plural component sprayed epoxy coating shall not exceed 80 microns.

- The conversion factor for salt concentration on a steel surface to change between milligrams per square metre and micro grams per square centimetre is 10 mg/m^2 to 1 microgram/cm^2 (1ppm is equal to 1 mg/l and 1 micro grams/ml)
- Grit blasting DOES NOT remove all salts and bacteria and a decontaminating wash may be required followed by re-blasting.
- For maintenance work it is recommended that the Corrosion Engineer be consulted concerning tests for bacterial contamination.
- *Under workshop conditions or new steel, the dust contamination shall not be in excess of Dust Quantity Rating 1 as per the pictorial standard and a particle size Class 3 in accordance with SANS 8502-3. Residual dust and debris, size Class 3 means particles are just visible with normal or corrected vision.
- *Under field conditions the Corrosion Engineer may issue a relaxation so that the dust contamination shall not be in excess of dust Quantity Rating 2 as per the pictorial standard and a particle size Class 3 in accordance with SANS 8502-3.

7.4.2. BLAST PROFILES FOR CORRODED STEEL

Corroded steel inherently has a higher roughness surface profile due to wasting of the surface. Therefore, blast profiles on corroded steel may tend towards the higher of the ranges specified in Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL) above.

Excessive average blast profiles above 125 microns and / or porosity of the substrate prohibits the use of solvent borne thin coatings because of the risk of the high points grinning through the coating film and resulting in “measle” corrosion. The risk of solvent entrapment increases on porous surfaces and very rough surfaces.

For average blast profiles above 125 microns, it is only permissible to use solvent free coatings or coatings with a volume solid of 95% or above.

- High volume solids coatings can have high viscosity which may reduce the wetting out ability on porous surfaces.
- 100% solids filled coatings (e.g. ceramic or glass) may require bespoke low viscosity primers to assist with wetting out.

When using solvent free coatings, higher blast profiles may lead to an improved mechanical key due to the better anchor pattern and higher adhesive bond strengths.

7.4.3. BLAST PROFILES FOR CORRODED CAST IRON

Corroded cast iron inherently has a higher roughness surface profile due to wasting of the surface. Therefore, blast profiles on corroded cast iron may tend towards the higher of the ranges specified in Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL) above.

Excessive average blast profiles above 125 microns and / or porosity of the substrate prohibits the use of solvent borne thin coatings because of the risk of the high points grinning through the coating film and resulting in “measle” corrosion. The risk of solvent entrapment increases on porous surfaces and very rough surfaces.

Cast iron also has a higher roughness surface profile before blasting due to the coarse grain structure. Old corroded, cast iron may in addition also have porosity, pitting, graphitisation, and irregular surface. Therefore, blast profiles on cast iron will be considerably higher than blast profiles on new steel. See Section 11.6 (CAST IRON REHABILITATION AND CORROSION PROTECTION) for additional information.

For cast-iron surfaces, it is only permissible to use solvent free coatings or coatings with a volume solid of 95% or above.

- High volume solids coatings can have high viscosity which may reduce the wetting out ability on porous surfaces.
- High solids low viscosity solvent free coatings such as polyester, epoxy vinyl ester or epoxy are the required coating materials for refurbishment of old cast iron pipes, pumps and valves.
- 100% solids filled coatings (e.g. ceramic or glass) may require bespoke low viscosity primers that assist wetting out, as per manufacturer recommendations.

When using solvent free coatings, higher blast profiles may lead to an improved mechanical key due to the better anchor pattern and higher adhesive bond strengths.

For cast iron pipes, pumps and valves note that the effective high blast profile and porosity will require that corrosion protection material thickness shall be at least double the relevant steel pipeline corrosion protection thickness.

7.4.4. ABRASIVE BLAST MATERIAL

The blast-cleaning abrasive shall comprise of clean, sound hard particles free from foreign substances such as dirt, oil, grease, toxic substances, organic matter, water soluble salts and foreign metals. The abrasive material shall be washed, screened, and graded for size. The blasting abrasive type shall meet the requirements as specified in ISO 11125 for Metallic abrasives and ISO 11127 for Non-Metallic abrasives.

7.4.4.1. CERTIFICATION

The abrasive material supplier shall certify that all products supplied conform to all the requirements specified.

7.4.4.2. SHAPE AND SIZE

The individual abrasive particles shall be angular in shape and suitable to achieve the specified blast profile.

Recommended particle sizes:

Non-metallic material	0,2 to 0,8 mm or 0,4 to 1,4 mm
Metallic material	0,3 to 0,9 mm

7.4.4.3. HARDNESS

The minimum hardness of abrasive material shall be as follows:

For non-metallic material	6 on the Moh's scale
For metallic material	390 HV (Vickers hardness)

7.4.4.4. pH

The pH of the prepared abrasive grit or slurry mixture shall not be below 6.2.

7.4.4.5. WATER SOLUBLE SALTS IN ABRASIVES

The conductivity of slurry of abrasive material shall be less than 25 mS/m in accordance with ISO 11127. (This slurry test is not suitable for ferrous abrasive such as steel grit.)

Alternative test method - NACE SSPC NV-2 as follows:
Chlorides less than 7ppm
Sulphates less than 10ppm
Nitrates less than 17ppm
(1ppm is equal to 1 mg/l and 1 micro grams/ml)

For water soluble salt test methods on steel surfaces, refer Section 7.6.2 (WATER SOLUBLE SALT TEST METHODS).

7.4.4.6. MOISTURE CONTENT

The moisture content for abrasive material shall not exceed 0,2%.

7.4.4.7. RE-CYCLING

Re-cycled steel grit blasting-material shall be used if:

(a) Blasting-materials were only used on degreased surfaces.
(b) Dust and debris is removed from the blasting-material.
(c) Particles are kept angular and within specified sizes.

Re-cycled slag blasting-material may only be used for rough blasting and pre-blasting. Re-cycled slag blasting-material shall not be used for final blasting.

NOTE: When using recycled abrasives, special care shall be taken to ensure that the dust and debris residue on the surfaces shall not exceed the limits specified in Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL)

7.4.5. AIR SUPPLY

Air supply equipment shall be fitted with efficient oil and water traps to avoid contamination of the surface. At least one oil and one water trap shall be fitted at the compressor and one water trap at the blast pot.

The air pressure shall be a minimum of 600 kPa at the nozzle measured with a needle pressure gauge but not withstanding the contractor shall ensure that both the volume and the pressure of the air is sufficient to achieve the required blast cleanliness and blast profile standard at the required rate of production.

The air pressure supply at the compressor shall, as a guideline be a minimum of 700 kPa or preferably more, to provide the minimum required nozzle air pressure.

The contactor shall be responsible for his own lack of efficiency and productivity if the compressed air that he supplies is inadequate.

Refer Section 7.6.1.3 (TESTING COMPRESSED AIR FOR OILS (REFER SANS 8573)).

7.4.6. BRISTLE BLASTING

For small local patch repairs the use of bristle blasting equipment is acceptable in terms of this specification provided that both the specified cleanliness standard as well as the minimum blast roughness profile is achieved. Bristle blasting does not remove weld spatter and all other steel finish requirements such as radius on sharp edges, weld bead height etc. and must be removed by other methods to conform to the specifications.

Bristle blasting is a mechanical abrasion cleaning process that is performed on metallic surfaces by a brush-like rotary power tool driven by either electric power or pneumatic power. The tool consists of sharpened, high-carbon steel wire bristle types that are designed with a forward-angle bend, i.e., the shank of the wire is bent in the direction of tool rotation. Once the bent shank section of the wire bristle has worn away, the bristle belt must be replaced.

During operation, the rotating bristle tips strike the surface with kinetic energy that is equivalent to processes that use grit blast media. This repeated contact of sharp bristle tips with the target surface results in localized impact, rebound, and the formation of craters, thereby simultaneously cleaning and profiling the surface, while exposing a contamination-free base metal.

When using bristle blasting, measuring of the roughness profile is mandatory for quality control purpose.

Bristle blasting is only to be used for small areas and conventional grit blasting shall be used for large areas. Conventional blasting provides a more angular anchor pattern compared to bristle blasting.

Small area is considered to be the equivalent of a A4 sheet, 0.05m^2, approximately 25cm x 25cm.

NOTE: Bristle blasting shall not be confused with the use of a needle gun. A needle gun provides a peened surface and is not a suitable profiled surface.

7.5. SURFACE PREPARATION FOR OTHER MATERIALS

7.5.1. GALVANIZED SURFACES TO BE COATED

Mainline bulk water pipe and buried pipes shall not be galvanized.
Structural steel for C1 to C3 atmospheric conditions as defined by ISO 12944-2 classification of environments may be hot dip galvanized or duplex coated as per ISO 12944-5.

The use of galvanized surfaces inside valve chambers is not permitted, due to high levels of humidity generally found in the chambers.

See Section 9.12 (MANDATORY REQUIREMENTS) for additional information with respect to galvanizing.

7.5.1.1. PASSIVATION

Galvanized surfaces to be coated shall **not** be passivated.

7.5.1.2. DEGREASING

Galvanized steel surfaces shall be degreased prior to coating, in accordance with Section 7.2.3 (DEGREASING) and the manufacturer's instructions, or a mild acid-detergent degreasing solution to be approved by the Corrosion Engineer.

7.5.1.3. PROFILE

- Sweep-blasting
  Large areas shall be prepared by sweep-blasting with non-metallic abrasive in accordance with Section 7.2.7.7 (SWEEP-BLASTING). Cracking, flaking, or any form of delamination of the zinc due to excessive blast-cleaning shall not be permitted. Removal of zinc thickness by blast-cleaning shall not exceed 10 µm.
- Mechanical
  Surfaces that cannot be sweep-blasted shall be abraded manually or mechanically with abrasive paper having a minimum roughness grade 220 or by using non-metallic abrasive pads.
- Dust and Debris
  All dust and debris shall be removed by vacuum-cleaning in accordance with the limits specified in Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

7.5.1.4. PRIMER

Primer for galvanized surfaces shall be applied immediately after surface preparation, not exceeding the time limits specified in Section 7.2.7.1 (HUMIDITY AND TEMPERATURE).

7.5.2. ALUMINIUM SURFACES TO BE COATED

Aluminium surfaces to be coated shall be treated as follows:

7.5.2.1. DEGREASING

Surfaces shall be degreased in accordance with Section 7.2.3 (DEGREASING).

7.5.2.2. PROFILE

Sweep-blast the surface with non-metallic abrasive in accordance with Section 7.2.7.7 (SWEEP-BLASTING)

7.5.2.3. DUST AND DEBRIS

All dust and debris shall be removed by vacuum-cleaning to a cleanliness standard SANS 8502-3 as per Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

7.5.2.4. PRIMER

Primer for aluminium surfaces shall be applied immediately after surface cleaning, not exceeding the time limits specified in Section 7.2.7.1 (HUMIDITY AND TEMPERATURE).

7.5.3. CORROSION RESISTANT AND STAINLESS STEEL

Components fabricated from corrosion resistance and stainless steel shall not be contaminated with iron or carbon steel through the use of contaminated grinding discs, wire brushes, scratch marks, steel grit etc.

Conventional slag abrasives often contain up to 35% ferrous and ferric compounds where the resultant iron residues can set up corrosion cells on the surface of stainless steels. The blasting abrasive type shall meet the requirements as specified in ISO 11127 for Non-Metallic abrasives.

Note that platinum slag and garnet may contain iron in the form of ferrous and ferric compounds and should therefore not be used.

Permissible abrasives for blasting stainless steel which is to be coated and immersed shall be:

- Aluminium Oxide.
- Glass Grit.
- Stainless Steel Grit.

Care must be taken to ensure that the specified surface profile is achieved because stainless steel is harder than carbon steel and therefore more difficult to obtain roughness.

7.5.3.1. UN-COATED SURFACES (PICKLING AND PASSIVATION)

Stainless steel surfaces shall not be contaminated with carbon steel, scratched, or stressed. The following areas shall be pickled and passivated:

(a) All un-coated areas.
(b) Ground and sheared edges.
(c) Heat affected zones caused by welding or cutting.

It is recommended that, if possible, pickling and passivation be done by the dipping process. Proprietary pickling and passivation chemicals (as supplied by approved suppliers) shall only be used in accordance with the manufacturer's recommendations. Care shall be taken not to exceed the maximum contact time recommended.

After pickling and passivation, surfaces shall be thoroughly washed with clean potable water to remove all traces of acid. Surfaces shall be allowed to dry, then polished where necessary, using polishing compounds recommended by the stainless steel manufacturer.

7.5.3.2. SURFACES TO BE COATED

- Degreasing
  Surfaces shall be degreased in accordance with Section 7.2.3 (DEGREASING).

- Profile
  Corrosion resistant steel surfaces shall be blast-cleaned with stainless steel grit or non-metallic abrasive to create a profile in accordance with table in Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL). The use of steel shot and steel or cast-iron grit is strictly prohibited. Stainless steel tends to have a harder surface and is more difficult to obtain blast profile. Surface profile shall be a minimum of 30 µm for atmospheric corrosion conditions and 50 µm for immersed corrosion conditions.

  Where blasting is impractical, a written concession shall be obtained from the Corrosion Engineer for alternative surface preparation such as manual or power sanding with abrasive paper. In all instances, clean, uncontaminated surface preparation equipment must be used.

- Dust and Debris
  Dust and debris shall be removed by vacuum-cleaning in accordance with Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

- Time Limitation of application of coating systems
  The time interval between blast cleaning of stainless steel and application of coating should be immediate or as short as practically possible to prevent the formation of a chrome-oxide layer developing.

7.5.4. SYNTHETIC MATERIALS TO BE COATED

7.5.4.1. DEGREASING

Surfaces shall be degreased in accordance with Section 7.2.3 (DEGREASING).

7.5.4.2. PROFILE

Abrade the surface with abrasive paper having a minimum roughness grade 220 grit to achieve a uniform matt finish.

7.5.4.3. DUST AND DEBRIS

Dust and debris shall be removed by vacuum-cleaning as per Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

7.5.5. COATED SURFACES

7.5.5.1. PRE-COATED SURFACES TO BE OVER-COATED

- Degreasing
  The pre-coated surfaces should be tested and if required the surfaces shall be degreased in accordance with Section 7.2.3 (DEGREASING).

- Profile
  Pre-coated surfaces to be over-coated outside the over coating period shall be abraded with abrasive paper having a minimum roughness grade 220 grit to a uniform matt finish.

  All un-coated areas and all areas with micro rust shall be re-blasted to the original surface finish as specified.

- Dust and Debris
  Dust and debris shall be removed by vacuum-cleaning in accordance with SANS 8502-3 as per Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

7.5.5.2. COATED SURFACES TO BE REPAIRED

- Spot repairs
  Spot repairs shall be carried out in accordance with the original specification or as specified by the Corrosion Engineer. Repairs shall overlap the undamaged area by a minimum of 25 mm. Repairs shall be built up to the original undamaged coating thickness.

  For detailed repair instructions, refer to the relevant repair procedures applicable to specific coating and lining materials detailed in the appropriate sections.

- Preparation of Bare Areas
  Bare areas such as where local damage has occurred or alternatively field joint cut back areas, the bare surface areas shall be prepared by spot-blasting to Sa3 in accordance with Section 7.2.6 (WATER SOLUBLE SALTS LIMITS).

  For small local patch repairs, if spot-blasting is not possible, the Corrosion Engineer shall have the discretion and authority to issue a concession to allow hand preparation methods to a bright metal surface.

7.6. TEST METHODS

Tests, instruments, methods, and criteria shall be as specified below or in the Project Specification.

7.6.1. OIL AND GREASE

All surfaces to be coated shall be tested for oil and grease contamination before surface abrasive blasting using one of the methods below.

7.6.1.1. ULTRA VIOLET LIGHT TEST METHOD

Suitably powerful ultra violet light equipment can be used under darkened conditions to detect oil contaminated surfaces that fluoresce.

NOTE: Many oils and grease do not fluoresce.

7.6.1.2. WATER BREAK-FREE TEST METHOD

For the water break-free test method the surface shall be wetted with water and the entire surface shall be covered by an unbroken film.

Note: Due to the size of some components the water break-free test is not practical, and the UV light test must then be used.

7.6.1.3. TESTING COMPRESSED AIR FOR OILS (REFER SANS 8573)

The following test methods shall be used for testing compressed air for oil contamination, when the compressed air is blown onto one of the three surfaces mentioned below:

- The white cloth method will show the oil when held up to a bright light.
- The glass sheet and warm water method which will show rainbow colours on the water surface.
- The white paper held up to a bright light.

7.6.1.4. SOLVENT-WIPING

Where water soluble lubricants may be present the surface shall be further tested by wiping with a clean cotton wool swab soaked in solvent. No stain shall be evident on the swab after solvent-wiping.

7.6.2. WATER SOLUBLE SALT TEST METHODS

An approved method shall be used to carry out salt contamination tests prior to washing and after abrasive blast cleaning. One salt contamination test shall be carried out at each end of the pipe. For other steel structures or for maintenance work the frequency of testing shall be as indicated in the Project Specification or more frequently as required by the Corrosion Engineer.

The following three tests may be used as screening for ferric chloride:

- Weber Riley spray may be used as a screening qualitative test only for atmospheric conditions to indicate the presence of ferric chloride. Weber Riley shall not be used for immersed conditions.

- Watman papers may be used as a screening qualitative test for immersed and atmospheric conditions, but only to indicate the presence of ferric chloride.

- Conductivity test instruments that use liquid swab on the surface to dissolve soluble metallic salts may also be used as a screening qualitative test for immersed and atmospheric conditions. Conductivity test instruments results do not accurately quantify salt concentrations for individual ions such as sulphates or nitrates. These instruments can incorrectly assume that the conductivity reading relates only to chlorides.

If any screening test indicates an unacceptable level of salt or there is any dispute in the concentration level, then the quantitative test below shall be used.

The generally accepted quantitative test methods are as follows:

- Bresle patch predominately for horizontal surfaces.
- Chlor condom tests for vertical surfaces and inverted (upside-down) surfaces.
- CSN test kit (the Chloride, Sulphate and Nitrate test kit)
- Merck-o quant.
- Swab and titration.

The majority of tests do not separately detect sulphates, nitrates, and soluble ferrous ion.

Substrate surfaces shall be tested for the presence of water-soluble salt contaminants using a reliable repeatable method as per above and the results shall not exceed the limits as per the table below:

WATER SOLUBLE SALTS	FOR DRY/ABOVE GROUND CONDITIONS	FOR IMMERSED OR BURIED CONDITIONS
Maximum at any point using test method described in Section 7.6.2 (WATER SOLUBLE SALT TEST METHODS)	A max of 150 mg/m^2 of chloride	Chloride - Max of 70 mg/m^2 Soluble ferrous ion contaminants - Max of 100 mg/m^2 Sulphate contaminants - Max of 170 mg/m^2

NOTE: The conversion factor for salt concentration on a steel surface to change between milligrams per square metre and micro grams per square centimetre is 10 mg/m^2 to 1 microgram/cm^2.

Water soluble salt decontamination may require repeated washing and re-blasting cycles.

7.6.3. STANDARD OF MECHANICAL SURFACE PREPARATION

Mechanical surface preparation shall be visually compared to the standard shown in SANS 8501-1.

7.6.4. BLAST PROFILE

The blast profile of the substrate surfaces shall be determined in accordance with SANS 5772. (pin type profile gauge)

Alternative test methods such as profile impressive test tape (for example Testex tape) or digital ultrasonic/stylus blast profile instruments should be used at the discretion and with permission of the Corrosion Engineer.

7.6.5. RESIDUAL DUST AND DEBRIS

Substrate surfaces shall be tested for the presence of residual dust and debris in accordance with SANS 8502-3 as per Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

7.6.6. BLASTING-MATERIAL

All blasting-materials shall be approved by the Corrosion Engineer.

7.6.6.1. METALLIC ABRASIVE

Abrasive shall be tested in accordance with ISO 11125 for particle size, hardness, density, foreign matter, and moisture.

7.6.6.2. NON-METALLIC ABRASIVE

Abrasive shall be tested in accordance with ISO 11127 for particle size, hardness, density, moisture, and water-soluble contaminants.

7.6.7. SURFACE PREPARATION

The Coating Contractor shall ensure that the condition of each item to be coated is such that it is fit for coating or lining, or both, as relevant.

Pre- and surface preparation shall conform to Chapters 6 (MANUFACTURE AND PRE-PREPARATION) and 7 (SURFACE PREPARATION) respectively of this specification.

Immediately after surface preparation each item or special shall be examined, including the inside surface, where possible, for compliance with the relevant requirements.

For pipes and specials intended for butt welding the prepared surfaces shall extend to the pipe ends.

8. APPLICATION AND QUALITY CONTROL

Shall be read in conjunction with ANNEX F: QUALITY CONTROL PLAN TEMPLATES) and relevant sections of Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES)

STANDARDS

Equipment, materials and operational methods shall comply with the relevant SANS, ISO, BS, DIN or equivalent American Standard.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification.

Reference is made to the latest issues of the following Standard Specifications:

SANS	1091	National colour standard.
SANS	2808	Determination of film thickness.
SANS	5772	Preparation of steel substrate before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces - Profile of blast-cleaned steel surfaces by a micrometre profile gauge.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
SANS	8502-3	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 3: - Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method).
SANS	9000	Model for quality assurance in production and installation.
BS	5493	Protective coating of iron and steel structures against corrosion.
SSPC	PA 2	Procedure for the determining conformance to dry coating thickness requirements.

8.1. MATERIAL

(a) The Contractor shall have available the latest editions of all the relevant National Specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warrantied by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include

mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

(e) This is a general quality control standard applicable to a variety of liquid and powder applied materials used as coatings and linings.

(f) Materials and procedures shall comply with the relevant SANS Specifications and generally accepted best practice.

(g) All materials in a coating system shall be purchased from the same manufacturer unless approved by the Corrosion Engineer. If they are not supplied from the same manufacturer, the compatibility must be demonstrated by testing the minimum acceptable bond strength and must be carried out to the satisfaction of the Corrosion Engineer.

(h) Details of coating materials to be supplied and approved – refer to Section 3.1 (APPROVALS BEFORE AWARD OF CONTRACT). The Contractor shall only proceed with the purchase of coating materials upon receipt of written Approval from the Corrosion Engineer.

(i) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

Coating material selection shall also be approved by the material manufacturer/supplier. The Contractor shall receive a written assurance from the material suppliers that the materials comply with the specified requirements.

(j) Full traceability of each batch of coating material shall be maintained. All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following data that shall be available for immediate review by all parties:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which shall incorporate the place and date of manufacture
- Shelf life / expiry date (if appropriate)
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SABS mark or an ISO 9001 certificate where applicable
- Health and safety, hazard warnings and environmental instructions

(k) All coating materials shall be handled and stored by type and batch in an approved dry and enclosed store in accordance with the material Manufacturer's recommendations. The temperature shall not drop below 0°C nor exceed 40°C.

(l) Usage of materials from undamaged containers shall be on a first in, first out basis and no materials shall be used that have exceeded the shelf life (expiry date) recommended by the manufacturer.

8.2. SPECIAL COATING AREAS

(a) Areas that are inaccessible after assembly shall be prepared and fully coated with the specified system to the specified requirements before assembly. The coating shall be fully cured before assembly. Examples such as overhead cranes, pumps, valves, gates etc.

(b) Mating surfaces of joints, where applicable, shall be coated before assembling. The coating shall be uniform in thickness and shall not interfere with the

mechanical tolerances. After assembly, the outside surface of the joints shall be fully coated in accordance with the requirements of the installation.

(c) The pipe ends/cut-backs shall be pre-blasted in the pipe manufacturers works. For detailed information refer to Section 7.3 (FIELD JOINT SURFACE PREPARATION).

(d) Friction grip areas shall be left un-coated unless otherwise specified.

(e) For pipe diameters that are too small for safe man entry, the special coating areas (internal circumferential field joints, by-pass pipes, scour pipes etc.) shall have the internal lining application method statement and method of quality control pre-approved by the Corrosion Engineer. The contractor shall be required to demonstrate the effectiveness of the proposed methods before the relevant commencement of work on site.

8.3. APPLICATION

8.3.1. ACCEPTABILITY OF ITEMS TO BE COATED

The items shall conform to Section 6.2 (FABRICATION REQUIREMENTS) with the proviso that “pipes” shall read “items” to be coated.

8.3.2. COATING THICKNESS

Coating thicknesses shall conform to Section 8.4.3.1 (METHOD OF MEASUREMENT) or as specified in the Project Specification.

One of the most critical parameters in corrosion protection is the dry film thickness of the applied coating and lining. Too low a thickness will not give the required protection while too great a thickness will not only increase cost but might give rise to problems such as loss of flexibility, loss of adhesion and loss of impact resistance.

This is particularly important with multi-layer systems, where the film thickness of each coating or lining is as important as the total thickness.

The minimum thicknesses in this specification shall apply. However, the minimum thickness may be increased by the Corrosion Engineer in the Project Specification.

8.3.2.1. COATING THICKNESS FOR PUMPS, VALVES AND CAST IRON PIPES

For cast iron pipes, pumps and valves, the corrosion protection material thickness shall be at least double the relevant steel pipeline corrosion protection thickness.

8.3.3. COATING APPLICATION

8.3.3.1. ENVIRONMENTAL CONDITIONS

- Dusty Conditions
  Coatings shall not be applied in dusty or contaminated conditions.

- Surface Temperature
  Coatings shall not be applied if the surface temperature of the steelwork is less than 3°C above dew point or outside the range 10-40°C, unless otherwise specified by the coating manufacturer.

- Relative Humidity and Time of Application
  The first coat shall be applied as soon as possible after blast cleaning, but not exceeding four (4) hours if the relative humidity (RH) is below 70% or two (2) hours if the RH is between 70% and 85%.

  For the detail requirements on Humidity and Temperature refer to Section 7.2.7.1 (HUMIDITY AND TEMPERATURE).

- Ambient Temperature
  Coatings shall not be applied when the ambient temperature is less than the minimum or greater than the maximum specified by the manufacturer of the coating material.

- At the discretion of the Corrosion Engineer in the event that the relative humidity is consistently between 80% and 90% blast-cleaning may only take place if the steel is at least 5°C above the condensation temperature (dew point) of the air and if the steel is coated within one hour after blasting, provided that the paint or coating systems that are used under conditions of high humidity are not moisture sensitive.

8.3.3.2. MIXING OF TWO PACK COATING SYSTEMS

- For two pack materials, the use of part of the contents (split packs) is strictly forbidden unless written authorisation by the Corrosion Engineer is obtained.

  The Contractor shall ensure that all paints are mixed in accordance with the manufacturer's technical data sheets.

- In the case of two-pack materials, each component containing pigments shall be thoroughly mixed. The two components shall then be mixed together in the proportions supplied by the manufacturer until the mixture is completely homogeneous.

- In the case of solvent based epoxy materials, it is recommended that the mixed material be allowed to stand for an induction period, as recommended by the manufacturer, before use.

- During application, coating materials shall be agitated regularly to keep the solids in suspension. The preparation time, induction time and pot life of these materials shall be closely adhered to.

- Power mixing must be used where at all possible. Any deviation from mixing procedures shall be at the written discretion of the Corrosion Engineer.

  Where power mixers are required a low speed power mixer, which does not introduce air into the coating material being mixed, shall be utilised. For pipeline lining application and field joints where man access is possible the use of power mixers is mandatory.

- For small coating and lining patch repairs, touch ups and field joints, mixing with a flat paddle by hand is only permissible for small volumes below 5 litres. The mixing with a rod is not allowed.

- The use of squish packs is permitted provided mixing of squish pack as part of a pre-qualification test for adequate cure polymerisation. The cured polymerisation shall be determined as per Section 8.4.4 (DEGREE OF CURE OF TWO-COMPONENT MATERIALS).

8.3.3.3. PLURAL SPRAY MIXING

The plural spray mixing method statement and method of mix ratio quality control shall be pre-approved by the Corrosion Engineer. The contractor shall be required to demonstrate the effectiveness of the proposed methods before the relevant commencement of work on site.

The accuracy of the mix ratio shall be verified regularly as determined in the relevant quality control plan for the material.

For all plural spray materials including epoxy, polyesters and polyurethane, additional risk mitigation shall apply to avoid the material being applied off ratio such as;

- Full time quality control inspection during spray and /or
- Computer interlock for automatic safety mechanism that will shut down the plural spray machine in the event of going off mix ratio and /or
- Colour change indication as a visual check that the ratio is correct

8.3.3.4. MIXING APPLICABLE TO POWDERS

The powder shall be dry and free flowing and uniformly suspended in a fluidised bed or agitator in a hopper immediately before application. Clumping and agglomerating of powder is not permitted.

8.3.3.5. APPLICATION REQUIREMENTS

Application methods and requirements shall be as prescribed in the relevant product Section, to be read in conjunction with the manufactures data sheets, whichever is the more stringent.

- Equipment
  Application equipment shall be maintained in a clean condition and in good working order. The use of equipment not maintained in good condition may lead to rejection of the coating.

- Compatibility of Coats
  All primer, intermediate and finishing coats shall be mutually compatible with proper cohesion.

  Mainline coating, lining, and field joints inclusive of tape wraps and shrink sleeves, shall be mutually compatible with proper intercoat adhesion.

- Surface Restoration of Substrate
  Should immediate lining/coating not be possible, or should any atmospheric oxidisation take place between the completion of blast cleaning and commencement of lining/coating, such oxidisation shall be removed by flash blasting to restore the specified surface finish. Removal of dust and debris shall be in accordance with Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

- Supports
  During coating application, the items shall be so supported to prevent damage to the wet coatings until the coatings have hardened adequately. Items shall remain supported during curing, storing, and handling.

8.3.3.6. METHOD OF APPLICATION

- Application
  Coatings and Linings shall be applied by any appropriate method recommended by the manufacturer thereof and approved by the Corrosion Engineer.

- Cleanliness During Application
  During application and curing of the coating layers, the items shall be protected against contamination by dust or other foreign matter and shall be kept dry and shaded from direct sunlight.

  If the environmental conditions such as dust and moisture are not able to be controlled on the site, the Corrosion Engineer shall have the discretion to specify an appropriate single coat system to avoid the risk of inter coat bond contamination and subsequent bond failures.

  All coats shall be clean and free from dust, oil, moisture and perspiration before over-coating. Precautionary measures must be put in place for overnight conditions as

dew or frost may form on the previous layer and have a detrimental effect on inter coat bond strength.

Operators handling blast-cleaned or partially painted surfaces shall wear clean gloves to avoid contamination of the surface.

- Coat Colours
  The colour of each subsequent coat shall be different to that of the previous coat except where two finishing coats of the same colour are necessary to achieve colour uniformity.

  The first coat is not permitted to be grey as it does not give adequate contrast to the grit blasted substrate.

  The final coat colour is not permitted to be similar to that of rust or corrosion product (brown, orange and red).

- Over-coating Times
  Over-coating times shall be not less than the minimum nor greater than the maximum specified by the manufacturer relevant to the ambient temperature.

  Strict adherence to over-coating times is particularly important for coatings which are subsequently immersed.

8.3.3.7. PIPE END QUALITY INSPECTION

(a) Extension of Lining

For flanged pipes and pipes or specials intended for joining with flexible couplings or for site welding by means of double sleeve weld-on couplings, the lining shall extend to the ends of pipes and specials including edges and shall extend by at least 300 mm on the outside of the pipe. Linings shall overlap coated surfaces on the outside by at least 50 mm.

(b) Butt Weld Edges

For pipes and specials intended for site butt welding, lining and coating shall extend up to a distance of 100 mm from the pipe ends.

8.3.3.8. IN-SITU APPLIED LINING

No welding whatsoever shall be performed on any pipe or special on which the lining or coating has been completed, without Approval of procedure in writing by the Corrosion Engineer. Where applicable the temporary protected surfaces shall be blast cleaned before coating with the specified system.

Different coating and lining systems for in-situ applications may require specialized procedures and quality control methods.

The Approval shall only be considered by the Corrosion Engineer after submission by the Contractor of acceptable proposals.

8.3.3.9. EXTERNAL CORROSION PROTECTION APPLIED UNDER TENSION

For corrosion protection material applied under tension as a sheet, a film or tape wrap the weld bead may have to be pre-coated with a stripe coat or mastic to avoid tenting and creation of voids at the weld bead.

8.4. TESTING PROCEDURES

To be read in conjunction with Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES), and the sections of the respective coating systems in this document.

8.4.1. VISUAL INSPECTION

All surfaces shall be inspected visually and shall be free from tears, runs, sags, wrinkles, blisters, change in colour or gloss, orange peel, dirt, visible pinholes, dust or fluff occlusions or any other visible defects.

8.4.2. HOLIDAY INSPECTION

100 percent of the lining and coating of all pipes shall be tested and there shall be no electrical insulation defects on any area inspected.

If the manufacturer of the coating material warns against di-electric fatigue, the holiday testing shall be limited and repeated testing shall be avoided. If the quality inspector does not have adequate confidence, then repeated high voltage spark testing is permissible provided the material does not suffer from di-electric fatigue.

Use ASTM D 5162 (Standard Practice of Discontinuity (Holiday) Testing of Nonconductive Protective Coating on Metallic Substrates) and check for compliance with procedures covering the determination of discontinuities using two types of test methods:

Test method A - Low voltage wet sponge (pin-hole detection)
Test method B - High voltage spark tester (potential defect and pin-hole detection)

High voltage spark testing is mandatory for linings as well as coatings for buried structures. The spark test voltages shall be determined in accordance with Section 8.4.2.2 (TEST METHOD B (HIGH VOLTAGE)) below.

For films exceeding 500 µm thickness, the high voltage sparking electrical insulation defects detector shall be used. High voltage spark testing is permissible at lower thicknesses provided the test voltage is reduced proportionately.

Repeated or prolonged high voltage spark testing may cause di-electric fatigue in certain materials such as phenolic epoxies and polyurethanes.

Low-voltage wet sponge electrical insulation defects inspection is only applicable to films not exceeding 500 µm thickness in atmospheric applications.

8.4.2.1. TEST METHOD A (WET SPONGE)

Test method A may be used for detection of discontinuities in coatings of thickness not exceeding 500 µm. It is not suitable for the testing of electrically conductive coatings that contain conductive pigments, such as metallic pigments and some types of carbon black which give continuous defect indication. Wet sponge testing will not detect low DFT spots in coatings and will not detect potential defects such as bubbles, surface porosity, weld spatter. Wet sponge testing is also sensitive to the orientation of the pin-hole relative to gravity. For example, wet sponge testing may not find pinholes on a soffit.

Inspection procedure shall ensure that the sponge is wet at all times and that air bubbles are not trapped in a pinhole or in the defect. Potable water shall be used to wet the sponge. Wetting agent shall be added to the water for DFT in excess of 250 µm.

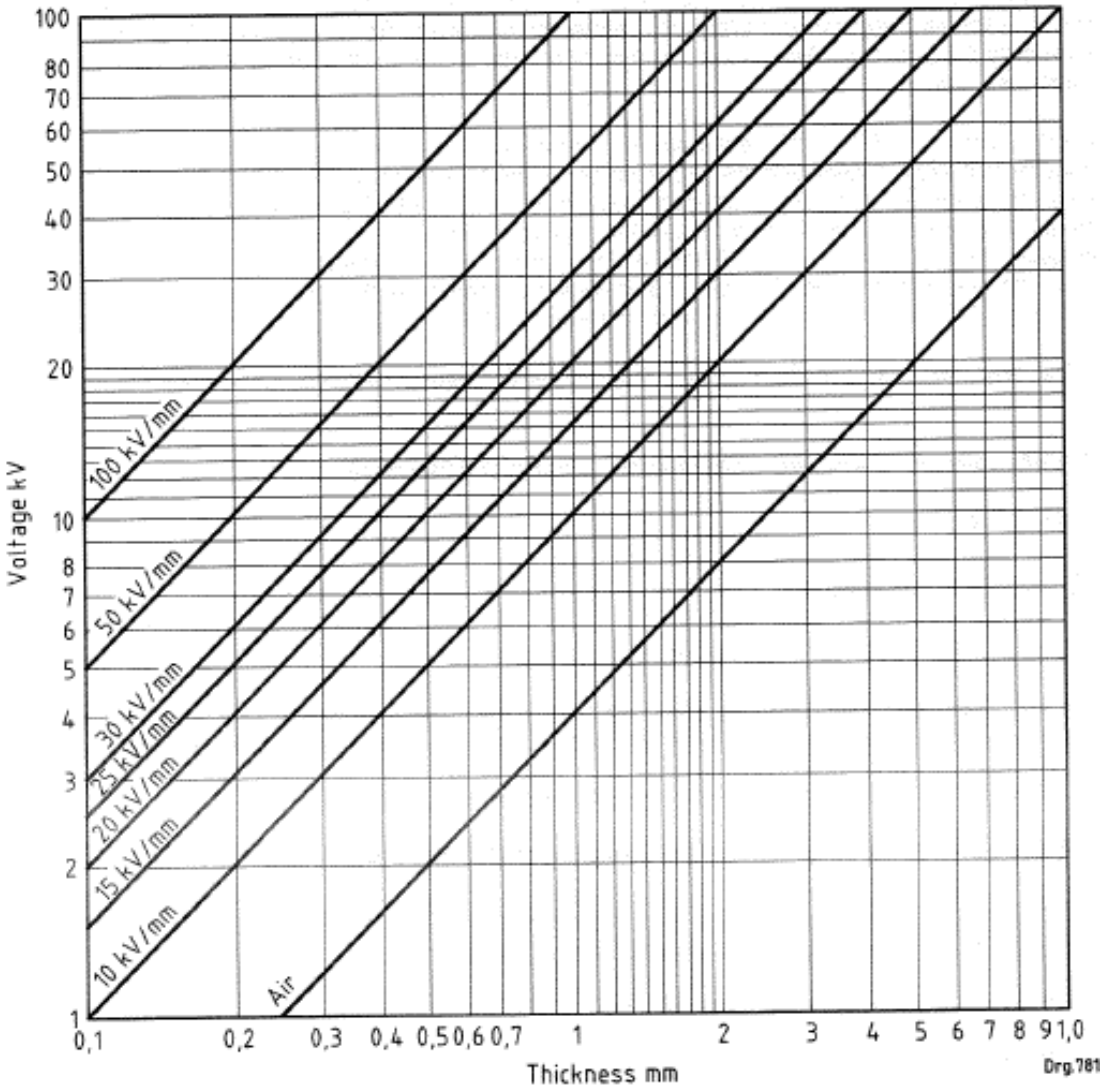
8.4.2.2. TEST METHOD B (HIGH VOLTAGE)

The test voltage for use in test method B will depend upon the coating or lining thickness, and its dielectric strength. If too high a voltage is used, a holiday might be produced in the coating or lining by the act of testing. If the voltage is too low, thin areas that do not comply with the requirements might not be detected.

NOTE: The breakdown voltage is the product of the dielectric strength of the coating or lining and its thickness.

Figure below can be used to assist with the selection of the correct voltage for method B. The diagonal lines in the figure below represent the dielectric strength of the coating material. To determine the minimum test voltage, the minimum coating or lining thickness is entered in the graph on the x-axis and minimum test voltage is found where thickness value means the “air” line.

The maximum test voltage value can be similarly determined with reference to the dielectric strength of the coating or lining material. This information is normally available from the coating or lining manufacturer. The test voltage is the minimum test voltage plus 10% of the difference between the minimum and maximum test voltage.



HIGH VOLTAGE SPARK TEST – VOLTAGE SELECTION GRAPH

8.4.3. DRY FILM THICKNESS (DFT)

The DFT shall be determined using either the Minimum Thickness or the Standard Deviation criteria.

8.4.3.1. METHOD OF MEASUREMENT

The default method of DFT measurement shall be in accordance with SSPC PA - 2 Procedure for determining the conformance to dry coating thickness requirements, with specific reference to Section 9 of SSPC PA - 2 and a restriction level of 1.

The method of measuring and evaluating coating and lining thickness shall be a minimum thickness which shall mean that no readings below the minimum thickness may be accepted.

8.4.3.2. ALTERNATIVE METHOD

In the alternative and with the written directive from the Corrosion Engineer and if specified in the Project Specification, the thickness requirement for a specification can be determined by standard deviation around a mean with maximum and minimum thickness requirements.

8.4.3.3. VARIABILITY OF METHODS

The Corrosion Engineer shall consider the variability associated with hand spraying versus the consistency that can be obtained with automated machine spray.

(a) Measurements and instrument types shall be in accordance with SSPC PA - 2 and a restriction level of 1, which means that the minimum DFT of the paint or coating may not be reduced by a factor to allow for the blast profile. This shall be interpreted as 100% of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(b) The frequency of measuring DFT shall be as per SSPC PA - 2unless specified differently in the Project Specification.

(c) In the case of coats applied after the erection of steel work on Site, the frequency at which measurements of the DFT are taken shall be at the discretion of the Corrosion Engineer's Inspector or his nominated representative(s) and may be dictated by accessibility.

(d) DFT in excess of the prescribed maxima shall not necessarily constitute reason for rejection if the paint film is demonstrated to be sound in all respects.

(e) Owing to delayed solvent release, solvent-borne coatings shrink over a period of time resulting in a lower film thickness and therefore it is important that DFT measurements be taken after seven days.

(f) The default method of measuring coating or lining DFT shall be as described in points a-e above. At the discretion of the Corrosion Engineer alternative methods of measurement may incorporate standard deviation and mean thickness. Should the reading(s) indicate that there may be areas of coatings or linings thinner than specified, then additional testing may be necessary and or rectification or repair to ensure that minimum requirements are met.

(g) The method used to measure DFT, and the significance of the readings for each particular project, shall be agreed upon by all parties prior to commencement of the work.

(h) The test report relating to DFT readings should be reported in accordance with SSPC PA - 2.

8.4.3.4. AUTOMATED SHOP APPLIED LINING AND COATING

The film thickness on all pipes shall be measured non-destructively by an approved electro-magnetic instrument.

(a) For pipes smaller than 600mm in diameter, a minimum of four readings shall be taken at equally spaced intervals around the circumference, approximately 300 mm from each end of the pipe. The first reading shall be over the weld bead. When practicable an additional four readings at equally spaced intervals around the circumference in the centre of the pipe shall be taken. The thickness shall not be less than the minimum specified over 100 percent of the area including weld beads. The Inspectorate may at their discretion supplement the above test by checking wet film thickness on any or all pipes during application of the epoxy resin.

(b) For pipes of 600mm in diameter or larger, a minimum of 8 readings shall be taken equally spaced around the circumference at 300mm from each end of the pipe and at two other equally spaced positions along the length of the pipe.

8.4.3.5. HAND AND IN-SITU APPLIED LINING AND COATING

For pipes larger than 600mm in diameter, 8 readings shall be taken equally spaced around the circumference at positions not more than 10 metres apart along the length of the pipe. All the applied lining and coating thicknesses shall be tested by means of an approved eddy current or magnetic instrument. The first reading shall be over the weld bead. The thickness shall not be less than the minimum specified over 100 percent of the area including weld beads.

8.4.4. DEGREE OF CURE OF TWO-COMPONENT MATERIALS

The degree of cure of a two-component material will vary with time, temperature and ventilation and shall be assessed by solvent wiping in accordance with the method given in SANS 8501 (methyl ethyl ketone resistance test).

Alternatively, the degree of cure can also be determined by measuring the hardness in Barcol, an indenter type test typically used for polyester, vinyl-ester and fibre glass type materials.

Rubber and urethane materials may have their degree of cure determined by hardness testing in accordance with International Rubber Hardness Degree (IRHD) Shore A or D or other methods as described by the manufacturer in the material data sheet.

8.4.4.1. METHYL ETHYL KETONE RESISTANCE

a) Materials and equipment

- Methyl ethyl ketone (MEK)
- Cheesecloth, that is 100 % cotton, approximately 300 mm x 300 mm in size, and that contrasts in colour with the coating that is evaluated.
- Power safety equipment, as determined by the solvent material safety data sheet (MSDS), for example solvent-resistant gloves and respirator.

b) Procedure

- Select areas on the coated surface at least 150 mm long on which to run the tests. Clean the surface with tap water to remove any loose material and allow it to dry.
- Measure the dry film thickness of the coating in the selected areas in accordance with SANS 2808. Make a 150 mm x 25 mm rectangular test

area on the undamaged cleaned surface using a pencil or other suitable solvent-resistant marker.

- Fold the cotton into a pad of double thickness and saturate it to dripping wet condition with the specified solvent. Do not allow more than 10s to elapse before proceeding to the next steps.

- Place a properly protected index finger into the centre of the pad while holding excess cloth with the thumb and remaining fingers of the same hand. With the index finger at 45° angle to the test surface, rub the rectangular test area with moderate pressure, first away from the operator and then back towards the operator. One forward and back motion is one double rub, and complete at the rate of approximately 1/s.

- Continue rubbing the test area for a total of 25 double rubs. Take care to stay within the rectangular test area. Reposition the finger on an unused clean portion of the cloth and re-saturate the cloth with the selected solvent to a dripping wet condition. Do not allow more than 10s to elapse before continuing the double rub procedure on the market test area for an additional 25 double rubs. Immediately inspect the middle 125 mm of the rubbed area, disregarding 13 mm at each end, for fingernail hardness and visual changes in appearance, comparing the rubbed area with an adjacent unrubbed area. Gloss and hardness will tend to return to initial values as recovery time increases.

- Visually examine the cloth for indications of coating removal. There shall be no discolouration on the contrasting colour cloth after 50 double rubs.

8.4.5. ADHESION

Use the appropriate test method, for compliance, as specified in the generic materials Chapters.

The reduction in adhesion is required to be tested and quantified when comparing new and aged samples expressed as a percentage reduction in bond strength from initial adhesive strength. Use of recognised appropriate adhesion test methods such as cross cut, cut strip, peel pull, direct glued dolly pull or push off, reverse hydraulic pressure blister etc. is recommended to enable product comparison. The ageing process should also be carried out using a recognised method such as hot water soak or cyclic environment testing.

The adhesive bond strength samples shall in addition allow for evaluation of the bond between the mainline coating or lining and the relevant field joint system. The adhesive test results should state whether the failure was a cohesive failure of the coating or lining material, or an interfacial adhesive failure between the coating or lining and the substrate or field joint material. The aged adhesive bond strength test should be conducted on wet samples. *The highest initial adhesive strength is preferable in conjunction with the least reduction of adhesive strength due to ageing***.**

NOTE: Cross hatch adhesion testing is only permitted for atmospheric environments.

There are limitations on the suitability of the test method selected for the different type of coatings and linings.

Each Chapter that references this specific generic test will have a particular method of performing adhesion testing, using appropriate bond strength test methods, such as peel pull, direct pull off, reverse hydraulic pressure.

8.4.6. IMPACT RESISTANCE (FOR COATINGS ON PIPES ONLY)

Use the appropriate test method, for compliance, as specified in the generic materials Sections. Depending on project requirements the Project Engineer may request data on blunt impact resistance, sharp impact resistance, forward and reverse impact resistance which may or may not be considered in conjunction with cut and gouge resistance as well as abrasion resistance. Organic materials normally exhibit interrelated properties and characteristics relative to impact resistance.

NOTE: There are limitations on the suitability of the test method selected for the different type of coatings and linings.

8.4.7. PERMEABILITY AND RESISTANCE TO WATER DIFFUSION

Use the ASTM-D1653 test method or equivalent.

NOTE: The limitations, based on film thickness of the coating, as per the test method.

8.4.8. TOXICITY AND TAINTING

Lining that will be subject to potable water service shall comply with the requirements of SANS 241-1.

8.5. REPAIR OF COATINGS AND LININGS

For rehabilitation refer to Chapter 9 (CONSIDERATION FOR COATING AND LINING SELECTION).

(a) Evaluation of coating and lining must be done to establish the extent of damage and to determine if repair or refurbishment is required.

(b) All repairs and procedures shall be approved by the Corrosion Engineer and subject to inspection procedures as set out in Section 8.4 (TESTING PROCEDURES).

Where the damage is extensive the inspection procedures as described in Section 9.3.1 (BACKFILL AND COATING SELECTION) shall be followed and the remedial procedures shall be agreed upon in writing with the Corrosion Engineer.

(c) All repairs shall comply with the requirements of the repair-product manufacturer's data sheet. The Corrosion Engineer may at his discretion request that repaired coating areas undergo adhesion tests.

(d) Any damage occurring during transit from the Contractor's premises to the site, shall be the responsibility of the Contractor. The Contractor responsible for installation of equipment at site shall repair any damage occurring on site during handling, assembly, storage, transport and erection.

(e) The repaired area shall be tested in accordance with the relevant Section 8.4 (TESTING PROCEDURES) above for compliance with the relevant requirements for thickness, full cure, and electrical insulation defects, respectively.

(f) Any item showing electrical insulation defects exceeding an average of five per square metre (a cluster of pinholes within a radius of 25 mm being regarded as a single defective area), or flaking or other signs of loss of adhesion, shall not be patch repaired. The item shall be blast cleaned in its entirety and re-coated in accordance with the relevant requirements of the specification.

(g) Any small area that has damage down to the steel substrate shall be deemed a major defect and repaired in accordance with Section 8.5.2 (REPAIR METHODS FOR MAJOR DEFECTS).

8.5.1. REPAIR METHODS FOR MINOR DEFECTS

The repair of areas showing electrical insulation defects, lack of full cure or low film thickness shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with a maximum roughness grade 100 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with SANS 8502-3 and Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

(d) Wipe the abraded paint surface with methyl ethyl ketone and allow to dry.

(e) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE: **1.** When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.
2. Apply a final topcoat over the repaired area to achieve uniform finish to the item.

8.5.2. REPAIR METHODS FOR MAJOR DEFECTS

The repair of areas showing damage down to the steel surface shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Blast-clean all damaged areas to Sa3 (SANS 8501-1).

(c) Feather the surrounding paint for a distance of 50 mm beyond the damaged areas with a maximum roughness grade 100 abrasive paper.

(d) Vacuum-clean the surface to remove dust and debris in accordance with SANS 8502-3 and Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

(e) Wipe the abraded paint surface with methyl ethyl ketone and allow it to dry.

(f) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE: **1.** When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.
2. Apply a final topcoat over the repaired area to achieve uniform finish to the item.

9. CONSIDERATION FOR COATING AND LINING SELECTION

Prior to finalisation of the Project Specification, the corrosion protection system selected shall be approved by the Corrosion Engineer.

9.1. GENERAL REQUIREMENTS

Sections One to Eight of this specification are of a general nature and shall be applicable to all projects including pipelines, pump stations, valve chambers, dam infrastructure, water treatment plants and any other associated infrastructure in the water industry. This Section shall assist the Corrosion Engineer and project team in selecting appropriate coating and lining systems.

Generically different coating and lining materials have various properties, and no single material will be most suitable for all applications. The Corrosion Engineer shall consider the properties below and select those that are most important to achieve the design life of the asset.

Some of the required properties common to coatings and linings are:

- durability with long life expectancy,
- ease of installation and repair,
- can be effectively applied to pipe bends, branches, tapers, and at field joints,
- quick to apply and cure,
- good adhesion to the substrate,
- good resistance to abrasion and impact,
- flexible and structurally stable under the expected loading conditions, handling, transportation, and backfilling,
- water resistant and chemically stable,
- prevents corrosion by either passivation or providing a complete barrier to permeation by water and oxygen.

Additional requirements for coatings:

- resistance to cathodic disbondment,
- minimizes cathodic shielding,
- resists soil applied stress,
- UV resistance/degradation.

Additional requirements for linings:

- smooth surface profile (low friction factor) to provide good hydraulic efficiency,
- resistance to water hammer and transient pressure surges,
- resistance to microbial colonization,
- resistance to leaching, must not contaminate the water.

The above is a non-exhaustive list and typically only a few of the above may be critical for a particular project.

The purchaser shall select the most suitable materials and systems for the specific application. Corrosion Protection systems differ considerably from application to application. On very long pipelines it might be beneficial to vary the coating system for different sections in accordance with the environment through which the pipeline passes. Consultations should be held early in the planning stages between the purchaser, material manufacturers and suppliers, the consultant and the inspecting organization, when relevant, to help the purchaser and the pipe coater to select the best possible materials and systems.

The following examples of coating and lining systems such as liquids, powders, tapes, composites, and multi-layer, have been used in South Africa, and have substantially different properties and characteristics relative to each other:

- Epoxy
- Fusion bonded epoxy
- Elastoplastic polyurethane
- Rigid polyurethane
- Polyester
- Fusion bonded polyester
- Vinyl Ester
- Glass-flake reinforced materials
- Cement mortar
- Rubber lining
- Galvanizing
- Fibre glass and carbon reinforcement wraps
- Polymer modified bitumen
- Plastic tape wrapping
- Petrolatum wrapping
- Polyethylene medium density (sintered)
- Two-layer visco-elastic wrapping
- Three-layer polyethylene system

9.1.1. CONSIDERATIONS TO EXTEND THE DESIGN LIFE

Consideration must be given to both the design life to first maintenance as well as the ultimate design life that is required from the pipeline. This will have a significant bearing on the selection criteria for the corrosion protection systems as well as the techniques to apply these systems and perform the necessary quality control.

Unless otherwise stated in the project specifications the design life to first maintenance of the corrosion protection system (Ri3 of ISO 4628 - 3) shall be forty (40) years and the ultimate design life shall be eighty (80) years.

The implication of the design life criteria is that the corrosion protection materials selected must be suitable for the corrosive environment both inside and outside the pipeline and offer an extended life expectancy.

Consideration must be given to whether or not it is anticipated that either the internals or the externals of the pipes will be available for future maintenance and the decision considers the risk and consequences associated with corrosion failure of the pipeline.

The corrosive environment along the pipeline both internally and externally is seldom constant. The Corrosion Engineer must consider the risk of local conditions producing highly aggressive corrosive environments that are not anticipated from average environmental conditions for that pipeline. Refer Sections 9.2 (LINING SYSTEMS FOR VARIOUS PIPELINE ENVIRONMENTS), 9.3 (COATING SYSTEMS FOR VARIOUS CORROSION ENVIRONMENTS), 9.6 (FIELD JOINT CORROSION PROTECTION) and 9.12 (MANDATORY REQUIREMENTS) hereunder.

The Corrosion Engineer and Project Specifiers shall frequently be called upon to select from a variety of different coating and lining products that are either suitable or most appropriate for specific corrosion environments. This may require comparative performance testing of such products so that a properly informed decision can be made. The philosophy associated with doing fair, equitable and transparent performance evaluations to indicate either lowest initial cost or lowest life cycle cost to meet life expectancy requirements is addressed in Section 10.1 (EVALUATION PROCESS).

9.1.2. CORROSIVITY

The following sub-sections provide guidance on the corrosivity of different environments which are dealt with under the respective headings:

- Water to Steel
- Soil to Steel
- Water to Concrete
- Soil to Concrete
- Atmospheric Corrosion
- Microbiologically influenced Corrosion.

Corrosivity is a measure of the corrosive aggressiveness of an environment or material towards another material. In an environment of high corrosivity, corrosion will start easily and proceed at a fast rate shortening the life expectancy.

Corrosion is an electro-chemical process and when assessing corrosivity the Corrosion Engineer shall take note of the position of the structure, water table, seasonal wetlands and marsh lands, atmospheric micro-climates, and other local environments.

The Corrosivity index is a measure of the corrosivity of the environment towards the material under consideration. It is defined by environmental parameters (actions, such as chemical characteristics) and gives limiting values for them that are used to characterise and rank the exposure class.

Depending upon the exposure class and its aggressiveness, requirements are given for measures to be taken to mitigate the corrosion of the structure or pipeline. These include, but are not limited to, the use of specific materials, control of materials compositions, minimum performance criteria of materials, acceptable levels of inspection and quality control, and mandatory consultation with relevant specialists if not at the discretion of the Corrosion Engineer.

The material of the structure or pipeline, its design and any coating or lining system, shall be chosen with due cognisance of the exposure class of each environment in which it will operate.

The corrosivity of water and ground water shall be evaluated for aggressiveness to steel and concrete and a bacteriological analysis is needed to determine the likelihood of Microbiologically Influenced Corrosion (MIC).

The corrosivity of soil to steel or to concrete shall be evaluated by considering, as a minimum, the following soil parameters:

- soil type, (clay, silt, sand, loam, coarse aggregate etc.)
- presence and amount of organic material and peat,
- resistivity and redox potential,
- moisture content,
- chemical characteristics (such as pH, chloride, sulphur, sulphate and sulphide ions, magnesium, ammonium and nitrate ions, alkalinity / acidity, and aggressive carbon dioxide),
- bacterial activity (MIC, biofilms and SRB),
- external environmental factors such as differential aeration, drainage, “long-line” changes, disturbed / undisturbed soils,
- stray electrical currents (DC and/or AC).

Some of the actions that the Corrosion Engineer can take in consultation with a Cathodic Protection Specialist and if required a Concrete Technology Specialist for the sections relating to corrosivity of water and soil to steel are as follows:

- Change the backfill material.
- Recommend an alternative pipeline route.
- Select durable coating and field joint systems that are compatible, easy to apply and have performance properties that are suitable for the corrosion exposure classes along the pipeline route.
- Use a cathodic protection system, impressed current or sacrificial anode, as required.

Some of the actions that the Corrosion Engineer can take in consultation with a Concrete Technology Specialist for the sections relating to corrosivity of water and soil to concrete are as follows:

- Change maximum water/cement ratio.
- Change minimum strength class.
- Change minimum cement content.
- Change type of cement: (CEM I to CEM V).
- Change aggregate type and size.
- Change depth of concrete cover to and type of steel reinforcement.
- Change minimum air content.
- Change methods of concrete manufacture including mixing, transportation, placement, compaction, finishing and curing.
- Apply an impermeable surface membrane or seal coat.
- Use selected backfill material and placement techniques to reduce the soil permeability and change the soil and ground water chemistry.

9.1.2.1. CORROSIVITY OF WATER TO STEEL

Reference shall be made to the latest version of DIN 50 929 Part 3 to assess the probability of corrosion of metallic materials in contact with water.

Unless otherwise indicated water should be tested in accordance with SANS 241 latest edition.

As a minimum the following Corrosivity indices of aggressiveness of water to steel should be determined: Calcium Carbonate Precipitation Potential (CCPP) and Corrosivity Ratio. The Corrosivity Ratio is the ratio of the amount of chlorides and sulphates to the alkalinity of the water. A common driver of corrosion of steel in contact with water is the chloride and sulphate concentration with respect to carbonates. There are several formulas defining the Corrosivity Ratio that use different ionic species to calculate the alkalinity of the water.

The Corrosion Engineer shall ensure that a suitably qualified chemist shall perform a water analysis and/or a soil - water extract analysis as appropriate. The chemist must then calculate the Corrosivity Ratio using the alkalinity defined as the total alkalinity comprising the sum of the bicarbonate, carbonate, and hydroxide alkalinities. The Corrosion Engineer shall consider the Corrosivity Ratio in his decision making.

To avoid steel corrosion water should be supersaturated with respect to calcium carbonate with a positive CCPP of between + 2 and + 5 mg/l $CaCO_3$. Water, with a Corrosivity Ratio greater than 1, is considered to be corrosive to steel and the Corrosion Engineer should select an appropriate coating and lining.

The origin of the water to be tested and its sampling position in relation to the steel structure shall be recorded. Information to be provided that is needed to assess the corrosivity of water to steel includes the following:

- whether the water is flowing or static.
- the range of water velocities against the steel structure.
- if the water is natural (raw) water, or treated (potable) water, or effluent from an industrial process.
- if the water is sea water, from a river or lake, or is ground water, or is a water extract from a soil sample.
- the location of the steel structure: under water, at a water/air interface or in a splash zone.

The above bullet points may increase the corrosivity and should be taken into consideration in the coating and lining selection.

9.1.2.2. CORROSIVITY OF SOIL TO STEEL

In addition to the requirements under Section 9.1.1 (CONSIDERATIONS TO EXTEND THE DESIGN LIFE) above, the corrosivity of soil to steel and the probability of corrosion of metallic materials in contact with soil shall be assessed using the latest version of DIN 50 929 Part 3.

The sum of the ratings of the soil parameters investigated or measured gives a total score from which the soil corrosivity index (category) is determined. The probability of pitting or general corrosion is assessed and an estimated mean corrosion rate for the type of corrosion can be found using the table in the Explanatory Notes to DIN 50 929 Part 3.

Soil Corrosivity Index	Soil aggressiveness	Action to be specified
Ia	Virtually not aggressive	At the discretion of the Corrosion Engineer
Ib	Weakly aggressive	At the discretion of the Corrosion Engineer
II	Aggressive	Recommended consultation with Cathodic Protection and Coating Specialist
III	Strongly Aggressive	Mandatory consultation with Geotechnical, Cathodic Protection and Coating Specialist

In the case of pipelines, the Corrosion Engineer shall ensure that the route be investigated by a Geotechnical Engineer and a report provided indicating the soil types to be crossed as defined by the Unified Soil Classification System USCS (ASTM standard D-2489) and the soil indicator properties of Plastic Limit, Liquid Limit and Plasticity Index (ASTM standard D-4318). The report shall include the locations from where the soil samples were taken and information about nearby borrow pits that can be used to provide suitable backfill material for the pipeline trench.

In the event that the USCS/ASTM standard above is not used then the Corrosion Engineer shall ensure that the Geotechnical survey and Cathodic Protection survey use the same soil type classification system to determine the soil corrosivity.

The presence of rock may result in soil conditions not being homogenous along the pipeline. The type of rock e.g. coal, shale or high iron content rocks with low resistivity or rocks with a high electrical resistivity shall be considered by the Corrosion Engineer in consultation with the Cathodic Protection specialist. Boulders or intact rock formations can interfere with the ionic flux return path and create local cathodic shielding effects.

9.1.2.3. CORROSIVITY OF WATER TO CONCRETE

The following Corrosivity indices relating to the aggressiveness of water to concrete shall be determined:

Calcium Carbonate Precipitation Potential (CCPP), Langelier, Puckorius, Riddick, Corrosivity Ratio and Basson

Unless otherwise indicated the water should be analysed in accordance with SANS 241 latest edition.

The table below gives values of the above corrosivity indices of water to determine the BS EN 206-1 concrete corrosivity exposure classes for water in dams, reservoirs and pipelines as well as for ground water extracts from soil samples that cause concrete chemical attack.

The first three are calcium carbonate scaling indices that indicate whether the calcium hydroxide in the concrete will be leached into the water and the last three take account of conditions that can lead to corrosion of the reinforcing steel in the concrete.

Corrosivity Index	Corrosivity Exposure Classes for concrete chemical attack		
	XA1 Slightly Aggressive	XA2 Moderately aggressive	XA3 Highly aggressive
CCPP	0 to -5	-5 to -10	More –ve than -10
Langelier	0 to -1	-1 to -2	More –ve than -2
Puckorius	7 to 8	8 to 9	> 9
Riddick	25 to 50	50 to 75	> 75
Corrosivity Ratio	0.5 to 0.8	0.8 to 1.2	> 1.2
Basson corrected N_c	400 to 700	800 to 1000	≥ 1100

In addition to the exposure classes determined from the corrosivity indices above, the values of aggressive chemical characteristics referred to below, shall be considered.

LIMITING VALUES OF EXPOSURE FOR CHEMICAL ATTACK OF CONCRETE BY WATER

The classification of aggressive chemical environments for water and ground water to concrete referenced as XA1, XA2 and XA3 can be found in table 1 and table 2 of BS EN 206-1:2000. The values in table 2 are based on water at temperatures between 5ºC and 25ºC and a ground water velocity sufficiently slow to approximate to static conditions.

The most onerous value for any single chemical characteristic determines the class.
Where two or more aggressive characteristics lead to the same class, the environment shall be classified into the next higher class, unless a special study for this specific case proves that it is not necessary.

Other exposure classes such as X0, XC1 to XC4, XD1 to XD3, XS1 to XS3 and XF1 to XF4 deal with risk of corrosion induced by carbonation, chlorides and freeze/thaw attack and are comprehensively detailed in table 1 of BS EN 206-1:2000.

The Corrosion Engineer and Concrete Technology Specialist shall refer to table F.1 BS EN 206-1:2000 for recommended limiting values for composition and properties of concrete to improve the resistance against the exposure classes given in table 1 referenced above.

Note that BS EN 206-1:2000 does not take nitrate concentrations into consideration and reference should be made to British Research Establishment (BRE) Special Digest 1:2005 to the table found in Box C10 page 35.

9.1.2.4. CORROSIVITY OF SOIL TO CONCRETE

The corrosivity of soil environments to concrete are based upon the latest editions of BS EN 206-1 and British Research Establishment (BRE) Special Digest 1.

The Corrosion Engineer and where required the Concrete Technology Specialist shall consider the corrosivity of soil to concrete in accordance with the above documents.

Many of the considerations and testing information relating to the corrosivity of water and ground water to concrete described in the preceding section are equally applicable to soil and soil-water extracts for the evaluation of soil corrosivity towards concrete.

Further to the soils testing given in table 2 of BS EN 206-1:2000, additional soils tests shall be carried out in accordance with Part C Assessing the aggressive chemical environment of British Research Establishment (BRE) Special Digest 1:2005.

9.1.2.5. CORROSIVITY OF ATMOSPHERE

The Corrosion Engineer shall determine the atmospheric corrosivity in the vicinity of the structure that must be protected. If the materials of construction are not suitable for the corrosive environment, then a coating or lining is required. The coating material suppliers and coating applicators shall provide the Corrosion Engineer with warranties for their products in accordance with the Corrosion Index and environment classification and for the life expectancy and time to first maintenance required by the equipment owner.

The Corrosion Engineer may in his discretion specify corrosion protection systems that are more robust than the generic guideline systems in SANS 12944.

The atmospheric corrosion index and environment classification are defined in the following table. This index relates to a classification system for corrosivity of atmospheric environments generally in accordance with and adapted from SANS 12944-2 which is protective paint systems and ISO 9224 corrosion of metal and alloys in atmospheres.

The described environmental conditions act as a guideline on the types of environmental exposure categories with C1 least corrosive and CX most corrosive environment.

Rating	Corrosivity	Environments	Description
C1	Very low	External	Dry zone, very low pollution and low time of wetness.
		Internal	Dry air-conditioned with low relative humidity and insignificant pollution.
C2	Low	External	Dry or cool temperature zone with minimum pollution, short time of wetness e.g. rural areas.
		Internal	Unheated, no air-conditioning with restricted variation in temperature, humidity and minimum condensation or pollution.
C3	Medium	External	Temperate zone with medium urban areas between 1-30km from the ocean.
		Internal	Moderate frequency of condensation, moderate pollution from process plants and industry.
C4	High	External	Temperate subtropical to tropical, low to high levels of industrial air pollution within 1km from coastal areas.
		Internal	High frequency of condensation, time of wetness, high levels of air pollution from production process.
C5 Marine/ Industrial	Very high	External	Subtropical to tropical, periods of time of wetness, very high levels of industrial air a few 100 meters of the ocean.

Rating	Corrosivity	Environments	Description
		Internal	High frequency of condensation, long periods of time of wetness, and/or high levels of air or process pollution.
CX	Extreme	External	Extended time of wetness, very high industrial air polluted areas, off shore or within a few 100 meters of the ocean and in the vicinity of salt water splash zones, subject to high frequency of condensation from humidity, mist & fog.
		Internal	Almost permanent condensation or extended periods of exposure to extreme humidity and/or high levels of industrial air pollution from production process.

9.1.2.6. CORROSIVITY DUE TO BACTERIA AND OTHER MICROORGANISMS

Microbiologically Influenced Corrosion (MIC) refers to the influence of microorganisms such as bacteria and fungi on the kinetics of corrosion processes of metals and non-metallic materials, caused by microorganisms adhering to the material interfaces in slime layers that are usually called biofilms.

If the corrosion is influenced by the activity of the microorganisms, water has to be present. In addition, four requirements need to be met shown in the table below:

Requirement	Provided by	Kind of growth
Energy source	**LIGHT** **CHEMICAL SUBSTANCES**	**PHOTOTROPHIC** **CHEMOTROPHIC**
Carbon source	**CO_2** **ORGANIC SUBSTANCES**	**AUTOTROPHIC** **HETEROTROPHIC**
Electron donor (which is oxidized)	**INORGANIC SUBSTANCES** **ORGANIC SUBSTANCES**	**LITHOTROPHIC** **ORGANOTROPHIC**
Electron acceptor (which is reduced)	**OXYGEN** **NO_2^-, NO_3^-,** **SO_4^{2-}, CO_2**	**AEROBIC** **"ANOXIC"** **ANAEROBIC**

The slime layer or biofilm comprises a community of different types of bacteria some of which secrete organic acids and extracellular polymeric substances (EPS) that are mainly composed of polysaccharides and proteins with usually minor concentrations of nucleic acids and lipids.

The EPS is highly hydrated (95 to 97 % water) and provides a matrix in which the organisms can immobilize themselves, establishing stable synergistic communities.

Some types of microorganisms involved in the MIC process are Sulphate-Reducing Bacteria (SRB), Metal-Reducing Bacteria (MRB), Metal-Depositing Bacteria (MDB), Acid-Producing Bacteria (APB) and Fungi.

In order to confirm MIC the environment surrounding the corroding site including the biofilm, water and corroded material will have to be sampled and the microorganisms identified. This will require specialized microbiological techniques probably including microscopic examination, growth of incubated cultured samples, spectrophotometric methods and measurements of redox and corrosion potentials. The guidance of a suitably qualified and experienced microbiologist and quick access to appropriate certified laboratories is essential.

In the case of biofilms and corrosion products on pipe linings, the best sampling procedure is to remove a piece of the pipe wall together with the water or liquid being transported so that the biofilm remains intact, undisturbed and does not dry out.

MIC is a serious problem for water infrastructure and can cause very high and unpredictable corrosion rates. SRB are reported to cause accelerated pitting and crevice corrosion. Some authorities advocate that MIC can be controlled by cathodically protecting the steel structure so that it has an instant-off potential of at least -950mV with respect to a saturated Cu/CuSO4 reference electrode.

9.2. LINING SYSTEMS FOR VARIOUS PIPELINE ENVIRONMENTS

Consideration should be given to the choice of appropriate linings for:

- Hydraulic performance requirements, such as hydraulic roughness and friction factors, resistance to bio-film growth, pigging operations, flow measurement and inspection facilities etc.
- Corrosion Protection

The Corrosion Engineer shall ensure that the field joint system is compatible with mainline lining systems selected. The field joint lining material or field joint corrosion system shall be specified simultaneously with the mainline lining system selection.

9.2.1. LINING MATERIAL FOR POTABLE WATER

Materials used for the lining of pipes shall be non-toxic and shall not impart any odour, taste, or colour to the water, which shall be verified by tests conducted in accordance with the South African drinking water standard, SANS 241.

The Corrosion Engineer shall approve the use of products having passed the minimum requirements of SANS 241, including having complied with the organoleptic requirements for non-tainting and odour specified for Class II water in SANS 241.

Furthermore, the aqueous extract obtained in accordance with SANS 241 shall comply with the chemical requirements for non-toxic lining material for Class 1 water in SANS 241.

9.2.2. CHEMICAL RESISTANCE

In water treatment works the use of chemicals may increase corrosivity in the immediate vicinity of the dosing point. The lining material selected for use in water treatment works may need to be more robust and have higher levels of chemical resistance than the linings used on mainline pipes and the Corrosion Engineer shall take this aspect into consideration.

The Corrosion Engineer shall ensure that the lining materials have sufficient chemical resistance and safety factor for the higher chemical concentrations in the intended service duty.

Typical chemicals used in dosing or treatment processes are:

- Chlorine, lime, bentonite, chloramine, ammonia, ozone, flocculants, UV disinfection etc.
- pH adjustment of water by addition of acid or alkalis

9.2.3. DESIGN FOR DE-AERATION

Entrained air can give rise to local accelerated corrosion conditions and may damage linings directly or may contribute to water hammer. Collapsing air pockets can cause damaging transient pressure spikes. Therefore, branches for fitting of air valves on pipelines shall be adequately spaced and sized to allow efficient removal of air pockets and entrapped air from the pipeline. Air valve branches act as access points for pipeline inspection and maintenance.

9.2.4. RESISTANCE TO EROSION WEAR AND CAVITATION

On a typical water distribution system there will be local areas that are subject to much higher rates of erosion wear and cavitation when compared to mainline pipe.

Linings subjected to these conditions will deteriorate more rapidly over a period of time. The first choice of the Corrosion Engineer should be to avoid the conditions listed below by changing the design, if this is not possible or practical then the linings should be selected that are more resistant in these conditions.

If the lining thickness is increased substantially compared to the main specification a longer life expectancy may be obtained but the lining will continue to wear due to erosion abrasion or water jetting.

The default choice should be to use a lining material that has hard wearing filler to resist erosion. In order of increasing wear resistance, the filler type can be as follows:

Glass-flake
Silicon Carbide
Aluminium Oxide
Aluminium Silicate

Furthermore, the shape of the hard-wearing particles must be preferably lamellar or flake and not round or spherical. The reason is that spherical fillers deflect abrasive particles in the flow onto the adjacent softer resins that are holding the wear resistant particles in place.

Ceramic bead filled epoxies should be avoided where fine sand or silt is carried in flowing water.

Areas listed below will require more frequent inspection and maintenance and should be specified to be protected with wear resistant coating or lining materials.

9.2.4.1. JETTING

Certain hydraulic structures (pumps, valves, bypasses) may cause local high velocity areas and suffer from water jetting damage. The lining material selection shall have the highest possible adhesive bond strength, a harder surface and greater thickness. The Corrosion Engineer shall ensure the use of structurally strong corrosion protection and wear resistant coating material in jetting conditions.

9.2.4.2. CAVITATION

The pipe work and system shall be designed to prevent the underlining causes of cavitation.

The Corrosion Engineer needs to be aware that linings cannot prevent cavitation but can simply be used to repair cavitation damage or provide resistance against future cavitation damage.

The common mechanism is that entrained vapour bubbles are carried forward in the water flow into an area of relatively higher pressure where the vapour bubbles are compressed until they collapse. The collapsing vapour bubbles implode and create high stresses from impact forces on the underlining substrate.

Characteristic cavitation damaged surface looks like an aero chocolate.

Cavitation is generally caused by a combination of the following:

- Flow disturbances upstream of the high-pressure area.
- Insufficient Nett Positive Suction Head (NPSH) on a pump inlet.
- Sharp bends, flow restrictors, valves, probes, vortex breakers may all give rise to vapour bubbles.
- Collapsing vapour bubbles as they move from low to high pressure areas.

The recommended lining materials to resist the damage caused by cavitation shall be based on hundred % solid resins reinforced with lamellar fillers such as flakes made from hard wearing materials. An alternative repair method is hard face welding with cognisance of the galvanic corrosion effect of dissimilar metals.

9.2.4.3. SEDIMENT EROSION

If the sediment load in the water is high the Corrosion Engineer shall take additional care in selecting lining systems that are more resistant to wear and abrasion. In high flow velocity areas suspended particles will increase the wear rate.

9.2.4.4. TURBULENT FLOW

Corrosion Engineering must identify areas prone to turbulent flow, alleviate the conditions and/or select more wear and abrasion resistant linings.

Areas subject to turbulent flow will corrode at a faster rate and linings will deteriorate rapidly and require more frequent inspection and maintenance.

9.2.4.5. IMPACT GOUGING AND SCOURING

Raw water from dams and rivers may contain foreign objects which could cause damage to protective linings. Scour outlets and sleeve valves are areas that often suffer from this type of damage. The Corrosion Engineer shall select linings which have more wear and abrasion resistance.

9.2.4.6. WATER HAMMER WITH RESPECT TO CEMENT WATER LINING

Where cement mortar lining materials are used and the pipeline will be subject to water hammer conditions the design of the steel pipe wall shall ensure that the stress resulting from internal hydraulic pressure shall not result in a tensile hoop strain in the steel exceeding 800 micro-strain. If pressures causing strains exceeding 800 micro-strain are likely to occur, then off-set cracking and lining de-bonding with potential corrosion behind the lining may occur. If this condition cannot be met, other lining materials should be considered.

If cement mortar lining is used where the pipeline will be subject to water hammer conditions, the cement used in the mortar mix shall be CEM1 in accordance with SANS 50197-1.

The pipe designer engineers shall model both transient and static stress conditions.

9.2.4.7. SEISMIC AND BLASTING ACTIVITIES WITH RESPECT TO CEMENT WATER LINING

The possibility of damage to coating and linings arising from seismic and blasting activity due to open cast mining and trench excavation shall be considered in the pipeline design and choice of materials, such as cement mortar lining, fibre reinforced polymer modified bitumen and flexible steel pipe.

9.2.5. WASTEWATER AND SEWERS

Corrosivity

Generally, the aggressive environment of wastewater and sewer systems results in higher corrosivity than that for raw and potable water. This means that the Corrosion Engineer shall apply his mind and use lining systems that are more robust to address this environment. MIC, bacterial corrosion and slimes are more prevalent in wastewater and sewer systems. The corrosivity is almost never constant and is dependent on the upstream industries or community's effluent. There is risk that chemicals such as acids, alkalis, solvents, oils, fats and greases may all be discharged into effluent or sewer systems, often in contravention of local regulations.

Pumped and Gravity Piping Systems

Pumped systems or rising mains are full flow pressurised systems and the pipes are usually made from steel or HDPE with long radius bends. For steel pipe, the lining will be subject to higher levels of particle erosion wear and abrasion when compared to water pipelines. Steel rising mains do not have the facility for rodding eyes to allow access to clear blockages. Conversely, gravity mains that flow partially full are normally constructed from straight sections between man holes or rodding eyes that are provided to allow clearing of blockages.

The wear rates will vary dependant on the flow velocity necessary to prevent settlement of entrained particles in the effluent and therefore the Corrosion Engineer needs to select a lining system that can withstand the higher levels of abrasion as well as chemical attack.

Methane and hydrogen sulphide

In effluent and wastewater systems methane and hydrogen sulphide are commonly found and this can greatly increase the corrosion rates of steel as well as concrete. Furthermore, these two gases also cause blistering and attack the coatings and linings especially the overt of effluent pipes that are not flowing full but have a free liquid surface.

Fat oil grease – blockages of pipe

Under cold conditions, fats, oils and grease can congeal and create blockages in sewer and effluent pipes. The Corrosion Engineer may need to look at low friction material of construction and/or alternatively linings that can also withstand high pressure water jetting and steam cleaning to clear blockages. Special attention needs to be given to smaller diameter pipes e.g. (non-man entry pipes) and their field joints.

9.3. COATING SYSTEMS FOR VARIOUS CORROSION ENVIRONMENTS

Prior to finalisation of the Project Specification, the corrosion protection system selected shall be approved by the Corrosion Engineer.

- The Corrosion Engineer must ensure that the field joint system is compatible with mainline coating systems selected. The field joint coating material or field joint corrosion protection system shall be specified simultaneously with the mainline coating system selection.

  Only mainline coating systems that have compatible field joint and damage repair systems shall be used. The Corrosion Engineer shall place emphasis on ensuring compatibility and adhesion of the corrosion protection on field joints with mainline coatings so as to avoid the risk of creating a local corrosion cell.

  The Corrosion Engineer shall ensure that the level of corrosion performance of the field joint system shall be at least equal to that of the mainline coating system in terms of the performance criteria such as adhesion, cathodic disbondment, dielectric strength and electrical resistivity, to avoid cathodic shielding.

- Guidance on selection of protective systems:
  The choice of material for coating depends on the terrain through which the pipeline passes and may vary from section to section. In waterlogged soils (usually clay soils) or where the resistivity of the soil is lower than 100 ohms, or pipelines immersed in water shall have additional protective measures, such as a more permeation resistant coating together with cathodic protection, should be used.

  Buried pipelines are subjected to stray current interference from DC traction rail network. This might require the installation of cathodic protection irrespective of soil

resistivity conditions. Under interference conditions, high negative voltages could be experienced, requiring coatings which are capable of withstanding significant cathodic over-potential.

Coating systems shall be suitable for cathodically protected pipelines (see SANS 15589-1).

9.3.1. BACKFILL AND COATING SELECTION

The Corrosion Engineer shall study the specification for the grading and screening of the Selected Backfill granular material with a maximum particle size that is specified for the project. Coarse backfill or run of trench material may contain stones and rocks that can easily damage external coating of the pipeline. Bedding material is under the pipe and carries the pipe's weight, selective backfill or fine sand is normally for compaction on the side of the pipe and up to 300mm above and over the pipe, and normal backfill or run of trench material can be used to fill the balance of the trench to normal ground level. In rocky terrain, precautions should be taken to prevent damage to the coating. The use of Selected Backfill and or rock guard might be required.

The selection of the backfill/bedding and the specification for the backfill/bedding in terms of maximum particle size distribution and hardness shall be more clearly detailed in the separate pipe laying and backfill/bedding specifications. Notwithstanding the backfill/bedding used around a buried pipe shall not have stones, rocks or other sharp alternatively hard objects which can potentially cause damage on the coating of the pipe. Compaction of the backfill/bedding on the sides of the pipe can cause significant damage to the external coating especially as before mentioned hard and sharp particles are present in the backfill/bedding.

The ideal situation is that the Corrosion Engineer together with the design team selects the pipe coating material and pipe backfill/bedding material.

If the backfill/bedding material is selected first, then the coating material will have to be chosen to be suitable for the conditions. This may increase the cost of the coating material.

If the coating material is selected first, then the bedding/backfill material will have to be suitable to not damage the coating. This may increase the cost of the bedding/backfill material.

In the two alternatives above, it is the responsibility of the Corrosion Engineer to ensure the final suitability of the corrosion protection on the pipeline.

CAUTIONARY NOTE: Rock guard or rock shield are materials intended to be wrapped around the outside of a coated pipe to prevent physical damage to the coating, but otherwise they play no part in the corrosion protection of the pipe.

9.3.2. IMMERSED IN WATER

All steel pipe immersed in water shall be manufactured from corrosion resistant steel and coated and lined. The Corrosion Engineer shall consider that under stagnant/anaerobic conditions, stainless steels may suffer pitting due to differential concentration cell corrosion. Examples of river crossings up to the edge of the flood plains and pipes encased in concrete such as dam walls, reservoirs and where future access will be near impossible.

9.3.3. BURIED IN SOIL

Consideration shall be given to the points below:

- The use of **appropriate bedding** and selected backfill material shall meet the required standards. Returning the excavated material (run of trench) to the trench is to be

avoided unless special Approval is obtained and can only be used under special conditions. Relaxation of the backfill material quality requirement and a concession based on the use of rock shield shall not be granted.

- Reference specification shall be in accordance with SANS 3001-GR10, -GR11 or - GR12 as appropriate.

- **Robustness** of the coating system shall be selected with consideration of the available backfill material and compaction equipment. The backfill shall be compacted and care must be taken that the compaction does not damage the external corrosion protection.

- When choosing the lining and coating material of the pipes a possible **flexing** of especially large bore pipes during handling and operation must be taken into consideration.

- The coating material must be easily **repairable** in the field.

- Coating material or dual systems must be applied to **adequate thicknesses** to promote service life.

- Compatibility of coating with the **cathodic protection system** (Dielectric strength and cathodic shielding)

- A bond breaker pipe wrap may be required for large diameter pipes (greater than >1,5m) where soilcrete bedding is used for the haunch area of the pipe. The soilcrete angle of support at the centre of the pipe is normally 90 degrees and larger angles may result in pipe floatation.

- A DCVG survey shall be done after construction to identify any coating damage as a result of inadequate care during backfilling and compaction.

9.3.4. ENCASED IN CONCRETE

In cases where future maintenance access is not possible or extremely difficult, then corrosion resistant pipe material must be considered on a life cycle cost basis. The recommended best practice is stainless steel pipe coated and lined in the concrete encasement.

Example: Inlet and outlet pipes to reservoirs, river crossings, dam wall, scours etc.

The reinforcing bars may under no conditions be in electrical contact with the pipe. The minimum concrete cover as specified must be in place between the pipe and or thrust/puddle flanges and the reinforcing bars where the pipe passes through concrete walls.

Where the pipe enters and exits the concrete interfaces must be sealed with semi-flexible polyurethane or hydrophilic sealant.

Care shall be taken during concrete placement to avoid damage of the coatings.

9.3.5. IN CHAMBER WALLS

No flexible or compressible coating material may be used to protect the pipe and thrust/puddle flanges when passing through concrete walls and therefore only rigid corrosion protection systems may be used. All pipe work and puddle flanges, including stainless steel pipe work, passing through concrete walls shall be coated.

The reinforcing bars may under no conditions be in electrical contact with the pipe and then shall be the specified minimum concrete cover between the pipe and or thrust/puddle

flanges where the pipe passes through concrete walls.

Where the pipe enters and exits the concrete interfaces must be sealed with semi-flexible polyurethane or polysulphide sealant.

Care shall be taken during concrete placement to avoid damage of the coatings. A DCVG survey shall be done after construction to identify any coating damage as a result of inadequate care during concrete placement. This survey will also find the coating damage inside the chamber wall.

9.3.6. CHAMBERS AND CORROSION ENVIRONMENTS –

The environment inside chambers is considered a high humility environment and is rated as C5I in terms of corrosivity in accordance with ISO12944 for the purposes of this specification document. Cold water flow through steel pipes generally results in a condensing micro-environment inside the chamber. Therefore, the corrosion protection requirements on the inside of chambers in terms of coatings, materials of construction and electrical fittings shall be typically as follows:

- Electrical requirements for chambers:
  - Chambers with zero risk of flooding – IP66 or better may be used.
  - Chambers with occasional risk of flooding – IP68 shall be used.

- Material of construction in chambers:
  - Cat ladders, grating, walk ways, platforms – for splash and immersion: Stainless Steel or fibreglass
  - Cat ladders, grating, walk ways, platforms – for atmospheric service: Stainless Steel, Hot Dip Galvanized or fibreglass
  - Manhole opening and covers - 3CR12, fibre reinforced concrete or polymer concrete. The design of the manhole cover shall take into consideration theft, security and ease of access.
  - Draft pipes for ventilation shall be constructed from non-corrosive material such as:
    - PVC, GRP and Polyethylene
    - Stainless steel is susceptible to corrosion pitting in a chlorine atmospheric environment and in purified water systems.

- Ventilation:
  Chambers are considered confined spaces and require adequate draft ventilation consisting of two vents, one with a pipe extension on the vent to ensure proper air circulation. The ventilation openings shall be designed to be snake and vermin proof and prevent rain ingress. The material of construction shall be as above. The size of the ventilation openings shall be bigger than those of any air valves to prevent air flow restriction resulting in a partial vacuum when draining the pipeline.

- Drainage:
  The design of the chamber shall be such that ground water or pipe leakage water can drain from the chamber. All chambers shall have a sump to provide a pumping point to de-water the chamber. Where practical, chambers shall have a drainage outlet to ground level in order to prevent flooding of the chamber.

9.3.7. ABOVE GROUND (ATMOSPHERIC CORROSION)

It is essential that the topcoat of corrosion protection systems is **UV resistant** and does not degrade under sunlight and UV.

All epoxy coating systems exposed to UV light are subject to chalking and a gradual loss of coating thickness. For prolonged UV exposure epoxy should be over coated with UV resistant coatings. Spare pipes and specials shall be protected against UV exposure during storage.

The coating material must be able to withstand **high temperatures** of up to 70 degrees Celsius due to midday sun baking on a pipe, as well as withstand freezing conditions too minus 10 degrees Celsius.

Differential thermal expansion between the steel pipe and the coating shall be taken into consideration to ensure compatibility under conditions of thermal expansion during day/night cycling.

Where **supports, saddles and straps** are used above ground care needs to be taken to protect the coating system by use of suitable packing material (plastic and rubber etc.).

The selection of coating must take into account potential damage by impact or vandalism after construction.

9.4. CATHODIC PROTECTION

The Corrosion Engineer shall be aware that there are many different soil and environmental conditions under which Cathodic Protection of the external surface of the pipeline is required. In these circumstances, the Corrosion Engineer shall consult with the relevant Cathodic Protection specialist.

REFER TO VOLUME 2 CATHODIC PROTECTION

9.4.1. AC AND DC MITIGATION

The Corrosion Engineer shall be aware that there are certain conditions under which AC and or DC interference may occur on the pipeline. Under these circumstances the Corrosion Engineer shall consult with a relevant Cathodic Protection specialist.

AC and DC that may be induced onto a pipeline can create a significant health and safety risk, as a result of high voltages and current discharge from the pipeline or valve chamber and must be properly mitigated.

The Corrosion Engineer shall be compelled to consider the risks of induced AC and or DC stray currents as well as interference from other pipelines under the following conditions:

- When power lines, railway lines and/or other pipelines share the same servitude
- When power lines, railway lines and/or other pipelines are parallel or adjacent
- When power lines, railway lines and/or pipelines diverge from each other or cross each other's paths.

9.5. COMPATIBILITY OF COATING WITH CATHODIC PROTECTION

The Corrosion Engineer shall be aware that there are substantial differences in performance and electrical characteristics of the various mainline coating systems. Care must be taken with the selection of coating and field joint systems to ensure optimal compatibility with Cathodic Protection systems. The Corrosion Engineer shall consult with a relevant Cathodic Protection Engineer.

Reciprocal consultation and agreement on coating selection between Corrosion Engineer and Cathodic Protection Engineer is essential.

Cathodic protection of the pipeline is not only needed to limit the corrosion at coating defects but also to mitigate the effects of stray currents (both AC and DC) due to nearby railways, powerlines and other cathodically protected pipelines. This mitigation is needed

both during pipeline construction and during the operational life of the pipeline.

The steel pipe surface is effectively cathodically protected from corrosion when the pipe to soil instant-off potential is in the range of -0.95 to -1.1V when tested with a Copper/Copper Sulphate ($Cu/CuSO_4$) electrode. If the steel pipe surface becomes more negative than -1.1V the risk increases for cathodic disbondment of the coating. If the steel pipe surface becomes less negative than -0.95V the corrosion risk increases. Refer to the project dedicated cathodic protection specification.

A selection of important criteria for the evaluation and selection of coating materials for use in conjunction with Cathodic Protection are the following:

9.5.1. CATHODIC SHIELDING

Cathodic protection current shielding can be defined as any condition which reduces the amount of protective cathodic protection current that reaches the pipe metal surface. This becomes a problem whenever the current level is reduced to a value that is less than that required to protect (polarize) the pipe surface from corrosion attack. Cathodic protection shielding can occur anywhere through the return path from the pipe metal surface to the anode bed when a pipe is subject to cathodic protection.

Cathodic shielding by a coating is the term used to describe the situation where a coating has disbonded from the steel pipe and cathodic protection is no longer effective in preventing corrosion of the steel in the area underneath the disbonded coating. This type of coating is described as “shielding”. One way of distinguishing a “shielding” coating from a “non-shielding” coating that is compatible with cathodic protection, is to test the pH of the liquid under the disbonded coating. If the pH of the electrolyte is alkaline it means the cathodic protection system is working and the coating is “non-shielding”.

An aged coating that has developed a blister or has disbonded allows water and oxygen to permeate to the steel. Under a “shielding” disbonded coating anodic and cathodic sites are set up on the steel surface by oxygen concentration differences leading to crevice corrosion and pitting. If the coating were “non-shielding” it would allow the cathodic protection current or ionic flux in the electrolyte to generate hydroxide anions that would raise the pH, make the steel cathodic, and prevent corrosion.

Cathodic shielding is detrimental to cathodic protection of pipelines and shall be avoided, therefore the Corrosion Engineer and Cathodic Protection Engineer must agree that the coating selected for the pipeline shall not exhibit Cathodic shielding tendency.

A non-shielding coating requires conductivity greater than approximately 10^{-5} A/cm^2 to pass the cathodic protection current.
Conductivity of FBE is between 10^{-10} to 10^{-12} A/cm^2.
Conductivity of MLPE is approximately 10^{-12} A/cm^2.

An electrically insulating protective coating with insulation resistance of 10^6 $Ohm.m^2$ is good; and, depending upon the service conditions, a coating with a minimum resistance of 10^4 $Ohm.m^2$ is acceptable.

For additional information refer to CITWIF: Volume Two - Cathodic Protection.

9.5.2. CATHODIC DISBONDMENT

Cathodic disbondment is the failure of adhesion between a coating and a metallic surface that is directly attributable to cathodic protection conditions and that is often initiated by a defect in the coating system, such as accidental damage, imperfect application, excessive permeability of the coating, or the application of excessive cathodic potential more negative than -1.1V ($Cu/CuSO_4$).

Cathodic disbondment is detrimental to corrosion protection of pipelines and conditions leading to disbondment shall be avoided.

9.5.3. DETERIORATION OF ELECTRICAL PROPERTIES OF THE COATING OVER TIME

The aged bond strength and aged moisture absorption are important factors when considering a coating system. The information can be obtained from coating manufacturers directly or by way of the Atlas cell testing methodology.

9.5.4. INTERDEPENDENCE BETWEEN COATING AND CATHODIC PROTECTION

The design of the coating and cathodic protection systems is interdependent, and consultation is required between the Corrosion Engineer and Cathodic Protection Engineer.

The consultation shall discuss the following coating properties: resistivity/resistance, conductivity, impedance, capacitance, permeability of coatings, Electrical Impedance Spectroscopy (EIS) testing etc.

9.6. FIELD JOINT CORROSION PROTECTION

This section is a general field joint guideline and details shall be given in each generic coating and sections.

Refer to Section 7.3 (FIELD JOINT SURFACE PREPARATION) for the surface preparation requirements.

Irrespective of the lining and coating systems of the mainline pipe, any temporary protection that has been applied on the cut-back ends shall be removed prior to application of the field joint material.

It is not permitted to apply field joint lining and coating over the temporary protective on the cut-back ends.

9.6.1. TRENCH ACCESS TO EXTERNAL SURFACES OF PIPE FIELD JOINTS

(a) The Project Manager/Engineer shall ensure compliance with trench safety regulations before corrosion protection of field joints is carried out.

(b) The Corrosion Engineer shall witness and approve a Pre-Qualification Trial (PQT) and Application Procedure Specification as per 4.4.3 and 4.4.4.

(c) The Corrosion Engineer shall ensure that the fox holes are adequately sized to provide sufficient clearance for the application of the corrosion protection system.

(d) High pressure airless spray and cartridge spray systems typically require a minimum stand-off distance for the spray gun tip of 500mm as well as additional working clearance for the spray operator.

(e) The availability of twin pack epoxy aerosol spray cans can reduce clearance requirements.

(f) Use of 90-degree spray tips may reduce working clearance requirements between the pipe surface and the trench wall/floor.

(g) The brush, roller and application pads require less working clearance between the pipe and the trench wall/floor.

(h) It is preferable that pipe wrapping should be done by a wrapping machine regardless of pipe diameter.

(i) Tape wrapping machines require minimum pipe to trench wall/floor clearances.

(j) Larger diameter pipes become increasingly difficult to wrap with constant tension and it is mandatory to use wrapping machines for pipes larger than 800mm diameter.

9.6.2. FIELD JOINT COATING COMPATIBILITY TO MAINLINE COATINGS

(a) It is preferable that the mainline coating and field joint coating materials and application method are the same to give a seamless corrosion protection system with the same electrical, chemical, and physical properties.

(b) Field joints are potential weak points in the pipeline corrosion protection systems and as such alternative field joint materials shall be proven to be equal to or better than the mainline coating.

(c) If the field joint material is different to the mainline coating, the field joint material shall have the same electrical properties as the mainline coating.

(d) The cathodic disbondment resistance of the field joint system shall be equivalent to or better than the mainline coating.

(e) The adhesion between the field joint and mainline coatings shall be greater than the cohesive strength of the individual coatings.

(f) Furthermore, the adhesive bond strength of the field joint system to the bare steel shall be greater than its cohesive bond strength. Under a destructive adhesion test some of the field joint material shall remain adherent to the steel pipe surface.

(g) The resistance to water absorption of the field joint material shall be equal to or better than that of the mainline coating.

(h) The water vapour transmission rate of the field joint material shall be equal to or better than that of the mainline coating.

(i) Any test work performed to evaluate field joint coating systems that are different to mainline coating systems shall be taken from representative samples applied under field conditions.

(j) If the Corrosion Engineer decides to use a different field joint coating material when compared to the mainline material, they shall refer to Section 9.12 (MANDATORY REQUIREMENTS).

9.6.3. NON-MAN ACCESS TO PIPE FIELD JOINT INTERNALS

(a) For pipes smaller than 800mm (600mm with a safety concession) man access should not be permitted.

(b) The Engineer shall evaluate the different internal field joint lining application methods for pipes too small for man access by means of a CCTV camera and/or Pre-Qualification Test to compare the performance of pull through lining systems to remotely operated blast and spray systems.

(c) For cement mortar lining the use of pull through application method shall be used.

(d) The application of the internal corrosion protection field joint system must be made after each weld has been completed.

9.6.4. MAN ACCESS TO PIPE FIELD JOINT INTERNALS

(a) For new construction and where man access into pipelines is permitted in terms of safety regulations, access may be provided from the pipe laying head and by means of a welded T stub section at intervals no greater than 500 meters.

(b) The T stub sections shall have a blank flange fitted with an air valve or an alternate method for venting and bleeding air as per the design requirement for that pipeline.

(c) For new construction, the progress for laying the pipeline shall occur simultaneously with the internal corrosion protection and steel pipe laying may not progress if it will create access restrictions for internal corrosion protection.

(d) The contractor shall coordinate the activities of the lining and coating crew with the pipelaying crew on a daily basis to ensure the field joint corrosion protection is timeously completed and quality released.

(e) For pipes smaller than 1m nominal bore, the pipelay contractor shall not lay more pipes per shift than the lining crew is able to complete and release the internal field joint lining.

(f) The pipelay crew shall not proceed more than one shift / day ahead of the internal field joint protection crew. Should a concession be required it shall be accompanied by a detailed method statement, with due consideration to access for field joint corrosion protection relative to pipe diameter.

9.7. CORROSION PROTECTION OF DIFFERENT JOINT SYSTEMS

The choice of mainline coatings and lining systems is influenced by the field joint corrosion protection systems for the different types of pipe joints (e.g. butt welds, bolted flanges, mechanical couplings, spigot and sockets, etc.)

Buried flanged and mechanical joints are not recommended unless absolutely necessary in which case the Corrosion Engineer shall take special precaution to ensure the integrity of the joint does not deteriorate as a result of potential future corrosion.

9.7.1. MECHANICAL COUPLINGS

(a) Electrically discontinuous pipe joints will require the welding of continuity bonding for cathodic protection that may damage the coating and lining. Provision must be made to prevent burning of the lining by using low heat weld systems or attachment blocks.

(b) The use of mechanical couplings for buried pipe is not recommended where damage of coatings and the lining of the coupling during installation and pipe movement in operation is possible and where future access is not possible. If a centre register is installed to stop the coupling from moving, a centre register that will not damage the lining is required.

(c) The mechanical couplings that provide longitudinal restraint should generally only be used where accessible and where adequate provision had been provided to prevent damage to the coating in the wetted areas on pipe internals.

(d) The external surfaces of bolts and nuts on mechanical coupling systems need to be protected with suitable profile mastics over coated with durable outer wraps.

(e) The corrosion protection specification for mechanical couplings shall preferably be the same as the mainline coating and if this is not possible then shall be the same as the requirements for field joint coatings described in Section 10.6 (ADDITIONAL USEFUL PROPERTIES FOR COATINGS, LININGS AND FIELD JOINT SYSTEMS).

9.7.2. FLANGED JOINTS (REFER TO DRAWINGS IN ANNEX B: DRAWINGS)

(a) The corrosion protection specification for flanges shall preferably be the same as the mainline lining and if this is not possible then shall be the same as the requirements for liquid applied field joint coatings described in Section 10910.6 (ADDITIONAL USEFUL PROPERTIES FOR COATINGS, LININGS AND FIELD JOINT SYSTEMS).

(b) For full corrosion protection on flanged joints between the gasket and the flange, the lining in the pipe bore must be overlapped onto the flanged face to terminate under the gasket, in such a way as to prevent crevice corrosion from occurring between or on flange faces.

(c) The coating of the rebate on the flange faces must be finished flat and flush with the steel sealing face for flat face flanges. A flat finish may be achieved with a sandpaper rubbing block, a profile, or other methods. The flatness of coating on a flange face shall be checked with a straight edge.

(d) Flat faced flanges must be fitted with full faced gaskets. Flanges with gramophone finish must on the flange sealing face be coated to a coating thickness of not more

than 80 microns. Coatings on the gramophone finish must be brush applied to prevent filling the grooves.

Recommendation for flat face flanges

(i) For the anticipated crevice corrosion that typically occurs in the water industry, the width of the rebate (A) on the flange face for liquid coatings to be covered by the gasket shall be specified as a minimum of 3x organic coating DFT or greater at the discretion of the Corrosion Engineer.

(ii) A rebate must be cut into the flange face with a depth of at least equal to the DFT of the lining. For example, a 600-micron epoxy lining will require an equivalent 600-micron rebate.

(iii) For CML the width of the rebate across the flange sealing face, should be approximately 1.5X the DFT of CML thickness. For a 15mm± 5mm cement mortar lining (CML) in a pipe, the rebate depth should be 15 mm. Cut back may only be done to comply with the strength requirement of the respective flange.

(iv) As an alternative to extending the CML onto the flange face, an epoxy coating of the flange can be extended to 100 mm beneath the CML.

(e) Raised faces require a flat surface. If a coating system is to be applied, the thickness shall be flat and even. If it is difficult to achieve a flat surface the coating must not be more than 80 microns. The full lining system shall end at the gasket interface.

Raised faces may be coated with a powder coating system as it will produce a flat even surface.

The bolts and the outer section of the flanges of raised face flanges must be protected to the full corrosion protection specification.

Modified raised face flanges should be used for cement mortar lining, with the lining extended up to the raised face on the flange.

(f) Full face flexible gaskets are generally used for low pressure applications and raised face flanges with hard gaskets are used in higher pressure applications. O-Ring sealing arrangements are used on larger flanges and high-pressure applications.

(g) Gasket materials that absorb moisture which changes their sealing properties shall be avoided.

(h) Rubber gaskets are subject to creep and compression set and may require re-tensioning of the bolts.

(i) Gasket materials that wick are not permitted.

(j) The wetted surfaces of the flanges of O-ring joints must be fully protected by the pipe lining corrosion protection system. Crushing of the corrosion protection material in the wetted areas must be avoided.

(k) Insulating flanges are used when the cathodic protection requires insulation at flanges.

(l) The external surfaces of the bolts and nuts on flange and coupling systems must be protected with suitable profile mastics over coated with durable outer wraps.

9.7.3. SPIGOT AND SOCKET JOINTS

On small diameter pipes where human access is not possible, spigot and socket joints are generally used. These pipes are generally lined with an epoxy system with an O Ring seal or cement mortar lining with a plug lining repair system at the welded joint. A fillet weld is used to rigidly join spigot and socket joints with appropriate cut backs to prevent damage to the coating and lining. As no internal fillet weld is possible, the continuity of the internal

lining system must be such as to avoid crevice corrosion.

Spigot and socket joints may be used on larger diameter pipes where human access is possible and internal fillet welds are recommended. Appropriate cut backs on coatings and linings must be provided to avoid damage during completion of the joints.

9.7.4. BUTT WELDED JOINTS

Butt welded joints are generally used where human access is possible. Appropriate cut backs at the welded joints must be provided to avoid welding heat damage to coatings and linings. The weld procedure and pipe wall thickness will determine whether an internal weld is required.

The profile of the weld bead must be smooth, slightly convex, free of defects and merge smoothly with the pipe barrel. The protrusions must be limited to the appropriate specification to achieve successful joint repairs. Refer to Sections 6.2.4.4 (Weld Finish) and 9.12 (MANDATORY REQUIREMENTS).

- Weld Bead Height with respect to shrink sleeves and tape wrap is more critical than the standard height of 3mm allowed in Section 6.2.4 (SHAPE IMPERFECTIONS). For either shrink sleeves or tape wrap the weld bead height shall be reduced to zero mm and b flush.

- This requirement for a flush ground weld bead is applicable to both factory manufactured steel pipe both a longitudinal and spiral welds as well as circumferential field weld joints.

- The weld height restriction is applicable to corrosion protection materials applied under tension as a sheet, a film or tape wrap.

9.8. JOINTS BETWEEN DISSIMILAR METALS

Joints between dissimilar metals are generally at flanged insulating joints. Full pin-hole free coating and lining systems must be ensured at these joints. The minimum paint thickness near the joint must be equal to the maximum specified for the less noble material.

When two dissimilar metals are welded the appropriate weld procedure must be used and the integrity of the weld ensured.

For additional information refer to Section 5.1.2 (CORROSION PREVENTION).

9.9. FASTENERS AND ANCHORS

Fasteners include anchors, nuts, washers, bolts, studs etc associated with base plates, flanges, couplings etc.

Where supports, saddles and straps are used above ground care needs to be taken to protect the coating system by use of suitable packing material (plastic and rubber etc.).

9.9.1. FASTENERS

Fasteners and washers that are installed in dry conditions must be hot-dip galvanized and the thread coated with Molybdenum Disulphide lubricant (dry spray) or rope dressing. Once dry, the rope dressing should be overcoated with multipurpose epoxy.

Chamber internals or areas subject to high humidity or wet/submerged conditions, intermittent wet dry cycling, the fasteners and washers shall be either:

- stainless steel pickled and passivated and coated with Molybdenum Disulphide lubricant or Nickel Anti-seize compound, or

- carbon steel / high tensile (including the threads) coated with fusion bonded fluoropolymer (example Teflon™/Xylan™ coating), or
- carbon steel / high tensile (including the threads) coated with rope dressing. Once dry, to be overcoated with multipurpose epoxy.

Where dissimilar metals contact occurs, e.g. stainless steel/hot-dip galvanized bolts and carbon steel flanges, care must be taken to avoid galvanic corrosion by coating the appropriate surfaces, *inter alia*:

- Bore of the bolt hole
- Back of the flange
- Shank of the bolt
- Bolt head
- Exposed thread
- Nut
- Exposed Washer surface
- Any other contact surfaces

Also, for illustration purposes refer to the drawings – ANNEX B: DRAWINGS

Fasteners that are buried in soil must be hot-dip galvanized and the thread coated with Molybdenum Disulphide lubricant and over coated with Petrolatum or Butyl tape wrapping or visco-elastic systems designed for buried conditions.

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Fasteners and washers - Dry	Carbon/ High Tensile steel	HDG plus threads coated with Molybdenum Disulphide lubricant (aerosol dry lubricant) or rope dressing.	45
	SS 304	Threads coated with Molybdenum Disulphide lubricant (aerosol dry lubricant) or Nickel Anti-seize compound.	Uniform cover
Fasteners and washers - Wet/Submerged/ Valve chambers	Carbon/ High Tensile steel	Fusion bonded Teflon/fluoropolymer coated bolts and nuts (including the threads).	30 to 50
	SS 316	1. Pickle and Passivate - See note 4 plus threads coated with Molybdenum Disulphide lubricant (aerosol dry lubricant) or Nickel Anti-seize compound.	Uniform Cover
		2. Fusion bonded Epoxy coated (thread surfaces excluded) plus threads coated with Molybdenum Disulphide lubricant (aerosol dry lubricant) or Nickel Anti-seize compound.	50
		3. Fusion bonded Teflon/fluoropolymer coated bolts and nuts (including the threads).	30 to 50
Fasteners and washers - Buried in soil	Carbon/ High Tensile steel	1. HDG plus threads coated with Molybdenum Disulphide lubricant (aerosol dry lubricant) or wax plus mastic with Bitumen or Tape wrapping.	45

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
		2. Fusion bonded Teflon/fluoropolymer coated bolts and nuts (including the threads).	30 to 50
	SS 304	Threads coated with Molybdenum Disulphide lubricant (aerosol dry lubricant) or Nickel Anti- seize compound plus Bitumen or Tape wrapping.	Uniform cover
Fasteners for flange adaptor/couplings – Drilled and tapped	Carbon/ High Tensile steel	1. HDG plus threads coated with Molybdenum Disulphide lubricant (aerosol dry lubricant) or wax plus mastic with Bitumen or Tape wrapping.	45
		2. Fusion bonded Teflon/fluoropolymer coated bolts and nuts (including the threads).	30 to 50
	SS 304	Pickle and Passivate - See note 4 plus wet assembly with Epoxy.	Uniform cover
Fasteners for flange adaptor/couplings - welded	SS 304	Pickle and Passivate - See note 4.	
Fasteners in concrete - marine conditions	Carbon steel/ stainless steel	All exposed parts must be encapsulated and sealed with epoxy putty, mastic or similar.	Seal and compreh ensive cover

9.9.2. ANCHORS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Anchors in concrete - Dry See Section 5.3.2 (ANCHORS IN CONCRETE)	SS 316	Threads coated with Molybdenum Disulphide Lubricant (aerosol dry lubricant) or Nickel Anti-seize compound.	Uniform cover
Anchors in concrete - Wet See Section 5.3.2 (ANCHORS IN CONCRETE)	SS 316	Threads coated with Molybdenum Disulphide Lubricant (aerosol dry lubricant) or Nickel Anti-seize compound plus nut and washer. FBE coated head and shank.	Uniform cover 50
Anchors in concrete - marine conditions	Carbon steel/ stainless steel	All exposed parts must be encapsulated with epoxy putty, mastic or similar.	Seal and compreh ensive cover

NOTE: It is not recommended to use uncoated stainless steel anchor bolts at coastal regions under C5M (marine conditions ISO 12944). Salt or chlorides will induce stress corrosion cracking in stainless steel.

9.10. SPARE PIPES - LONG TERM STORAGE OF PIPES

The Contractor shall provide all the necessary balks of timber and saw-dust filled bags used to support the pipes on soil, concrete or other hard surface and to separate them from each other.

Pipes shall be stacked to a safe height not exceeding two pipes high on cradles and on level ground.

Grass or other vegetation shall not be allowed to grow in the storage area within three metres of the pipes.

The Corrosion Engineer must be aware that certain materials degrade when exposed to UV radiation and therefore need to be protected. The effects of differential contraction and expansion due to different coefficients of linear thermal expansion of steel and the coating or lining materials also need to be considered and protection provided if required.

Atmospheric conditions such as humidity and suspended salts can have a detrimental effect on the coating and linings and mitigating measures must be implemented to counter these conditions.

Typical mitigation measures could include any of the following:

- Put under roof and keep out of sunlight.
- Install rigid end caps into pipes or blank covers onto or over pipe ends.
- Ensure that end caps and covers are durable and fixed securely.
- Thin plastic sheet is not permissible to closing pipe ends for long term storage.
- Special precautions should be taken with epoxy or polymer modified bitumen type material because these do not store well long term:
  - For bitumen-based coating materials apply temporary silver bituminous aluminium coating or white water based acrylic PVA.
  - For FBE type coating materials apply re-coatable Polyurethane.
- Tape wrap pipes are not permitted for long term storage.
- Apply temporary white water based acrylic PVA on the externals of the pipe coatings.

For long term storage of pipe that may be exposed to UV radiation, the preferred materials for both coatings and linings would be rigid polyurethanes and polyester glass-flake material incorporating the mitigation measures described above including an optional white water based acrylic PVA topcoat to extend the life.

9.11. PROPRIETARY ITEMS

Components that are supplied painted or protected e.g. gearboxes & actuators etc. **shall only be accepted** provided that, they meet the general corrosion protection requirements of this specification. If this specification cannot be adhered to the Contractor shall **submit full details of the equivalent coating systems** at tendering stage for Approval by the Corrosion Engineer.

9.12. MANDATORY REQUIREMENTS

Any variations to the list below shall require written Approval by the Corrosion Engineer.

	CONDITION/ MATERIAL	GENERAL REQUIREMENTS
1.	Hot-dip galvanizing	- Only permissible for use with pipes up to 200 mm diameter maximum and flow velocity less than 2 m/s. - For pipes 200 mm NB and smaller the Corrosion Engineer shall evaluate the soil conditions, and only if the soil conditions are non-aggressive, as per DIN Spec 50929 Part 3, shall it be permitted that galvanized pipe may be buried and meet the life expectancy requirements. - It is a requirement that buried galvanized pipe be externally over coated or wrapped with one of the specified materials in this specification. - Refer to Chapter 25 (GALVANIZING) for additional or more detailed information
2.	Sealant	- Interfaces where pipes pass through concrete walls shall be sealed with a Polyurethane or equivalent flexible sealant to be applied in accordance with the manufacturer's data sheets. - The use of Polysulphide sealant is not permitted.
3.	Un-coated stainless steel including 3Cr12	- Only to be used if no galvanic reaction can take place. - Shall not be used under anaerobic conditions/stagnant water. - Shall not be used in an environment containing chlorine/chlorides. - Shall not be buried in soil or encased in concrete, due to risk of pitting and cracking corrosion mechanisms.
4.	3Cr12	- Typically used for concrete encasement, and then to enhance corrosion resistance 3Cr12 material shall be coated externally and lined internally.
5.	Pickle and Passivate (Applicable to all Stainless Steel and 3Cr12)	- Stainless Steel shall be pickled and passivated unless it is coated. - Where Stainless Steel is in contact with a less noble material the Stainless Steel shall be coated. - 3Cr12 and Stainless-Steel pickle and passivation shall preferably be done by the dipping process.
6.	Galvanic cells (contact of dissimilar metals)	- Both metals in an immersed galvanic cell shall be coated. - In an atmospheric galvanic cell, the less noble metal shall be fully coated, and the more noble metal shall be coated for at least 250mm from the interface. - Where a galvanic cell is situated in concrete with a water path <150 mm both Carbon steel, 3Cr12 and/or Stainless Steel shall be coated. - Where concrete cover <75 mm over a galvanic cell, both Carbon steel, 3Cr12 and/or Stainless Steel shall be coated. - Where cast iron pumps and valves are specified with Stainless Steel trim, the corrosion engineer shall also specify coatings with a high dielectric insulating potential such as glass-flake materials to prevent galvanic corrosion.

	CONDITION/ MATERIAL	GENERAL REQUIREMENTS
7.	Anaerobic conditions	- Under anaerobic or stagnant water conditions the Corrosion Engineer shall consider the risk of oxygen depletion cells / differential concentration corrosion and may have to specify coating or lining of the stainless steel.
8.	Aggressive water and/ or restricted access	- Coated Stainless-Steel grade 316L shall be used in aggressive water conditions, or where access conditions shall NOT allow for the pipe lining to be refurbished in situ at some future date. - Encased in dam walls, reservoirs, river crossings, syphons etc.
9.	Crevices	- All crevices shall be sealed with approved mastics/putty.
10.	Colour coding and aesthetic appearance	- Re-coatable Polyurethane or Polysiloxane is recommended to be used where required for colour coding or aesthetic appearance in atmospheric service only, due to good UV resistance.
11.	Primers	- Standard practice shall be to apply liquid coating and lining materials directly to steel substrates without the use of primers. Primers shall only be used in special cases i.e. over-coating of galvanized surfaces, porous cast iron, concrete, and cement mortar.
12.	Twin pack Polyurethane	- Special precautions must be taken when working with twin pack Polyurethanes due to the moisture sensitivity of some of these materials.
13.	Carbon steel	- Carbon steel may only be used where access conditions shall allow for the pipe lining to be refurbished in situ at some future date.
14.	Ductile Iron	- In an environment where cathodic protection is required, it is necessary to cross bond the ductile iron pipes to make them electrically continuous specifically across joints. - Depending on soil conditions ductile iron pipes can exhibit significant corrosion and therefore with this specification ductile iron may only be used together with the same corrosion protection as specified for carbon steel.
15.	Protection of rebar inside concrete	- The Corrosion Engineer shall consult with the Civil Engineer and agree on the exposure environments and the type of corrosion protection for the steel reinforcing bars to be embedded in concrete. E.g. minimum cover of concrete, maximum stone size, type and minimum cement content, coated rebar, HDG rebar, 3CR12 or uncoated steel. - For uncoated steel, the cover of the rebar shall be determined by the exposed environment, quality and strength of the concrete and expected life of the structure. Minimum cover shall be in accordance with the structural design codes and certified by the Structural Engineer.

	CONDITION/ MATERIAL	GENERAL REQUIREMENTS
16.	Weld Bead Height with respect to tape wrap and shrink sleeves	- Weld Bead Height with respect to shrink sleeves and tape wrap is more critical than the standard height of 3mm allowed in Section 6.2.4.4 (Weld Finish). For either shrink sleeves or tape wrap the weld bead height shall be reduced to zero mm and be flush. - In the event of not being able to grind the weld bead flush, the weld bead may have to be pre-coated and profiled smooth with a stripe coat or mastic to avoid tenting and creation of voids at the edges of the weld bead. - This requirement for a flush ground weld bead is applicable to both factory manufactured steel pipe both a longitudinal and spiral weld as well as circumferential field welded joints. - Failure to do the above will result in tape wrap or shrink sleeves being prohibited for use.
17.	Plastic tape wrap and shrink sleeves.	- All polyethylene plastic tape wrapping systems and shrink sleeves may not be exposed to direct UV light for more than seven days. - Both polypropylene and polyethylene tape wraps are thermally unstable and expand under exposure to sunlight conditions causing loss of wrapping tension and loss of adhesion. - Certain adhesives used with plastic tape wrap can deteriorate under sunlight exposed conditions. - Therefore, the Corrosion Engineer shall ensure that plastic tape wrap systems are back filled as soon as possible and not left exposed to UV. - - Tape wrap and shrink sleeves shall only be applied over a minimum of 400 microns of liquid organic coating applied on grit blasted steel.

10. COMPARATIVE EVALUATION CRITERIA FOR MATERIAL SELECTION

The Corrosion Engineer has a responsibility to select appropriate project specific coating and lining materials, from a diverse range of products such as liquid epoxy, or polyurethane or polyester glass-flake, or 3LPE, or shrink sleeves, or tape wrap, or sintered PE, or cement mortar lining, etc. These coating and lining materials are described in the product specifications from Chapter 12 and onwards.

These coating and lining materials have diverse performance characteristics as well as certain advantages or limitations of use, and the choice of the coating and lining material is dependent on the relevant specific project requirements.

In particular, the choice of coating, lining and field joint material shall be made after considering the following constraints:

- End user requirements, budgets, and project timelines
- Design life, operation, maintenance, rehabilitation, and life cycle costing
- Manufacturing, pipe availability and construction limitations such as special skills and equipment
- Pipe fluid to be transported and pipe properties
- Pipeline environment (buried, immersed, encased in concrete and above ground)
- Coating, lining and field joint system properties

The Corrosion Engineer shall consider and evaluate the relative strengths and weakness of the available products using appropriate and formal methodology to compare test results across different generic types of systems.

The Corrosion Engineer and or Coating and Lining Specifier shall take note properties listed in some historic data tables do not allow for direct comparison of performance of the different generic products with respect to each other.

On completion of the selection procedure, the project specifications and the tender enquiry documents can then be issued.

The Corrosion Engineer and or Coating and Lining Specifier shall justify technically why certain generic product types were selected for the corrosion environments and life expectancy required from the corrosion protection system.

The Corrosion Engineer and or Coating and Lining Specifier shall require comparative performance testing of products using a standardised test methodology that allows for direct comparison of data in areas such as cathodic disbondment and permeation.

The corrosion protection of the mainline pipe cannot be evaluated in isolation and must be evaluated together with an appropriate field joint system, both internally and externally.

The Corrosion Engineer shall place emphasis on ensuring compatibility of the corrosion protection on field joints with mainline coatings. The best theoretical solution is to use the same corrosion protection on field joints as the mainline pipe, but this is only possible with certain products.

10.1. EVALUATION PROCESS

The Corrosion Engineer, as the coating and lining specifier, shall consider the Sections 10.2 (REQUIRED PROPERTIES TO COATINGS AND LININGS), 10.3 (MINIMUM PERFORMANCE PROPERTIES FOR COATINGS, LININGS AND THEIR FIELD JOINT SYSTEMS) and 10.4 (SPECIAL REQUIREMENTS FOR COATINGS AND FIELD JOINT SYSTEMS) below. Thereafter the Corrosion Engineer shall rank the specific project requirements from most important to least important for the particular project. The

Corrosion Engineer shall be required to rationally justify the ranking criteria. The ranking criteria that are not relevant can be disregarded.

There shall be four respective ranking criteria:

- Coatings
- Linings
- Field joint systems and
- Specials

The ranking criteria shall then form the benchmark requirement for the decision-making process. The corrosion protection systems that have the best test results relative to the ranking criteria, shall be selected to be included in the tender specification, with the requirement that the best suited technical products compete with one another commercially.

10.2. REQUIRED PROPERTIES TO COATINGS AND LININGS

1. Required properties common to coatings and linings are:

    - durability with long life expectancy,
    - ease of installation and repair,
    - can be effectively applied to pipe bends, branches, tapers, and at field joints,
    - quick to apply and cure,
    - good adhesion to the substrate,
    - good resistance to abrasion and impact,
    - flexible and structurally stable under the expected loading conditions, handling, transportation, and backfilling,
    - water resistant and chemically stable,
    - prevents corrosion by either passivation or providing a complete barrier to permeation by water and oxygen.

2. Additional requirements for coatings:

    - resistance to cathodic disbondment
    - minimizes cathodic shielding
    - resists soil applied stress

3. Additional requirements for linings:

    - smooth surface profile to provide good hydraulics with low friction factor
    - resistance to microbial colonization
    - resistance to leaching, must not contaminate the water

There are many national and international specifications and tests which can be used to determine most of these properties. The problem is that many test procedures are not widely applicable and have been developed to test specific generic types of coatings and linings. Furthermore, there are very few test procedures that address the compatibility between the field joint coating or lining system and the factory applied coating or lining.

10.3. MINIMUM PERFORMANCE PROPERTIES FOR COATINGS, LININGS AND THEIR FIELD JOINT SYSTEMS

The following points and sub-clauses are the **MINIMUM PERFORMANCE PROPERTIES** *of coating, lining and field joint materials*, as listed in the appropriate generic material Sections, shall be considered in evaluating the different options of corrosion protection:

1. **Adhesive bond strength.** Use of recognised appropriate adhesion test methods such as cut strip peel pull, direct glued dolly-pull or push-off, reverse hydraulic pressure blister etc. is recommended to enable product comparison.

For tape wraps, shrink sleeves and viscoelastic materials different adhesion test methods shall be used but the Corrosion Engineer and specifiers shall take note that these materials generally have lower adhesive bond strength than liquid applied systems.

The reduction in adhesion for all corrosion protection materials is required to be tested and quantified when comparing new and aged samples. The test results shall be expressed as a percentage reduction in bond strength from initial adhesive strength. The ageing process should also be carried out using a recognised method such as hot water soak or cyclic pressure or temperature immersion testing, or 90-day ambient immersion test.

The adhesive bond strength samples shall in addition allow for evaluation of the bond between the mainline coating or lining and the relevant field joint system. The adhesive test results should state whether the failure was a cohesive failure of the coating or lining material, or an interfacial adhesive failure between the coating or lining and the substrate or field joint material. The aged adhesive bond strength test should be conducted on wet samples. *The highest initial adhesive strength is preferable in conjunction with the least reduction of adhesive strength due to ageing under immersed conditions***.**

2. **Water absorption.** There are short term and long-term tests at different temperatures to determine the rate at which water is absorbed into the material under different environments. This is measured as a moisture mass gain difference between the dry sample and the same sample immersed for a period of time. The results may be expressed as a percentage mass gain or an absolute value grams per square meter surface area.

   An increase in moisture absorption content of a coating, lining or field joint can detrimentally affect its electrical or mechanical properties, dimensions, and appearance. *The least amount of water absorption is preferred.*

3. **Water Vapour Transmission (WVT) and Water Vapour Permeance (WVP).** Water vapour transmission (WVT) is the steady water vapour flow in unit time through unit area of a material. Water vapour permeance (WVP) is the water vapour transmission induced by unit vapour pressure difference (Δp) between the two surfaces of the material. WVP = WVT/Δp. The wet cup method is recommended. WVT is not a linear function of material thickness, temperature, or humidity. Care should be taken to ensure that testing is continued for a sufficiently long enough time period for steady state permeation to be established. *The lowest rate of permeation is preferred.*

4. **Impact resistance for materials.** These tests for sharp or blunt objects are needed to evaluate the coating, lining, or field joint materials ability to withstand poor handling, laying and backfilling practices. *The highest impact resistance is also preferred, in the forward or reverse direction, depending on specific requirements***.**

5. **Cut and gouge resistance for materials.** In addition to the reasons above for testing impact resistance, it is necessary to evaluate materials for their performance under high static loads and their deformation under concentrated knife edge or point loads. *The preferred selection criteria shall be the resistance appropriate for the anticipated handling, installation procedure, backfill type, soil conditions or operating fluid properties.*

6. **Dielectric strength.** This property/data is important for three reasons:

   To be able to correctly calibrate equipment used to check for electrical insulation discontinuities (EIDs) and thereby avoid unnecessary breakdown spark damage of the coating, lining, or field joint during quality control inspections. A high level of electrical insulation resistance is required to prevent galvanic corrosion of dissimilar metals.

For coatings subject to cathodic protection, the higher the di-electric strength the lower the current drain that occurs. The quantity and size of transformer rectifier units will decrease if the coating has higher di-electric insulating properties.

For materials with an excessively high di-electric properties, the electrical insulation resistance may result in cathodic shielding (refer Section 9.5.1 (CATHODIC SHIELDING).

7. **UV resistance.** For coated and lined pipe that may be stored above ground for some time before being backfilled in the trench, a good resistance to degradation by UV light is required. The time period that the coating will be exposed to UV measured in months, years or decades must be considered. *The least degradation of the coating, lining, or field joint material due to UV exposure is preferred, depending on specific project requirements. Refer to Sections on polyethylene, modified bitumen, epoxy and Section 9.10 (*SPARE PIPES - LONG TERM STORAGE OF PIPES*).*

8. **Accelerated cyclic environment ageing**. The purpose of this testing is to determine resistance to combinations of cyclic variations in pressure, temperature, humidity, fog, immersion in corrosive liquids such as deionised water, saltwater or aggressive acids or alkalis. The time to and nature of failure of the test material on prepared steel panels is recorded and assessed visually (infrared and other measurement techniques may also be used). *The longest time to and the least amount of failure (such as loss of adhesion or blistering) is preferred*.

10.4. SPECIAL REQUIREMENTS FOR COATINGS AND FIELD JOINT SYSTEMS

In addition to the minimum requirement clauses in Sections 10.2 and 10.3 above, the following properties are a requirement for coatings and field joint systems:

1. **Lap shear strength.** This is particularly important for field joint coatings and factory applied coatings that are subject to soil stress due to axial movement of the pipe, or vertical soil consolidation around the pipe circumference. *The best resistance to lap shear stress is preferable.*

   Lap shear strength is particularly important when the coating material has an edge such as with shrink sleeves and tape wrap where longitudinal movement may compromise the coating system. Where the field joint material is different to the mainline coating material the risk of lap shear problems increase.

2. **Electrical insulation resistance.** For a coating and field joint coating material to be compatible with a cathodic protection (CP) system this property needs to be determined so that the current density to achieve protection can be calculated and the CP system sized and designed accordingly. Tests of new and aged coating samples should be carried out using a recognised ageing method such as hot water soak or accelerated environment cycling. The highest electrical insulation resistance may contribute to cathodic shielding and corrosion where the coating is disbonded with access for corrosive ions to the steel substrate. Too low resistance will make the ICCP system uneconomic with excessive current draw to achieve polarisation at the required protection voltage. Where the field joint material is different to the mainline coating material the risk of differences in electrical properties increases.

3. **Cathodic disbondment resistance**. There are many variations in test methods to determine this property and just as many limits of acceptable disbondment can be found in specifications for steel pipeline coatings. In South Africa it is recommended to use a 3% sodium chloride electrolyte with a -3V DC potential (Cu/CuSO4) applied to a factory coated pipe sample. The test should be carried out for 90 days at room temperature (21 to 25°C) or an accelerated test can be run for 24 hours at -3.5V and at an elevated temperature of 65°C. Phenolphthalein can be used to indicate the extent of alkalinity generated under disbonded coating. The total area of disbondment not including the

area of the initial holiday should be reported as an equivalent circle diameter (ECD) of disbondment in mm. *The smallest amount of cathodic disbondment is preferred.* Where the field joint material is different to the mainline coating material the risk of differences in cathodic disbondment resistance properties increases.

The test standard to be used across generic coating and lining types shall be NACE TM0115. This standard can be used to compare the cathodic disbonding resistance of different generic types of materials.

10.5. SPECIAL REQUIREMENTS FOR LININGS AND FIELD JOINT SYSTEMS

In addition to the minimum requirement clauses in Sections 10.2 (REQUIRED PROPERTIES TO COATINGS AND LININGS) and 10.3 (MINIMUM PERFORMANCE PROPERTIES FOR COATINGS, LININGS AND THEIR FIELD JOINT SYSTEMS) above, the following properties are a requirement for linings and field joint systems:

1. **Abrasion resistance.** This property is required for linings subjected to raw waters with particulates, high velocities, scuffing and scratching during pipeline construction, inspection, and repairs. The following items need specifying when conducting a Taber abrader test: mass (kg) on wheel, roughness of wheel, and number of wheel revolutions. *The least mass loss of lining material is preferred*.

2. **Freedom from toxicity and tainting for potable water.** Potable water exposed to lining material under test conditions should comply with the physical and chemical requirements of SANS 241 including the organoleptic requirements (e.g. colour, smell, taste etc.) New testing requirements and limits for endocrine disrupting chemicals may be specified by certain WSPs and WSAs.

3. **Some linings such as coal tar epoxy and bitumen may age significantly** to allow leaching of their components. Other linings may support microbial biofilm growth that can detrimentally change the water quality being transported in the pipeline.

10.6. ADDITIONAL USEFUL PROPERTIES FOR COATINGS, LININGS AND FIELD JOINT SYSTEMS

Some examples of additional properties that may be tested or assessed for compliance with the requirements during manufacture and thereafter for construction or operating environments are: hardness, indentation resistance, penetration resistance, tensile strength and elongation at break, flexural strength, mandrel bend performance, resistance to environmental stress cracking, resistance to microbiological growth, porosity, density, chemical resistance, amount, type and properties of fillers and pigments, and thermal characteristics such as melt flow index, glass transition temperature, sag, softening point, and viscosity.

10.7. TEST METHODS AND LABORATORIES

Suitable recognised performance test methods and equipment are specified in documents published by the following organisations: SANS, ISO, EN, DIN, DNV, ANSI/AWWA, ASTM, NACE and SSPC. Where applicable these references have been included at the start of each Section of this specification.

The Corrosion Engineer shall specify, in accordance with his ranking as per Section 10.1 (EVALUATION PROCESS), a pre-qualification list of required material properties with appropriate test result limits for coatings, linings and field joint systems applicable to the specific project requirements.

Other than the tests for the performance properties listed in Section 10 and its sub-sections above, other laboratory tests, procedures and equipment are available such as: Atlas Cell, Differential Scanning Calorimetry (DSC), Dynamic Mechanical Analysis (DMA),

Electrochemical Impedance Spectroscopy (EIS), Electrochemical Noise (ECN) / Electrochemical Noise Measurements (ENM), Fourier Transform Infrared Spectroscopy (FT-IR), Gas Chromatography – Mass Spectroscopy (GCMS), Thermogravimetric Analysis (TGA), X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) and various forms of microscopy including Atomic Force Microscopy (AFM).

The requirement for use of each of the tests mentioned above should be evaluated. Only those tests that are relevant to the specific project environments and expected mode of failure of the coating, lining, or field joint system, should be considered.

Of the laboratory tests listed above in this sub-clause, Atlas Cell, EIS and FT-IR are probably the laboratory investigative techniques that are most likely to be used by the Corrosion Engineer, if required, when testing coatings, linings, and field joint materials.

Atlas cells are commonly used in accelerated cyclic environmental testing to age materials and to evaluate resistance to the cold wall effect. EIS can be used as a short-term test to allow early detection of actual corrosion mechanisms under non-accelerated conditions and provide quantitative data for properties such as coating resistance and capacitance, charge transfer resistance and the electrochemical double layer capacitance. FT-IR is most likely to be used for compositional analysis and “fingerprinting” of coating materials to ensure batch-to-batch consistency. It is also a useful tool in failure analysis to assess the degree of cure and in a wet analysis to determine the glass transition temperature (Tg) of the component materials.

In assessing the reported coating, lining and field joint material properties it is essential that certified accreditation of the laboratories, valid up to date calibration of test equipment and verification of the training and competency of their staff can be provided. The Corrosion Engineer has the responsibility to verify the accuracy and reliability of the data provided in laboratory test reports of coating, lining and field joint material properties.

10.8. HISTORICAL DATA OF ORGANIC LINING AND COATING MATERIALS

Modern developments of new coating and lining materials have created a greater variety of types than the historical classification.

Direct comparison of performance of the different generic products with respect to each other is not possible, because different test procedures and standards are used.

The Corrosion Engineer must consider either the data relating to material characteristics/manufacturing data or specify the requirements of the corrosion protection material applied to the substrate as per Sections 10.2 (REQUIRED PROPERTIES TO COATINGS AND LININGS) and 10.3 (MINIMUM PERFORMANCE PROPERTIES FOR COATINGS, LININGS AND THEIR FIELD JOINT SYSTEMS) or both.

11. REHABILITATION / RENOVATION

List of standards

ISO	11295	-	Classification and information on design and application of plastic piping systems used for renovation and replacement.
ISO/TS	24817	-	Petroleum and petrochemical, natural gas industries – Composite repairs for pipe work – Qualifications and design, Installation, testing and inspection.
ASME	PCC-2	-	Composite repair of pressure equipment and piping.
ASTM	F1743	-	Standard practice for rehabilitation practice of pipelines and conduits by Pulled-In-Place installation of Cured-In-Place thermosetting resin pipe (CIPP).
AWWA	M28	-	Rehabilitation of Water Mains.

This section deals with the philosophy associated with Rehabilitation, Renovation, Replacement and Repair and should be read in conjunction with the relevant sections of Chapters 1 to 8 of this document.

When the pipeline is rehabilitated, the choice of rehabilitation method shall consider the associated pipeline structures such as valve chambers, valves, pipe joints and fittings and the Corrosion Engineer shall then select the appropriate standard.

The Method of Rehabilitation is influenced by:
- Structural strength
- Materials type
- Installation methods
- Evaluation criteria as detailed below in Section 11.1 (EVALUATION CRITERIA FOR EXISTING AGED PIPELINES AND STRUCTURES).

Should the decision be taken to rehabilitate the existing pipeline and water infrastructure the following criteria need to be considered.

11.1. EVALUATION CRITERIA FOR EXISTING AGED PIPELINES AND STRUCTURES

The asset owner together with the Corrosion Engineer and / or Project Engineer shall use the following criteria as a guideline for selecting the appropriate rehabilitation methods incorporating renovation, replacement, and repair:
- Timeline (new infrastructure versus renovation or repair)
- Window of opportunity (water demand and budget related)
- Offline availability (duration of maintenance access time)
- Original design life and time to next maintenance opportunity
- Feasibility for new construction or rehabilitation (Influence of other services/utilities)
- Water flow, design capacity, and future water demand requirement
- Servitude and access (trenches, roads, buildings, services, working space)
- Environmental changes (access to pipelines, ground water changes, soil changes, overhead power lines).
- Water quality (sampling and changes in water quality)

11.1.1. EVALUATION OF AGED COATINGS AND LININGS

Inspection of pipelines in operation:
- Internal remote inspections – Parachute method, Intelligent ball, CCTV Camera, TOFDT, Eddy current etc.
- External remote defect location - DCVG surveys, CIPPS etc.

Inspection of pipelines offline:

- Physical inspection provided there is access (Refer to Section 11.4.1 (INSPECTION PROCEDURE)
- Assessment of existing coatings and lining conditions

Feasibility for renovation, repair, or replacement of old coating-lining systems.

11.1.2. EVALUATION OF AGED STEEL OR CAST IRON COMPONENT

Identify and locate all leaks.

Identify type of corrosion mechanism (Refer to Section 11.4 (ASSESSMENT OF CORRODED SURFACES)).

Structural integrity
- Destructive sampling and testing
- Obtain the original documentation including test pressure as at the time of commissioning
- Inspection of pipe wall steel thickness.
- Determination of steel grade.
- Compare remaining steel thickness with minimum design thickness
- Flow testing to evaluate head loss (biofilms, deposits, aging lining, or corrosion tubercles)
- Quantify and locate losses/leaks
- Internal or External corrosion (water quality, thermal imaging)

Jointing systems
- Condition of bolts, gaskets, flanges,
- Condition of electrical isolation of flanges (IF kits) where applicable
- Condition of electrical continuity bonds
- Locate and record all joint leaks

11.1.3. EVALUATION OF THE AGED CONCRETE

There are two types of concrete degradation that are generally of concern: cracking and softening.

Inspection of concrete structures and concrete pipes for:
Carbonation (phenolphthalein test for alkalinity, Oxygen permeability)
- Cracks (calcification, leaks, stains)
- Cover to steel, CML thickness
- Hardness (Schmidt hammer), Compressive strength
- Extent of damaged concrete (local or general)
- Spalling and steel reinforcement corrosion

At the discretion of the Corrosion Engineer, concrete testing and evaluation including taking sample cores, shall be performed by a suitably qualified Concrete Specialist.

For additional info refer Section 11.5.7 (CONCRETE REPAIR).

11.2. RECORD KEEPING AND HISTORICAL DATA

No amount of laboratory testing or accelerated ageing can outweigh the evidence of actual field and operational performance that attests to efficacy and durability, or lack thereof, of the coating, lining, or field joint systems under consideration. That is why it is so important to obtain an as complete record as possible of how and where the materials have been used and what their track record is. This track record should allow for or provide details to enable contact to be made with the relevant pipe manufacturers, the field joint applicators and most importantly with the asset owners, operators, or maintenance staff and any connected cathodic protection installers or workers.

The track record of candidate pipeline coating, lining and field joint systems shall in addition

include as a minimum the following information: the type of and size of pipe, the pipe jointing method, the specific types of coating, lining and field joint materials used, the period in use, the environmental conditions, and the period to first maintenance or repair.

Further relevant information includes the expected design life of the pipeline, if any difficult manufacturing, construction/installation, or repair procedures were encountered, and an assessment of what has been the weakest link causing failure leading to renovation, replacement or repair of the coating, lining, or field joint system.

Where possible a site visit shall be conducted to verify the reported performance of the candidate coatings, linings and field joint systems. The asset owners or operators shall be questioned as to whether they would have in retrospect used alternative materials for their assets and to provide the reasons for that decision.

11.3. ECONOMIC CONSIDERATION

The asset owner together with the Corrosion Engineer and / or Project Engineer shall use the following criteria as a guideline for selecting the appropriate rehabilitation methods incorporating renovation, replacement, and repair:

- Financial consideration (available budget and future planning)
- Emergency breakdown maintenance and planned maintenance
- Alternate water routes (ring main, parallel pipelines)
- Lost revenue due to water leaks
- Lost revenue due to illegal water connections
- Community disruption
- Health and safety
- Disposal of assets

11.4. ASSESSMENT OF CORRODED SURFACES

This can generally occur under two categories:

- Pipes, steel plates or coils in a stock yard
- Old pipes and ancillary steel assets that have seen service.

11.4.1. INSPECTION PROCEDURE

(a) Photographs must be taken of the corroded surface for record purposes both before and after surface preparation and repair.

(b) Photographs taken from both close up and general view must be available to the Corrosion Engineer.

(c) Samples of the corrosion deposit must be kept in a sterile glass container.

(d) If biofilms are present or bacterial corrosion is suspected, the Corrosion Engineer shall arrange for special sampling procedures and laboratory analysis.

(e) Corrosion and rust tubercles shall be carefully pried off the corroded surface and the underlined substrate examined and photographed. Pitting depths under tubercles shall be recorded.

(f) The presence of roots, sediment, silt, mud, slime, and calciferous deposits must be photographed and recorded.

(g) The failed coatings or linings must be inspected for under-film corrosion creep and loss of adhesive bond strength.

(h) Record blisters, cracks and delamination’s of coatings and linings.

(i) Record cracks and delamination’s in the polymer coating and lining that may be indication of damage to the base material.

(j) Record any other anomaly or factor which may have contributed to the corrosion.

(k) Record the number, position, and type of pipe joints.

Once the inspection has been completed, the corrosion damage must be exposed by manual, mechanical, high pressure water jetting, or abrasive blast-cleaning for assessment.

11.4.2. DEFECTS

After the corrosion deposit has been removed alternatively the failed coatings and linings have been removed, the exposed corroded surface will be inspected by the Corrosion Engineer for at least the following defects: (refer to the latest version of DIN EN 14879 – 1). Table 4 pictorial diagrams of Substrate Imperfections and the minimum and maximum requirements for different coating and lining materials.

(a) The number, size and distribution of pitting

(b) Quantify the number, length and orientation of cracks.

(c) Cracks and delamination in the steel or metal substrate shall be tested by methods such as Dye Penetrant Indication, Magnetic Particle Indication and X-ray or other

(d) Remaining steel thickness

(e) Areas that require surface or structural repairs

(f) Weld repairs to be done with appropriate weld procedure

(g) Areas that need grinding or smoothing

(h) Damaged sealing and mating surfaces

(i) Corrosion patterns and location

On completion of the corrosion inspection, a decision will be made by the Corrosion Engineer to categorize the extent of the corrosion damage as one of the following:

- A minor coating or lining defect
- A major coating or lining defect
- Other defects found on the structure.

The rehabilitation procedures shall then be specified by the Engineer.

11.4.3. REPAIR OF INSPECTED CORRODED SURFACES

(a) Smooth out all shallow pits with a pencil grinder.

(b) Weld up and grind to a smooth finish where:

- More than 25% of the material has been lost by pitting corrosion.
- Material loss detrimentally affects the strength of the item.

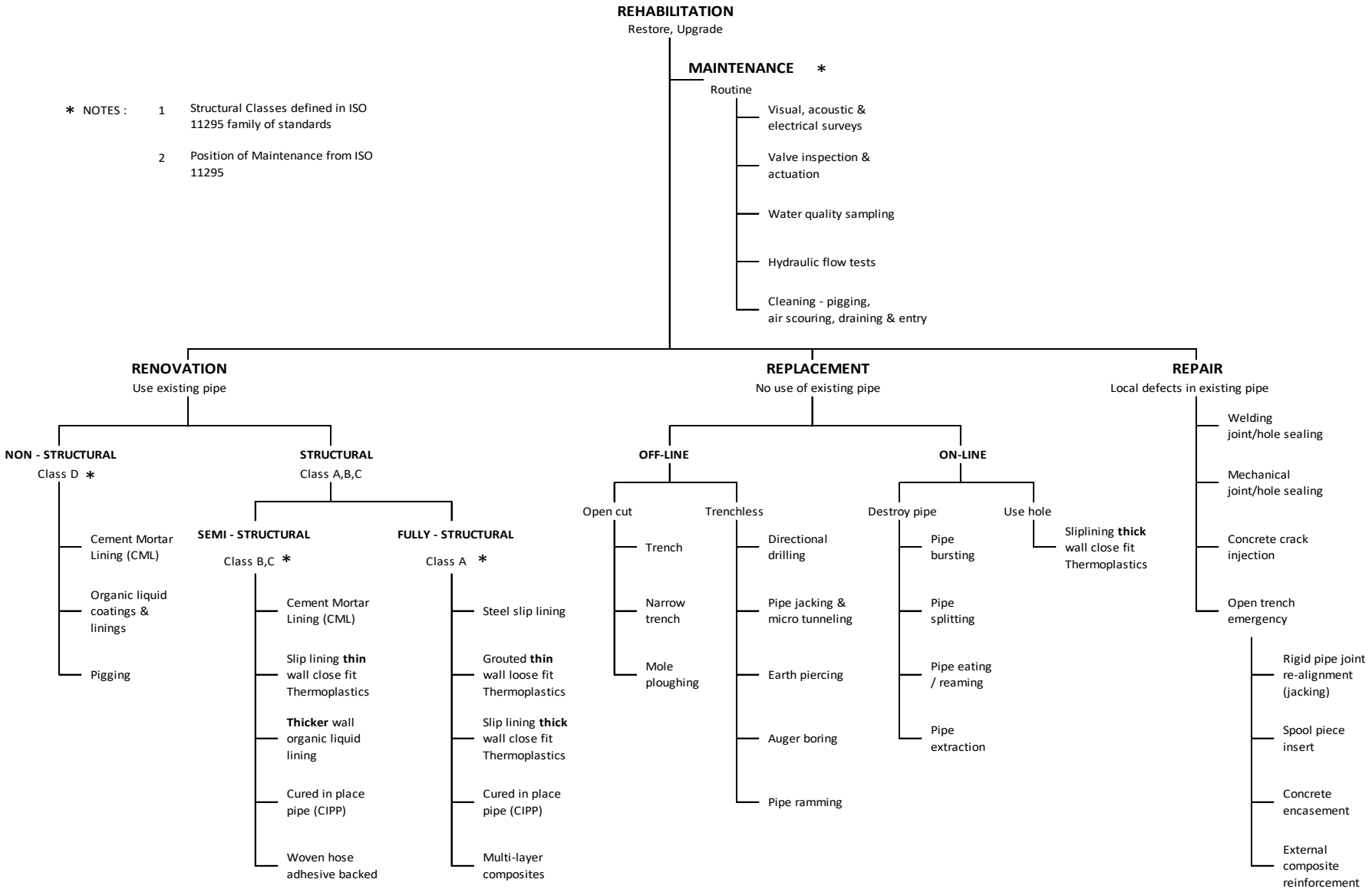
(c) Replace more severely damaged sections.

(d) Reinstate coating or lining removed during inspection using approved materials and methods.

11.5. METHODS OF REHABILITATION FOR PIPES

For repair of coatings and linings not meeting specification, or damaged after application, refer to the relevant Chapters for coating and lining materials. (Chapters 12 through 25)

Methods of rehabilitation including renovation, replacement and repair can be carried out using the appropriate methods listed below:


REHABILITATION
Restore, Upgrade
MAINTENANCE *
Routine
Visual, acoustic & electrical surveys
Valve inspection & actuation
Water quality sampling
Hydraulic flow tests
Cleaning - pigging, air scouring, draining & entry
* NOTES :
1 Structural Classes defined in ISO 11295 family of standards
2 Position of Maintenance from ISO 11295
RENOVATION
Use existing pipe
NON - STRUCTURAL
Class D *
Cement Mortar Lining (CML)
Organic liquid coatings & linings
Pigging
STRUCTURAL
Class A,B,C
SEMI - STRUCTURAL
Class B,C *
Cement Mortar Lining (CML)
Slip lining thin wall close fit Thermoplastics
Thicker wall organic liquid lining
Cured in place pipe (CIPP)
Woven hose adhesive backed
FULLY - STRUCTURAL
Class A *
Steel slip lining
Grouted thin wall loose fit Thermoplastics
Slip lining thick wall close fit Thermoplastics
Cured in place pipe (CIPP)
Multi-layer composites
REPLACEMENT
No use of existing pipe
OFF-LINE
Open cut
Trench
Narrow trench
Mole ploughing
Trenchless
Directional drilling
Pipe jacking & micro tunneling
Earth piercing
Auger boring
Pipe ramming
ON-LINE
Destroy pipe
Pipe bursting
Pipe splitting
Pipe eating / reaming
Pipe extraction
Use hole
Sliplining thick wall close fit Thermoplastics
REPAIR
Local defects in existing pipe
Welding joint/hole sealing
Mechanical joint/hole sealing
Concrete crack injection
Open trench emergency
Rigid pipe joint re-alignment (jacking)
Spool piece insert
Concrete encasement
External composite reinforcement

The following points need to be considered when selecting the appropriate rehabilitation method:

- Diameter and length limitations.
- Pipe material and condition.
- Rehabilitation class.
- Working space requirements at the pipe mouth.
- Continuously welded pipes, flanged, chambers or cut access.
- Access (man or remote).
- Lining field joint repair.
- Bends and tapers (reducers).
- Off- takes (Tee Piece and Y pieces).
- Electrical power.
- Water.
- Air compressors.
- Material logistics.
- Curing equipment/technique.
- Specialised installation equipment.
- Life expectancy.
- Inspection methods.
- Pipe layout (horizontal and vertical alignments).

For offline replacement refer to relevant coating and lining sections.

Advantages and disadvantages of the more commonly used rehabilitation methods used in South Africa.

11.5.1. CEMENT MORTAR LINING (CML)

Cement mortar lining technology is based on the principle of the inherent alkalinity of cement passivating the steel surface and thereby preventing corrosion. Cement Mortar Coating and Lining are specified in a later Section.

Cement mortar lining can be applied in the factory or in situ in the field. Application methods include spraying, spinning or by hand. Trowelling to provide a smooth surface to the CML can be by spring tensioned drag cone, rotary trowelling or by hand. Cement mortar mix design must be chosen to suit the method of CML application.

Advantages:

- Minimal steel pipe surface preparation (St 2).
- Easy to repair.
- Materials readily available.
- Robust lining.
- Autogenous healing of cracks.

Disadvantages:

- Drying shrinkage cracking can lead to de-bonding.
- Curing period before recharge.
- Reduction of internal diameter.
- 800 micro strain limitations on steel pipe wall expansion due to internal pressure.
- Lead joints may need welded keeper rings for electrical continuity.
- Maximum pipe diameter limitation.

11.5.2. ORGANIC LIQUID COATINGS AND LININGS

Liquid applied polymers cure to form protective barrier films on the substrate and prevent oxygen and water molecules from initiating corrosion cells. There are many different grades and types such as epoxy, polyurethane and polyester as specified in later Sections.

These organic materials can be applied by a variety of techniques such as brush, spray, roller, squish pack, applicator pad, screed, flood coating, pigging etc. Most organic materials are comprised of two components which must be mixed together in correct proportions and applied in a suitable environment.

Advantages:

- Easy to repair.
- Materials readily available.
- Many different generic types available with different properties.
- Can be applied thin (microns), or thick (millimetres).
- Can be applied to pitted surfaces depending on material type.
- Can be applied to surfaces of complex geometry.
- Minimal reduction of internal diameter.
- Rapid curing organic materials are available.
- Specialized application techniques are available for non-man entry size pipes.

Disadvantages:

- Requires appropriate surface preparation.
- Reparability is dependent on the organic material type.
- Curing period varies greatly dependent on temperature and material type.
- Minimum pipe diameter limitation for man entry access.

11.5.3. STEEL SLIP LINING

Steel slip lining is commonly used as structural reinforcement in large diameter steel or concrete pressure pipelines. The annulus between the host pipe and liner must be grouted for structural and corrosion protection reasons.

Advantages:

- Minimal pipe surface preparation.
- Lining provides structural strength.
- It allows the thinner liner.

Disadvantage:

- Can only be used on pipes large enough to allow man access.
- Steel slip line is limited to short length.
- Reduction of internal diameter.
- Installation method is complex.
- Steel liner needs internal coating repair at the liner joint welds.
- Cannot line around bends.

11.5.4. PLASTIC SLIP LINING OR SLEEVING METHODS

Slip lining is used to repair leaks or restore structural stability to an existing pipeline. Slip lining is completed by installing a smaller, "liner" into a larger "host pipe". The liner pipe can either be a close-fit or loose-fit installation. The liner pipe can either be structural, semi-structural or non-structural. The annulus between the two pipes can be either grouted, an adhesive applied to the outside of the liner pipe, or a close-interactive fit.

The most common material used to slip line an existing pipe is high density polyethylene (HDPE), but fiberglass reinforced pipe (FRP) and PVC are also used. Methods of slip lining include Swage and Roll Down for plastic pipe systems that are pulled or winched into place.

In accordance with this specification the use of plastic pipe lining shall be limited and controlled as follows.

- Pressure pipe applications: the plastic pipeliner shall be grouted into the host pipe.
- Low pressure pipe applications (hydrostatic head of less than 10m): the plastic pipeliner may also be loose fit or close-interactive fit and non-grouted but only in storm water and sewer line applications.
- Loose fit or close-interactive fit and non-grouted plastic liner pipes may not be used under conditions where ground water may enter the annulus through corroded host pipe perforations and may also not be used under conditions where column separation and negative internal pressure (vacuum) may arise.
- The Corrosion Engineer shall ensure that the hoop strength of the rehabilitated slip-lined or sleeved pipe meets the original pressure rating requirements. Therefore, the residual hoop strength of the host pipe can be considered in conjunction with the additional strength provided by the new liner.

Advantages:

- A trenchless technology requiring minimum excavation.
- May require minimum surface preparation of old host pipe where the annulus is grouted.
- Non-corrodible liner material.
- Cost effective compared to replacement steel pipe.
- Selected sizes of electro-fusion couplings are available.

Disadvantages:

- Requires removal of protruding obstructions such as pegs, pipe branches, loose materials, and cleaning methods such as flushing, high pressure water jetting, scrapping, grit blasting and pigging.
- Risk of weld protrusions or sharp edges that will create a longitudinal score in the plastic significantly weakening the pipe can be determined by camera inspection or gauging pig.
- Horizontal lengths of installation limited typically between 50 to 300 meters.
- Requires manhole or foxhole excavation access at each end of the slip line length.
- Not suitable for bends, changes in diameter and branches.
- Defects in butt fusion welds are difficult to locate in slip line pipes, especially when grouted.
- Defects are difficult to repair if man access is not possible.
- Terminations at ends of plastic slip line pipes are difficult to seal for high internal pressures and may require proprietary fittings to prevent leakage.
- Difference of thermal expansion between steel and plastic may cause problems.
- Reduced cross sectional area.

11.5.5. CURED IN PLACE PIPE (CIPP) INVERTED SOCK AND TUBE LINERS

Various systems of CIPP are available depending upon materials used, method of installation and length, location, and pressure rating of the pipeline:

The pre-manufactured fibreglass / polyester tube or sock is pre-impregnated with resin. The saturated tube liner is then either pulled or winched into place and inflated with compressed air or water. The saturated sock is inverted / reverted using water.

Once the liner is in place the resin is usually heated to induce a chemical catalyst or hardener to initiate the curing process. The curing process is usually by hot water, steam, or UV light for hot cured methods while ambient cured technologies can be used for smaller diameter renovation projects.

The CIPP liner is made of a non-woven polyester needle felt or glass fibre although for pressure pipes it is normal to provide a woven product to ensure extra strength to withstand the internal

pressures within the pipeline. A sheet made from PU, PE or PVC protects the sock liner during transportation and installation procedures.

The liner is impregnated with a polyester, vinyl ester, epoxy, or silicate resin, which has been mixed either in a vat or through static mixers, often using a vacuum pressure method and roller to ensure the full thickness and full length of the liner is saturated.

The resin will include a chemical catalyst to help start the curing process, depending on the curing type i.e. hot water, steam, UV or ambient cure.

Advantages:

- Suitable for sewer lines with minimal surface preparation.
- Can be used around bends and for changes in diameters.
- Extra strength to withstand the internal pressures.
- Longer pipeline lengths (up to 100m) can be rehabilitated with pre-impregnated socks.
- Short defective pipeline lengths can be rehabilitated with hand layup methods provided man access is possible.
- Higher strength can be achieved with multiple layer composite wall construction.
- Higher strength can also be achieved with carbon fibres as opposed to glass fibres or polyester fibres.
- Unidirectional fibre in the circumferential orientation achieves high strength reinforcement for high pressure applications.

Disadvantages:

- The fibres must be oriented circumferentially for maximum hoop strength.
- Chop strand matting may cause wicking of process liquid into the composite.
- Fast inflation could lead to stretching of the liner.
- Wrinkling of the liner around bends.
- Pre-manufactured socks must be made within allowable tolerances for the host pipe diameter.
- Changes in host pipe diameter or steps limit the suitability of pre-impregnated sock.
- Ground water leaking into the host pipe limits the choice of CIPP methods for use.
- Non-woven glass, chop strand matt, polyester fibre and needle punched felt may only be used in low pressure applications.

NOTE: For CIPP installed using hand layup method using fibreglass / GRP / carbon fibre see Sections 11.5.6 (COMPOSITE FIBRE WRAPS FOR STRUCTURAL REINFORCEMENT AND REPAIR) and 11.5.7 (CONCRETE REPAIR) below.

When using vacuum formed methods (resin infusion of GRP / FRP) see Sections 11.5.6 (COMPOSITE FIBRE WRAPS FOR STRUCTURAL REINFORCEMENT AND REPAIR) and 11.5.7 (CONCRETE REPAIR) below.

11.5.6. COMPOSITE FIBRE WRAPS FOR STRUCTURAL REINFORCEMENT AND REPAIR

The use of composite repairs of steel, cast iron and concrete pipe may be done under circumstances where welding repairs are not practical or where access is restricted or where replacement of the pipe is not feasible.

Fibre reinforced wraps are convenient to use for leak repairs on pipes as well as structural repairs to both concrete and steel pipes.

Fibre reinforced wraps are seldom used for mainline pipes or long lengths of mainline pipes because it would be cost prohibited.

Fibre reinforced wraps can be used externally to seal leaks without necessarily shutting the pipe down.

The design of the composite laminate used in the repairs, including the type of fibre, number of

layers of fibre and the orientation of fibre, shall be in accordance with the technical specification ISO/TS 24817 read in conjunction with ASME PPC-2.

This specification is conservative and therefore does not allow the use of composite for the repair of gouges and longitudinal cracks in pipe as described in Table 1 of ISO/TS 24817 – Guide to generic defect types.

This specification also does not allow the use of composite material for the repair class 3 above 2 MPa design pressure as per Table 2 of ISO/TS 24817- Repair class but does allow composite repair of class 1 and 2 pipes below 2 MPa internal pressure. The design pressure is to include transient water hammer pressures.

The design life for composite wraps shall be for a minimum period of 20 years (in accordance with the design code) and therefore the maximum allowable circumferential strain as well as axial strain shall be 0.25% as per Table 8 of ISO/TS 24817 – Allowable strains for composite laminar as a function of repair lifetime.

If there is need to wrap the pipe under pressure the load transference of the hoop stress between the pipe material of construction and the wrap shall be taken into consideration in the design.

The use either carbon fibre or glass fibre (GRP) composite wraps is permissible provided it is designed in accordance with the ASME PPC – 2 and ISO 24817. The fibre wrap can be applied internally or externally or both. External wrap is preferable provided access is possible.

Typical applications

- Repair of pre-stressed concrete pipes.
- Repair of steel pipe embedded in valve chamber walls.
- Repair of steel pipe encased in concrete.
- Repair of inaccessible steel pipe bends and specials.
- Strengthening local pipe sections.

Advantages:

- Cost effective repair for pipes encased in concrete.
- Maybe faster alternative to replacement of original pipe.
- Can do joint repair and joint sealing.
- Can be applied to damp concrete when the correct wet to dry primer is used.
- Easy to repair non-standard pipes and specials as an alternative to replacement.
- External repairs can be done on line.

Disadvantages:

- Repairs have a design life limited to 20 years.
- Drain the pipe to gain access.
- Hand laminating limited to man entry size pipe.
- If pipe spares are available, replacing the pipe maybe faster than composite repair.
- Composite repairs have some pressure limitations.
- Susceptible to impact loading.

For the fabrication of GRP pipes and tanks, design information can be obtained from the design codes for composite pressure vessels and piping EN 13121.

11.5.6.1. CONCRETE PIPE EXTERNAL AND INTERNAL COMPOSITE REPAIR:

For concrete surfaces, the use of a low viscosity penetrative and moisture tolerant primer is mandatory to ensure good adhesion.

Badly pitted steel surfaces must be welded up and ground to a smooth profile before application of

a corrosion protection layer followed by the composite material repair.

For carbon fibre composite, it is compulsory to first apply a corrosion barrier of glass-flake coatings based on the same resin as the composite to prevent a galvanic corrosion cell between the carbon and the steel.

11.5.6.2. INTERNAL PIPE COMPOSITE REPAIR:

Use a low shrinkage or non-shrinking resin matrix.

A grit blasted steel surface is required for a hand layup or vacuum methods to achieve the cleanest possible surface that will result in the best possible adhesion.

11.5.6.3. EXTERNAL PIPE COMPOSITE REPAIR:

Use a resin matrix with a high shrinkage ratio preferably >6% for an improved load transfer.

It is always preferable to grit blast the steel substrate to obtain the best possible adhesion. Where grit blasting the steel is not possible the surface cleanliness shall be specified by the Corrosion Engineer.

Special care needs to be taken with the design, grit blasting and wrapping of an operating pipe subjected to live loading.

The composite wrapping thickness required for a pressurised pipe shall be thicker than that for a depressurised pipe.

If the pipe must be excavated to allow for external wrap, the calculation shall determine the maximum span between supports that can carry the weight of the pipe and water, without damaging the pipe.

11.5.7. CONCRETE REPAIR

The Corrosion Engineer or Project Manager shall consult with a concrete repair specialist for an appropriate material and procedure that would be suitable for the repair of the concrete. The mechanism that has resulted in concrete degradation and the requirement for repair must be clearly understood before selecting the repair material and procedure.

Typical concrete degradation mechanisms would be:

Alkali aggregate reaction, carbonation, sulphation, chloride ingress, de-passivation of rebar and resulting spalling corrosion, erosion jetting or wear and soft water attack resulting in friable or crumbly surfaces.

Any concrete cracks should be inspected by a Concrete Specialist to determine the severity and appropriate repair method.

Typical repair methods would be:

11.5.7.1. CONCRETE CRACK INJECTION

Crack injection shall only be conducted by a knowledgeable specialist. A determination shall be made on whether the cracks are structural, hairline cracks, mobile cracks, stable cracks, temperature related and or associated with thermal cycling, rebar orientation etc.

Crack injection types may be low pressure, high pressure, with or without injection plates and using flexible or rigid materials in both fast cure and slow cure formulations.

11.5.7.2. CONCRETE PATCH AND COVER REPAIR

Concrete patch and cover repair shall only be conducted by a knowledgeable specialist.

This is typically required when spalling or rebar corrosion has occurred. The degraded concrete shall be broken out to expose the rebar at least one diameter behind the rebar. The rebar shall be properly corrosion protected with a suitable coating, returned/fixed to its original location before the cover over the rebar is applied. The Corrosion Engineer shall ensure that only non-shrink patch repair materials are used.

11.5.7.3. CATHODIC PROTECTION OF STEEL REBAR INSIDE CONCRETE

Cathodic protection for steel rebar inside concrete shall only be conducted by a knowledgeable specialist.

Cathodic protection of steel rebar in concrete structures is not common. If the corrosion survey/prediction highlights a potential issue, then it is possible to apply impressed current protection.

Where a pipe is subject to cathodic protection and joins a concrete structure such as a reservoir or chamber, the puddle flange on the pipe passing through the concrete structure shall be electrically isolated from the rebar in the concrete.

11.5.7.4. PRESTRESSED CONCRETE PIPE (PCP)

Prestressed concrete pipe was historical used for pressured water systems. Circumferential wires inside the concrete pipe wall may corrode and result in the loss in the ability to withstand the tensile load (hoop stress) that arises from the pressure inside the pipe. This may result in crack in the prestressed concrete pipe and ultimately leaks and pipe burst. PCP pipe is normally a spigot and socket joint which make the replacement of concrete pipe extremely difficult.

When leaks or cracks are found on prestressed concrete pipe eddy current scanning shall be done to determine the extent of the corroded or broken wires and critical areas. The Corrosion Engineer shall do preventive repairs where required.

One repair option is to shut down the water flow, scour and excavate and break the leaking pipe and replace it with steel pipe with appropriate coupling system.

The alternative option is to use a carbon fibre composite wrap / glass fibre (GRP) wrap that is designed in accordance with the ASME PPC – 2 and ISO 24817. The fibre wrap can be applied internally or externally or both. External wrap is preferable provided access is possible.

Refer to Section 11.5.6 (COMPOSITE FIBRE WRAPS FOR STRUCTURAL REINFORCEMENT AND REPAIR) for detailed information.

11.5.8. JOINTS SEALING - CONCRETE PIPES AND WATER RETAINING STRUCTURES

These systems are commonly used on concrete pipe joints as well as the expansion and construction joints of water retaining structures.

11.5.8.1. ELASTOMERIC SEALING SYSTEMS

Typical such materials will be rubber backing cords, expanded polyethylene foam, liquid applied systems such as polyurethane and flexible epoxy. Elastomeric bandages are also available in EPDM rubber, Hypalon, natural and neoprene rubbers. External clamps, internal mechanical seals for pipes either glued into position or mechanically clamped into position.

Reservoir lining systems or earth dam lining with a non-bonded Hypalon sheet that can be joined by fusion welding procedures.

Advantages:

- Extremely flexible, elastic and tough.
- Resistant to hydrostatic pressure within limitations.
- Cost effective sealant for reservoirs.
- Resistant to chemicals.
- A few systems can be applied to a damp substrate.

Disadvantages:

- Most systems cannot be applied to damp substrates.
- May not be resistant to ultraviolet/direct sunlight.
- If unsupported, limited resistance to pressure.

11.5.8.2. OTHER SEALING SYSTEMS

Typical such materials will be fibre glass, carbon fibre and mechanical clamps.

Advantages:

- Resistant to turbulent and high flow velocity.
- Very good cut and gouge resistance if there are sharp objects.
- Excellent wear and abrasion resistance for waste water treatment plants.
- Fast to install.
- Can add structural strength to both concrete and steel pipes.
- Can tolerate higher pressures than elastomeric systems.
- Cost effective sealant.
- Resistant to chemicals.
- A few systems can be applied to a damp substrate.
- Is resistant to ultraviolet/direct sunlight.

Disadvantages:

- Most systems cannot be applied to damp substrates.
- Less flexible than elastomeric systems.
- Need to make provision for the movement in a joint or crack to design the bond breaker width.

11.5.9. PIPE PIGGING

There are three general conditions where pigging is used for:
- Internal inspection using intelligent pigs,
- Cleaning pipes to restore hydraulic capacity,
- Application of corrosion protection linings (refurbishment or new pipe).

Pipe pigging gives the engineer the ability to deal with difficult corrosion protection applications where existing pipelines cross over or under roads and rivers or in ecologically sensitive areas where digging up the pipeline is environmentally undesirable or where pipeline excavation must be avoided due to socially sensitive locations.

Inspection of pipes by pigging can be conducted on pipeline lengths up to 300km using intelligent pigs. Cleaning of pipes by pigging can be conducted on pipeline lengths typically up to 50km.

Refurbishment using in-situ pipe pigging techniques to apply Corrosion Protection, is an attractive, lower cost alternative to replacement of pipelines. Down time is reduced, and the structural integrity of the pipeline is maintained.

Pipe pigging in-situ internal rehabilitation and Corrosion Protection may be specified for pipes of 6” to 36” (150 NB to 900 NB) in diameter and up to 20 km in length. These pipelines include buried or submerged sections, either of continuously welded or flanged pipe, as well as couplings or bell and socket joints.

Pipe pigging in-situ internal rehabilitation and Corrosion Protection is commonly used on pipelines over 1 km in length and where the pipe diameter is too small for man access, or where safe mas

access is not possible such as steep inclines.

Overview of Pipe pigging method

Temporary launching points and pig traps are fitted at the beginning and end of the pipeline to enable the launching and receiving of the pigs with the batches of chemicals and coating material.

The pigs are driven through the pipeline by two main methods:

- For de-sludging, cleaning, biofilm removal and descaling, the pigs can be propelled using the water pressure and launched on line.
- For the application of internal lining, the pipe must be clean and dry, and the pigs are propelled using dehydrated compressed air provided by large diesel compressors and desiccant dryers.
- The “PIGGING” application of corrosion protection process has 2 stages:
- Mechanical and chemical cleaning of the pipeline using foam and wire brush pigs to remove all deposits including debris, corrosion products.
- Application of the liquid polymer using specially designed coating pigs. The application comprises a several runs, ensuring a multi-layer, continuous coating of the specified thickness, along the complete length of the pipeline.

11.5.9.1. CLEANING PIPES USING PIGGING

- **Biofilm Removal**
  The biofilm removal is done with “soft bodied pigs” such as foam, rubber, or urethane without damaging the existing corrosion protection lining. Anti-fouling chemicals that kill biofilm are optional to be used in the cleaning process.

- **Mud and Sludge Removal**

  The mud and sludge removal are done with “medium bodied pigs” such as rubber or urethane to avoid damage to the existing corrosion protection lining.

  If the sediment is coarse it may cause longitudinal scraping damage to the corrosion protection and appropriate procedures and measures must be put in place to avoid such damage.

- **Descaling of Pipes**

  Descaling of pipelines can be done by a chemical or a mechanical process depending on the need to prevent damaging the corrosion protection.

- **Cleaning of pipes for corrosion protection**

  Hard bodied pigs of various types and stages are used in the cleaning procedure to provide a suitable surface for the application of the coatings.

  - Mechanical scouring by a scraper pig is used to loosen debris, corrosion products, etc.
  - Mechanical cleaning by a foam and wire brush pigs to remove all deposits including debris, corrosion products.
  - Chemical treatment by pairs of squeegee pigs, to ensure a clean, dry metal finish, including acid etching and phosphating for surface preparation.

11.5.9.2. INTERNAL INSPECTION BY PIPE PIGGING

Pre-cleaning using pigs must also be done before the pipes can be inspected by intelligent pigs. Intelligent pigs used Magnetic Flux Leakage (MFL) or Ultrasonic Testing (UT) to inspect the condition of the steel in the pipe wall and locate any areas where the pipe has suffered internal or

external corrosion metal loss, or where cracks, or laminations are present in the steel pipes.

Intelligent pigs can also be used to determine where steel wire circumferential reinforcing is corroded broken in pre-stressed concrete pipes.

11.5.9.3. LINING APPLICATION BY PIPE PIGGING

Pre-cleaning using pigs must also be done before the pipes can be lined using pigging techniques. The lining is normally applied as a viscous liquid, in a minimum of two layers, with the pigs launched from opposite directions to ensure consistent thickness and superior weld coverage.

The liquid coating is batched between pigs, and there after polymerises and sets to form a fully bonded internal lining, that depending on thickness may be considered as either a coating only or as a structural cured-in-place-pipe (CIPP) within a steel pipe. The correctly selected pig applied lining material has the ability to fill pits and repair channel erosion in the bottom of the pipe.

11.5.9.4. GENERAL CONDITIONS APPLICABLE TO PIPE PIGGING

Advantages:

- A lower cost alternative to pipeline renewal.
- Extension of the life of the pipeline beyond design expectations without trenching or digging up of damaged pipelines.
- The lining can be applied thickly to in-fill pits and repair channel erosion in the base of the pipe.

- Significantly reduced downtime compared to replacement or other refurbishment processes with no serious disturbance to normal production and operational processes.
- Pipes previously lined with old coal tar epoxy or bitumen can be successfully repaired using pigging techniques and specially formulated lining materials that can tolerate residual bitumen.
- Pipe pigging shall require special lining materials that are formulated to have rapid thixotropic recovery and have long pot lives.
- Pipe pigging lining materials suitable for use in the water industry, including seawater, drinking water, raw water, cooling water, sewage, and liquid wastes.
- Pipe pigging grade lining materials shall be of solvent-free formulation thus ensuring no solvent entrapment and with high build properties for excellent resistance to runs and sags at joints thus reducing the possibility of defects.

Disadvantages:

- The pipes must be piggable, meaning that the pig must be able to pass internally down the pipe without damage and being stuck.
- Valves and all devices, such as butterfly valves and plug or non-return valves, that can block the passage of pigs must be removed and replaced with temporary spool pieces.
- T-pieces and branches must be temporarily plugged.
- Short radius bends, segmented, fabricated or lobster back bends are not piggable.
- Minimum 3D bends that are smooth are required to ensure the proper cleaning, inspection, and application of an even film thickness lining.
- Changes in internal diameters cannot be accommodated by pigging unless the pipes are cut and flanged at these points.
- Restrictions for pigging are short pipes less than 1km in length as the process becomes progressively more expensive per unit length.
- The mobilisation costs for pipe pigging is high but project cost per kilometre reduces dramatically for longer lengths of pipe.

11.6. CAST IRON REHABILITATION AND CORROSION PROTECTION

REFER TO SECTION 7.4.2 (BLAST PROFILES FOR CORRODED STEEL).

11.6.1. GENERAL

Grey Cast Iron is a material with a relatively porous structure resulting in water retention in items that have been submerged in water for extended periods. This must be taken into account in terms of surface preparation and coating selection.

Grey cast iron prone to selective leaching known as graphitisation. This is not immediately apparent to the naked eye and results in loss of structural strength.

Ductile Iron (also referred to as Spheroidal Graphite Iron or Meehanite™) has similar characteristics as carbon steel in terms of corrosion resistance.

11.6.2. CAST IRON PUMPS & VALVES

New cast iron used in fabrication of pumps and valves shall be internally lined for corrosion protection as specified here under.

Old cast iron pumps and valves that require corrosion protective coating or lining shall have a substantially higher thickness and physically stronger or more robust coating material, than that generally specified for steel.

11.6.3. CAST IRON PIPES

Grey Cast iron has historically been used as a material of construction for old pipes embedded in concrete dam walls or buried in soil.

Cast iron has limitations because it requires specialized welding techniques and is at risk of cracking. Cast iron pipe typically requires mechanical couplings or has to be manufactured in a spigot and socket configuration.

In terms of this specification ductile iron pipes for use in raw water and potable water applications is NOT permitted unless, it has been coated externally and lined internally to the same standard and with the same types of materials as specified in this document for steel pipes.

11.6.4. CAST IRON DEGRADATION MECHANISMS

The most common degradation mechanism for grey cast iron exposed to water or buried in soil is called graphitisation.

The graphitisation has to be completely removed prior to coating.

Cast iron is susceptible the same corrosion mechanisms as carbon steel.

11.6.5. CORROSION PROTECTION OF AGED CAST IRON

REFER TO SECTION 11.1.2 (EVALUATION OF AGED STEEL OR CAST IRON COMPONENT)

AND 11.4 (ASSESSMENT OF CORRODED SURFACES)

11.6.5.1. ASSESSMENT OF CAST IRON

- For refurbishing pumps and valves a witnessed pressure test is mandatory and for cast iron pipes to be done where practical
- Perform a knife cut test to check for graphitisation
- Rough blast as per sections 7.2.2 (INITIAL INSPECTION), 7.4.2 (BLAST PROFILES FOR CORRODED STEEL),
- Redo the knife cut test at various locations and if cutting is not possible then the graphitisation has been removed by the blasting
- If the loss of metal compromises the integral strength of the item must be replaced or supported by other means such as 11.5.6 (COMPOSITE FIBRE WRAPS FOR STRUCTURAL REINFORCEMENT AND REPAIR) above
- Spray the blasted cast iron surface with a mist coat of distilled water
- Immediately check for gassing and porosity

- After 24 hours visually examine the surface for discolouration and blotches - refer section for to contamination and take the appropriate action.

11.6.5.2. DECONTAMINATION OF CAST IRON

(a) Cast iron may also be heavily contaminated with metallic salts, refer to sections 7.2.6 (WATER SOLUBLE SALTS LIMITS) and 7.6.2 (WATER SOLUBLE SALT TEST METHODS)

(b) If a heavy salt contamination is found then decontaminate using a metallic salt decontamination liquid.

(c) Cast iron exposed to marine environments is usually very heavily contaminated with Ferric Chloride salts and multiple additional decontamination cycles may be required.

(d) The standard method for salt decontamination is washing as described above. If washing is not practical or possible, then the cast iron component can be dry baked in an oven.

(e) Alternate decontamination method for both bacteria and salts as well as heavy oil contamination, is to place the cast iron components into a steam pressure auto clave and bake at steam pressures between 1 and max 3 bar for a minimum of 2 hours.

(f) If baking or steam is not practical or possible, then a high level of residual salt can be tolerated by a coating system of solvent free glass flake material minimum 2mm thick to be specified by the Corrosion Engineer.

(g) NOTE:- the decontamination of cast iron (bacteria, salts or oil) results in a porous surface that is then wetted. This porous surface needs to be dried very well before conventional coatings are applied. The alternative is to use primer systems that are tolerate of residual moisture that may be within the pores and porosity of the cast iron.

11.6.5.3. SURFACE PREPARATION OF CAST IRON

(a) Perform the assessment as per section 11.6.5.1 (Assessment of cast iron) above

(b) Check for blow holes as per section 6.3.2.1 (Castings)

(c) Do decontamination as per section 11.6.5.2 (DECONTAMINATION OF CAST IRON)

(d) Blast profiles shall be as per section 7.4.2 (BLAST PROFILES FOR CORRODED STEEL)

(e) Final re-blast of all surfaces to ISO 8501 - SA 3 prior to commencement coating of cast iron components.

11.6.5.4. COATING APPLICATION OF CAST IRON

(a) Cast iron has been known to gas and create bubbles, even 600 microns of 100% solid coating materials have been known to develop gas bubbles over 24 hours. For old cast iron that requires refurbishment and corrosion protection the total glass flake or ceramic reinforced coating thickness shall be a minimum of 1500 microns (1.5 mm) excluding the thickness of screed/ or putty to give a structurally strong reinforced coating.

(b) Stipple or rub low viscosity, penetrating primer that is moisture tolerant and has high solids > 95% into the cast iron, to a thickness of 50 to 150 microns DFT, or until porosity in the cast iron is visually coated.

(c) Pay special attention to priming cavitation damaged areas or areas with high levels of porosity

(d) As soon as primer is gelled and within the over coating time interval, fill blow holes, cavities, gouges and pitting with putty grades of different viscosities as required.

(e) The coating manufacturer shall confirm in writing that the primer, corrosion protection grade coating, putty and well as final topcoat are all compatible and bond to each other.

(f) Stripe coat with brush applied grade where required, or work into porous areas and pit marks.

(g) Where required re-profile the cast iron surface, especially areas such as pump cutwaters and valve support surfaces for sealing rings, if necessary, using ceramic reinforced wear material applied on top of the glass flake corrosion and permeation barrier coating

(h) Where required add fibre reinforced composite structural laminate using a resin that is compatible to the coatings.

11.6.5.5. INSPECTION OF CAST IRON

(a) Wait 24 hours and perform a visual inspection for signs of gassing or bubbles in the coating system.

(b) Perform the spark testing / holiday detection as per the standard procedure at a minimum of 7500 volts/mm. Repair defects as required.

(c) Once it is confirmed that the surface is free of all signs of gassing signs or defects, apply the final finishing coat of glass flake reinforced Polyester or vinyl ester coating for a total system DFT of minimum 1500 microns.

(d) Perform non-destructive dry film thickness tests on coating.

(e) Allow lining to ambient cure and perform MEK or acetone rub test to verify cure.

11.6.5.6. ALTERNATE COATING MATERIALS OF CAST IRON

(a) The above specification of minimum 1500 microns DFT can also be achieved with glass reinforced ***epoxy*** coating materials that have at least 95% solids, but greater care must be taken with drying the porous cast iron because moisture tolerant low viscosity epoxy primers with volume solids greater than 95% are difficult to find in the market.

NOTE:- that most high solids epoxy coating materials are very viscous and do not easily wet out the porous surfaces or extensive pitting found on old cast iron.

12. EPOXY COATING SYSTEM

STANDARDS

Equipment, materials, and operational methods shall comply with the relevant SANS, ISO, BS, DIN or equivalent American Standard.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification.

Reference is made to the latest issues of the following Standard Specifications:

SANS	2808	Determination of film thickness
SANS	5772	Preparation of steel substrate before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces - Profile of blast-cleaned steel surfaces by a micrometre profile gauge.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
SANS	8502-3	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 3: - Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method).
SANS	9000	Model for quality assurance in production and installation.
BSS	5493	Protective coating of iron and steel structures against corrosion.

12.1. MATERIAL

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warrantied by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

(e) Two pack Epoxies shall be in accordance with Chapter 10 (COMPARATIVE EVALUATION CRITERIA FOR MATERIAL SELECTION). Preference will be given to solvent free epoxies in confined spaces.

(f) Multi-purpose epoxy for atmospheric conditions shall be of the high build epoxy mastic type, modified with aluminium or glass-flakes, containing at least 90% solids. The benefit of using these types of materials is that they exhibit improved UV resistance and very slow rates of chalking compared to conventional epoxies.

(g) Multi-purpose epoxy for immersed conditions shall be of the high build epoxy mastic type, modified with glass-flakes, containing at least 90% solids.

(h) Materials and procedures shall comply with the relevant SANS Specifications and generally accepted best practice.

(i) All materials in a coating system shall be purchased from the same manufacturer unless approved by the Corrosion Engineer. If they do not come from the same manufacturer compatibility test demonstrating minimum acceptable bond strength must be carried out to the satisfaction of the Corrosion Engineer.

(j) Details of coating materials to be supplied and approved – refer to Section 3.1 (APPROVALS BEFORE AWARD OF CONTRACT).

(k) The Contractor shall only proceed with the purchase of coating materials upon receipt of written Approval from the Corrosion Engineer.

(l) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(m) Coating material selection shall also be approved by the material manufacturer/supplier. The Contractor shall receive a written assurance from the material suppliers that the materials comply with the specified requirements.

(n) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:
- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SABS mark or an SANS 9001 certificate where applicable

(o) All coating materials shall be kept in an approved dry and enclosed store. The temperature shall not drop below 0°C nor exceed 40°C.

(p) Usage of materials shall be on a first in, first out basis and no materials shall be used that have exceeded the shelf life recommended by the manufacturer.

12.2. SPECIAL COATING AREAS

(a) Areas that are inaccessible after assembly shall be prepared and fully coated with the specified system to the specified requirements before assembly. The coating shall be fully cured before assembly.

(b) Mating surfaces of joints shall be coated with a thin coat of epoxy at thickness 60 to 90 microns as specified. The coating shall be uniform in thickness and shall not interfere with the mechanical tolerances. After assembly, the outside surface of the joints shall be fully coated

(c) Steel edges to be welded after coating shall not be coated for a distance of 150 mm from the welding edge. The unlined strip of grit blasted surface shall be temporarily protected with a coat of (red or a different colour to the lining/coating) weldable primer between coating application and installation.

(d) Friction grip areas shall be left un-coated unless otherwise specified.

(e) For pipe diameters that are too small for safe man entry, the special coating areas (internal circumferential field joints, by-pass pipes, scour pipes etc.) shall have the internal lining application method statement and method of quality control pre-approved by the Corrosion Engineer. The contractor shall be required to demonstrate the effectiveness of the proposed methods before the relevant commencement of work on site.

12.3. APPLICATION

12.3.1. ACCEPTABILITY OF ITEMS TO BE COATED

Before the application of the coating, the steel surface shall be assessed, in accordance with SANS 12944-3, to determine if it is suitable to be coated.

12.3.2. SURFACE PREPARATION

The Contractor shall satisfy himself that the condition of each item to be coated is such that it is fit for coating or lining, or both, as relevant. Immediately after surface preparation each item or special shall be examined, including the inside surface, where possible, for compliance with the relevant requirements.

Pre- and surface preparation shall conform to Chapters 6 (MANUFACTURE AND PRE-PREPARATION) and 7 (SURFACE PREPARATION) respectively of this specification.

For pipes and specials intended for butt welding the prepared surfaces shall extend to the pipe ends.

12.3.3. COATING THICKNESSES

Coating thicknesses shall be measured in accordance with Section 8.4.3 (DRY FILM THICKNESS (DFT) and shall conform to the Project Specification.

Minimum coating thickness for immersed conditions should be 600 microns, and for above ground conditions a minimum of 300 micron.

For cast iron pipes, pumps and valves note: that the corrosion protection material thickness shall be at least double the relevant steel pipeline corrosion protection thickness.

12.3.4. MANUFACTURER'S INSTRUCTIONS

Recommendations supplied by the manufacturer in the form of the latest edition of printed data sheets, or given in writing on the manufacturer's letterhead, shall be followed.

The following details shall be made available to the applicator:

(a) Brand and type of epoxy resin

(b) Mixing and thinning instructions

(c) Recommended type and quantity of solvent required for thinning during application

(d) Pot life of mixed product

(e) Minimum and maximum recommended dry film thickness per coat

(f) Recommended time intervals between coats

(g) Recommended minimum and maximum steel surface temperatures during application

(h) Time for complete drying and curing on steel surfaces

(i) All relevant information the Manufacturer wishes to submit on his product

(j) Recommended method of coating application

Verbal information by the manufacturer's representative will not be accepted unless confirmed in writing by the manufacturer.

12.3.5. COATING APPLICATION

12.3.5.1. ENVIRONMENTAL CONDITIONS

- Dusty Conditions
  Coatings shall not be applied in dusty or contaminated conditions.

- Surface Temperature
  Coatings shall not be applied if the surface temperature of the steelwork is less than 3°C above dew point or outside the range 10-40°C, unless otherwise specified by the coating manufacturer.

- Epoxy shall not be applied when either steel or ambient temperature is below 10°C due to risk of improper polymerisation and aiming bloom.

- Relative Humidity and Time of Application
  The first coat shall be applied as soon as possible after blast cleaning, but not exceeding four (4) hours if the relative humidity (RH) is below 70% or two (2) hours if the RH is between 70% and 85%.

  For the detail requirements on Humidity and Temperature refer to Section 7.2.7.1 (Humidity And Temperature).

- Solvent based epoxy shall not be applied when the relative humidity exceeds 80%.

- Ambient Temperature
  Coatings shall not be applied when the ambient temperature is less than the minimum or greater than the maximum specified by the manufacturer of the coating material.

12.3.5.2. MIXING (APPLICABLE TO LIQUIDS)

For two pack materials, the use of part of the contents (split packs) is strictly forbidden unless written authorisation by the Corrosion Engineer is obtained.

The Contractor shall ensure that all paints are mixed in accordance with the requirements of Specification BS 5493.

All coating components, particularly two- or multi-component materials, shall be thoroughly mixed until a homogeneous mixture is achieved.

In the case of two-pack materials, each component containing pigments shall be thoroughly mixed. The two components shall then be mixed together in the proportions supplied by the Manufacturer until the mixture is completely homogeneous.

In the case of solvent based epoxy materials, it is recommended that the mixed material be allowed to stand for an induction period, as recommended by the manufacturer, before use.

During application, coating materials shall be agitated regularly to keep the solids in suspension. The preparation time, induction time and pot life of these materials shall be closely adhered to.

The use of plural spray equipment is permitted using one of two methods: at gun catalysation or mixing block with inline mixing tube.

The plural spray mixing method statement and method of mix ratio quality control shall be pre-approved by the Corrosion Engineer. The contractor shall be required to demonstrate the effectiveness of the proposed methods before the relevant commencement of work on site.

12.3.5.3. MIXER (APPLICABLE TO LIQUIDS)

Power mixing must be used where at all possible. Any deviation from mixing procedures shall be at the written discretion of the Corrosion Engineer.

For external coating patch repairs, touch ups and field joints mixing with a flat paddle by hand is only permissible for small volumes below 5 litres. The mixing with a round rod is not allowed.

For internal lining patch repairs, touch ups and field joints where man access is not possible mixing with a flat paddle by hand is permissible. The mixing with a round rod is not allowed.

Where power mixers are required a low speed power mixer, which does not introduce air into the coating material being mixed, shall be utilised. For pipeline lining application and field joints where man access is possible the use of power mixers is mandatory.

The use of squish packs is permitted provided mixing of squish pack as part of a pre-qualification testing indicates adequate cure polymerisation. The cured polymerisation shall be determined as per Section 8.3.3.2 (Mixing Of Two Pack Coating Systems).

12.3.5.4. MIXER (APPLICABLE TO POWDERS)

The powder shall be dry and free flowing and uniformly suspended in a fluidised bed or agitator in a hopper immediately before application. Clumping and agglomerating of powder is not permitted.

12.3.5.5. APPLICATION METHODS AND REQUIREMENTS

Application methods and requirements shall be as prescribed in the relevant product Section, read in conjunction with the manufactures data sheets, whichever is the more stringent.

- Equipment
  Application equipment shall be maintained in a clean condition and in good working order. The use of equipment not maintained in good condition may lead to rejection of the coating. Spray equipment shall be fitted with suitable oil and moisture traps and for safety reasons must be earthed to avoid the risk of static discharge. Refer to Section 8.3.3.5 (Application Requirements).

- Compatibility of Coats
  All primer, intermediate and finishing coats shall be mutually compatible with proper cohesion.

  Likewise, mainline coating, lining, and field joints inclusive of tape wraps and shrink sleeves, shall be mutually compatible with proper intercoat cohesion.

- Surface Restoration of Substrate

  Should immediate lining/coating not be possible, or should any atmospheric oxidisation take place between the completion of blast cleaning and commencement of lining/coating, such oxidisation shall be removed by flash blasting to restore the specified surface finish. Removal of dust and debris shall be in accordance with Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).

12.3.5.6. METHOD OF APPLICATION

- Application
  Coatings and Linings shall be applied by any appropriate method recommended by the manufacturer thereof and approved by the Corrosion Engineer.

- First Coat
  The first coat shall be applied to a minimum dry film thickness of at least 40 µm above the

peaks of the blast profile.

- Cleanliness During Application
  During application and curing of the coating layers, the items shall be protected against contamination by dust or other foreign matter and shall be kept dry and shaded from direct sunlight.

  If the environmental conditions such as dust and moisture are not able to be controlled on the site, the Corrosion Engineer shall have the discretion to specify an appropriate single coat system to avoid the risk of inter-coat bond contamination and subsequent bond failures.

  All coats shall be clean and free from dust, oil, moisture, and perspiration before over-coating. Care must be taken overnight as dew or frost may form on the previous layer and have a detrimental effect on intercoat bond strength.

  Operators handling blast-cleaned or partially painted surfaces shall wear clean gloves to avoid contamination of the surface.

- Stripe Coat and Crevices
- All metal edges, up stands, welds, bolts and nuts shall be adequately coated. Additional stripe coatings shall be applied after initial priming, if ordered by the Corrosion Engineer.

  Special attention shall be given to crevices and edges to ensure complete coverage and uniform paint thickness.

- Second and Subsequent Coats
  The second and subsequent layers shall then be applied within the recommended over-coating periods.

- Coat Colours
  The colour of each subsequent coat shall be different to that of the previous coat except where two finishing coats of the same colour are necessary to achieve colour uniformity.

  The first coat is not permitted to be grey as it does not give adequate contrast to the grit blasted substrate.

  The final coat colour is not permitted to be similar to that of rust or corrosion product (brown, orange and red).

- Over-coating Times
  Over-coating times shall be not less than the minimum nor greater than the maximum specified by the manufacturer relevant to the ambient temperature.

  Strict adherence to over-coating times is particularly important for coatings which are subsequently immersed.

12.3.5.7. PIPE END QUALITY INSPECTION

(a) Pipe Ends for Flexible Couplings

For pipes or specials intended for joining with flexible couplings the lining shall extend to the ends of pipes and specials including edges and shall extend by at least 350 mm on the outside of the pipe prior to coating. Coatings shall overlap lining surfaces on the outside by at least 50 mm.

(b) Butt Welded and Flanged Ends

For pipes and specials intended for site butt welding, lining and coating shall extend up to a distance of 100 mm from the pipe ends.

The unlined circumferential strip of grit blasted surface may be temporarily protected, if specified by the Corrosion Engineer, between the works and the site with a coat of (red or a different colour to the lining/coating) weldable primer, provided that the weldable

primer is completely removed by blasting before the joint repair is done.

(c) Double Weld on Sleeve and Spigot and Socket

For sleeve and spigot and socket couplings the pipe must be uncoated for a distance of 100 mm from the weld.

12.3.5.8. IN-SITU APPLIED LINING

No welding whatsoever shall be performed on any pipe or special on which the lining or coating has been completed, without Approval of procedure in writing by the Corrosion Engineer. Where applicable the temporary protected surfaces shall be blast cleaned before coating with the specified system.

Different coating and lining systems for in-situ applications may require specialized procedures and quality control methods.

The Approval shall only be considered by the Corrosion Engineer after submission by the Contractor of acceptable proposals.

For the detail requirements on in situ internal lining of pipes, relating to Humidity and Temperature limitations, refer to Section 7.2.7.1 (Humidity And Temperature).

12.3.5.9. QUALITY AND TESTING OF COATING AND LINING

Each specific material type shall have detailed quality and testing requirements in the particular Sections and in general these requirements include but are not limited to:

Finish/Visual Inspection
Adhesion
Coating Thickness
Electrical Insulation Defects/ Holiday Inspection
Material Defects
Curing
Dimensions

12.4. TESTING

To be read in conjunction with Section 4.3 (QUALITY ASSURANCE AND PROCEDURES).

12.4.1. CONTRACTOR'S AND ENGINEER'S INSPECTIONS

The Contractor shall submit the following to the Engineer, including data sheets where applicable, for Approval:

12.4.1.1. FOR MANUFACTURE OF COATINGS

(a) Drawings

(b) A programme

(c) A quality control plan

(d) A draft Operation and Maintenance manual

12.4.1.2. FOR CORROSION PROTECTION

(a) A programme

(b) The CITWIF Quality Control Data sheets for corrosion protection duly completed

(c) Blast material

(d) Coating products

(e) Pickling and passivating products

12.4.1.3. MANUFACTURE AND CORROSION PROTECTION PROGRAMME

The manufacture and corrosion protection programmes shall state the time and place when the following will be conducted:

(a) Inspection of material

(b) Hydrostatic testing of uncoated castings, pipes, and fittings

(c) Manufacture of components

(d) Fettling or dressing

(e) Degreasing

(f) Water soluble salts test

(g) Blast cleaning and application of the first coat.

(h) Application of intermediate and final coats.

(i) The commencement of site repairs.

The following steps shall be defined and included in the documentation of the quality inspection programme.

(i) Inspection by The Engineer

Inspection of equipment shall be carried out by the Engineer, his appointed representative or a nominated and approved inspection authority at the manufacturer's and corrosion applicator's works.

The Engineer's inspection shall in no way relieve the Contractor or Sub-contractors of any of their obligations to design, manufacture and supply equipment of superior quality and workmanship in accordance with the specification.

(ii) Independent Surveillance

The Engineer may employ an independent, technically qualified organisation to carry out quality surveillance of the work on his behalf.

The inspection authority has the right to inspect any item covered in the Contract at any stage of execution of the Contract.

Where imported supplies are to be inspected before shipment, the Contractor shall notify his suppliers abroad of the conditions applicable to inspections and also request them to notify the Department's representative abroad when consignments are ready so that arrangements for inspection may be made.

(iii) Material Tests

The Manufacturer's material test data certification and the Contractor's quality records shall be subject to examination by the Engineer or his representative. Reasonable samples of the cleaning and coating materials to be used may be removed for testing.

Rejection of the samples shall place a hold on the use of materials of the same batch number and any components that have already been cleaned/coated with rejected material shall be reworked.

(iv) Destructive Testing

The Engineer or his representative may carry out reasonable destructive tests to ascertain compliance with the Specification. Areas thus damaged shall be repaired by the Contractor to the satisfaction of the Engineer at no additional cost.

12.4.1.4. VISUAL INSPECTION

All surfaces shall be inspected visually as specified in Section 8.4.1 (VISUAL INSPECTION).

12.4.1.5. HOLIDAY INSPECTION

100 % of the lining and coating of all pipes shall be tested and there shall be no holiday on any area inspected.

Holiday testing shall be carried out in accordance with Section 8.4 (TESTING PROCEDURES).

12.4.2. DRY FILM THICKNESS (DFT)

The default method of measuring and evaluating coating and lining thickness shall be a minimum thickness which shall mean that no readings are allowed below the minimum thickness.

In the alternative and if specified in the Project Specification, the thickness requirement for the coating and lining can be determined by standard deviation around a mean with maximum and minimum thickness requirement.

The Corrosion Engineer shall consider the variability associated with hand spraying versus the consistency that can be obtained with automated machine spray.

(a) Measurements shall be taken in accordance with SANS ISO 2808, unless the frequency of readings is specified in the Project Specification.

(b) 100% of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(c) In the case of coats applied after the erection of steel work on Site, the frequency at which measurements of the DFT are taken shall be at the discretion of the Engineer's Inspector or the Engineers Representatives and may be dictated by accessibility.

(d) DFT in excess of the prescribed maxima shall not necessarily constitute reason for rejection if the paint film is demonstrated to be sound in all respects.

(e) Owing to delayed solvent release, solvent-borne coatings shrink over a period of time resulting in a lower film thickness and therefore it is important that DFT measurements be taken after seven days.

(f) Should the standard deviation and mean thickness reading have been agreed upon and indicated that there may be areas of coatings thinner than specified, then additional testing may be necessary. The DFT should be measured and reported in accordance with SANS 2808: 2008.

(g) The method used to measure DFT, and the significance of the readings for each particular project, shall be agreed upon by all parties prior to commencement of the work.

12.4.2.1. AUTOMATED SHOP APPLIED LINING AND COATING

The film thickness on all pipes shall be measured non-destructively by an approved eddy current instrument.

(a) Pipes smaller than 600 mm in diameter at least four readings at equally spaced intervals around the circumference, approximately 300 mm from each end of the pipe, shall be taken.

(b) Pipes of 600mm in diameter and above 8 readings equally spaced around the circumference shall be taken at 300mm at each end of the pipe and at two other equally spaced positions along the length of the pipe.

(c) The first reading, irrespective of diameter, shall be over the weld bead. When practicable an additional four readings at equally spaced intervals around the circumference in the centre of the pipe shall be taken. The thickness shall not be less than the minimum specified over 100% of the area including weld beads. The Inspectorate may at their discretion supplement the above test by checking wet film thickness on any or all pipes during application of the epoxy resin.

12.4.2.2. HAND AND IN-SITU APPLIED LINING AND COATING

For pipes above 600mm in diameter 8 readings equally spaced around the circumference shall be taken at positions not more than 10 metres apart along the length of the pipe. All the applied lining and coating thicknesses shall be tested by means of an approved eddy current. The first reading shall be over the weld bead. The thickness shall not be less than the minimum specified over 100 % of the area including weld beads.

12.4.3. DEGREE OF CURE OF TWO-COMPONENT MATERIALS

The degree of cure of a two-component material will vary with time, temperature and ventilation and shall be assessed by solvent wiping in accordance with the method given in Section 8.4.4.1 (Methyl Ethyl Ketone Resistance).

Alternatively, the degree of cure can also be determined by measuring the hardness of the polymer in Barcol, IRHD Shore A or D or other method as described by the manufacturer in the material data sheet.

12.5. DAMAGED COATINGS

Evaluation of epoxy to determine the extent of damage and if repair or refurbishment is possible.

(a) All repairs and procedures shall be approved by the Corrosion Engineer and subject to inspection procedures as set out in Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES)

(b) Where the damage is extensive and the original coating or lining must be removed, the remedial procedures shall be agreed upon in writing with the Corrosion Engineer and the inspection procedures as described in Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES) shall be followed.

(c) All repairs shall comply with the requirements of the repair-product manufacturer's data sheet. The Corrosion Engineer may at his discretion request that repaired coating areas undergo adhesion tests.

(d) Any damage occurring during transit from the Contractor's premises to the site, shall be the responsibility of the Contractor. The Contractor responsible for installation of equipment at site shall repair any damage occurring on site during handling, assembly, storage, transport, and erection.

(e) The repaired area shall be tested for compliance with the relevant requirements for thickness, full cure and electrical insulation defects respectively.

(f) Any item showing electrical insulation defects exceeding an average of five per square metre (a cluster of pinholes within a radius of 25 mm being regarded as a single defective area), or flaking or other signs of loss of adhesion, shall not be repaired. The item shall be blast cleaned and re-coated in accordance with the relevant requirements of the specification.

12.5.1. REPAIR METHODS FOR MINOR DEFECTS

The repair of areas showing electrical insulation defects, lack of full cure or low film thickness shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with a minimum roughness grade 100 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with SANS 8502-3 and Section 7.2.7.5 (Residual Dust And Debris).

(d) Wipe only the abraded paint surface with methyl ethyl ketone or solvent as recommended by the paint manufacturer and allow to dry.

(e) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE: 1. When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.
2. Apply a final topcoat over the repaired area to achieve uniform finish of the item

12.5.2. REPAIR METHODS FOR MAJOR DEFECTS

The repair of areas showing damage down to the steel surface shall, if approved by the Corrosion Engineer be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Blast-clean all damaged areas to Sa 3 (SANS ISO 8501-1).

(c) Feather the surrounding paint for a distance of 50 mm beyond the damaged areas with a minimum roughness grade 100 abrasive paper.

(d) Vacuum-clean the surface to remove dust and debris in accordance with SANS 8502-3 and Section 7.2.7.5 (Residual Dust And Debris).

(e) Wipe only the abraded paint surface with methyl ethyl ketone or solvent as recommended by the paint manufacturer and allow to dry.

(f) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE: 1. When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.
2. Apply a final topcoat over the repaired area to achieve uniform finish of the item

12.5.3. REFURBISHMENT OF AGED OR DEGRADED EPOXY SYSTEMS

The repair is dependent upon the degree of degrading of the epoxy system.

(a) If the surface is found to be pinhole free the procedure as described in 12.5.1 must be followed.

(b) If pinholes are found in the coating procedure Section 12.5.2 must be followed.

(c) If extensive pinholes and damage to the coating are found the coating should be replaced.

13. GLASS-FLAKE COATING

STANDARDS

Equipment, materials, and operational methods shall comply with the relevant SANS, ISO, BS, EN, NORSOK, ASTM or equivalent.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification.

Reference is made to the latest issues of the following Standard Specifications:

ASTM	D1002	Adhesive Strength onto Steel
ASTM	D1653	Water Vapour Permeability
ASTM	G95/G8	Cathodic disbonding resistance
ISO	20340	Relevant extracts from performance requirements for protective paint systems, as pre-qualification before use in this specification.
ISO	2812-2	Water Immersion
NORSOK	M-501	Surface preparation and protective coating
SANS	2808	Determination of film thickness
SANS	5769	Cleanliness of blast-cleaned steel surfaces for painting (dust and debris).
SANS	5772	Profile of blast-cleaned steel surfaces for painting.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings
SANS	8501-3	Part 3: Preparation grades of welds, edges, and other areas with surface imperfections
SANS ISO	9000	Model for quality assurance in production and installation.
SSPC	PA - 2	Procedure for the determining conformance to dry coating thickness requirements, with specific reference to Section 9 of SSPC PA - 2 and a restriction level of 1.

13.1. INTRODUCTION

Glass-flake coating and lining systems are generally used where higher performance and longer life expectancy is required than the base generic resin.

The Glass-flake corrosion protection systems are formulated from various generic base resins or polymers such as epoxy, polyester, and vinyl ester resin binders.

The principle of operation of glass-flake coatings and linings is called a tortuous path that creates a longer diffusion trail in cross section through the coating thickness.

The addition of Glass-flake reinforcement improves the corrosion protection properties of the coating or lining material. The improvements in performance are in areas such as permeation resistance, much slower rates of Moisture Vapour Transmission (MVT), and low rates of diffusion to small molecules such as oxygen. The consequence of adding the correct type and quantity of glass-flake is an order of magnitude or more reduction in osmosis through a coating or lining film.

For longer corrosion life expectancy, the glass-flake reinforced coating may be formulated with higher % of glass-flake loading or different types of flake, such as nano thickness or micro thickness. The advantage of thinner glass-flake is that more layers of glass are added to the tortuous path. The increase in layers of flake results in a longer diffusion path length, improved resistance to permeation and longer corrosion life expectancy.

One benefit of the increase in resistance to permeation exhibited by glass-flake coatings when compared to the same base resin is much higher aged bond strength after immersion (% adhesion retained after time).

The addition of glass-flake also improves the electrical resistance (Dielectric Insulation) of the coating and lining and substantially reduces cathodic disbondment. From a Cathodic Protection (CP) design perspective, glass-flake reinforced coatings, reduce current drain and may result in savings on the size of CP power supply units.

The use of glass-flake coatings, improves Cathodic disbonding resistance.

Glass-flake addition to epoxy or other resin systems, also improves properties such as wear and abrasion resistance, increased toughness, improved resistance against cutting, gouging, scour marks and scratching, when compared to the same base resin in a non-filled coating.

The addition of glass-flake also improves the UV resistance of epoxy, because any chalking and subsequent loss of coating thickness is limited to the surface layers and chalking does not penetrate.

The majority of the standards, application procedures and quality control methods used for other liquid applied coatings and linings are also relevant to Glass-flake coatings and linings.

13.2. MATERIAL

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warranted by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

(e) The Glass-flake coating or lining material shall be manufactured in accordance with SANS 9001. The Corrosion Engineer shall give preference to Contractor's utilising solvent free Glass-flake epoxy coatings, especially in confined spaces.

(f) For confined space patch repairs the Corrosion Engineer may give preference to catalyst cured systems such as polyester and vinyl ester because of potential mix ratio issues when using epoxy for small local repairs.

(g) Glass-flake linings for immersed conditions shall be of the high build type containing at least 95% volume solids.

(h) Glass-flake coatings for non-immersed / atmospheric corrosion conditions shall be of the high build type having a minimum of 50% volume solids and the manufactures shall certify that the solvent based glass-flake coating shall not solvent entrap. The benefit of using polyester, polyurethane or vinyl ester materials is that they exhibit very good UV resistance and do not chalk compared to epoxies.

(i) In terms of this specification a Glass-flake coating shall have a minimum Glass-flake or platelet loading equivalent to 10% of the mass or alternatively shall have a resistance to moisture vapour diffusion of at least 10^{-2} perm inch or perm cm or better.

(j) The resistance to moisture vapour permeation is directly related to corrosion life expectancy. Perm Inch is a commonly used American permeability co-efficient but can also be converted to a SI unit Nano gram per second per sqm per Pascal. Test method is usually defined as per ASTM D1653.

(k) Different thickness flakes and different percentage flake loading may be used at the manufacturers discretion to change the mechanical properties of the coating such as improved wear resistance or for putty and mastic type formulations.

(l) The Glass-flake coatings shall an elongation to break of at least 0.7%, and a resistance to impact of minimum 7 joules. This is so that the glass-flake material is not brittle and can resist small movements.

(m) Have excellent adhesion properties. Adhesion to steel shall be >15 MPa under laboratory conditions when measured in accordance with ASTM D 4541. Higher adhesion will assist life expectancy under high flow velocity conditions including all the edges and corners or at circumferential welds.

(n) The abrasion resistance using a Taber abrader as per procedure ASTM D4060-19 shall be less than 180 mg loss / 1000 cycles with a 1000gram weight with a CS17 wheel.

(o) Glass-flake materials and application procedures shall comply with the relevant SANS Specifications and generally accepted best practice.

(p) All materials in a coating system shall be purchased from the same manufacturer unless approved by the Corrosion Engineer. If they do not come from the same manufacturer compatibility test demonstrating minimum acceptable bond strength must be carried out to the satisfaction of the Corrosion Engineer.

(q) The Glass-flake coating or lining materials intended to be used on a project, should preferably be pre-qualified in accordance with NORSOK M-501 or similar certification. The Contractor shall submit details on the proposed materials for Approval and the Contractor shall only proceed with the purchase of coating or lining materials upon receipt of written Approval from the Corrosion Engineer.

(r) All coating materials shall be kept in an approved dry and enclosed store. The short term and long-term storage temperatures for all materials shall be as per the manufacturer's datasheet.

(s) Usage of materials shall be on a first in, first out basis and no materials shall be used that have exceeded the shelf life recommended by the manufacturer.

13.3. SPECIAL COATING AREAS

(a) Areas that are inaccessible after assembly shall be prepared and fully coated with the specified system to the specified requirements before assembly. The coating shall be fully cured before assembly.

(b) Mating surfaces of joints shall be coated with Glass-flake coatings & linings, primer (where specified) or first coat only. The coating shall be uniform in thickness and shall

not interfere with the mechanical tolerances. After assembly the outside surface of the joints shall be fully coated.

(c) Pipe cut backs and steel edges to be welded after coating shall not be coated for a distance of 100mm from the welding edge. The uncoated/unlined strip of grit blasted surface adjacent to any new weld shall be re-blasted after welding to the required cleanliness standard before application of the field joint coating or coating patch repair.

(d) Friction grip areas shall be left un-coated unless otherwise specified.

(e) For pipe diameters that are too small for safe man entry, the special coating areas (internal circumferential field joints, by-pass pipes, scour pipes etc.) shall have the internal lining application method statement and method of quality control pre-approved by the Corrosion Engineer. The contractor shall be required to demonstrate the effectiveness of the proposed methods, before the relevant commencement of work on site.

13.4. APPLICATION

(a) The coating application technique for Glass-flake materials may be a different spray technique to obtain a smooth finish.

(b) Compared to conventional coating systems, that are sprayed, the Glass-flake coatings require higher atomisation pressures relative to un-filled resins.

(c) Glass-flake coatings applied by hand require directional brush techniques.

(d) Applicators need to demonstrate both experience of previous Glass-flake application as well as formal training certificates from a Glass-flake coatings and lining manufacturer.

(e) Glass-flake coating spray is usually by airless pump but can also be by pressure pot and cup gun or even aerosol can, depending on type of glass-flakes.

(f) The thinner and smaller (irregular) diameter flakes spray more easily and apply smoother than old technology Glass-flake coatings.

(g) Thicker/ course Glass-flake coatings can result in a rough finish, unless applied by a skilled and experienced applicator.

(h) Quality Control of glass-flake coatings and linings should always include high voltage spark testing to find both actual defects as well as potential defects.

13.4.1. SURFACE PREPARATION

Pre- and surface preparation shall conform to Chapters 6 (MANUFACTURE AND PRE-PREPARATION) and 7 (SURFACE PREPARATION) respectively of this specification.

The Contractor shall satisfy himself that the surface preparation and condition of each item to be coated is such that it is fit for coating or lining, so that the contractor can honour his guarantee.

13.4.2. COATING THICKNESSES

Coating thickness shall be dependent on service environment and life expectancy requirements.

However, the minimum thickness shall be 400 microns DFT or alternatively thicker as specified in the Project Specification or by the manufacturer to meet the warranty requirements.

The following corrosion protection thickness specifications apply for different life expectancies in C5 marine industrial environments or steel work in chambers subject to high humidity and periodic flooding:

For 10 year design life expectancy to first maintenance specification minimum 800 microns DFT and 1000 microns average of a glass-flake coating.

13.4.3. MANUFACTURER'S INSTRUCTIONS

Recommendations supplied by the manufacturer in the form of the latest edition of printed data sheets, or given in writing on the manufacturer's letterhead, shall be followed. The following details shall be made available to the applicator:

(a) Brand and type of Glass-flake coatings & linings resin
(b) Mixing and thinning instructions
(c) Recommended type of solvent required for cleaning, as per data sheet.
Thinning of glass-flake coatings with solvent for spray application is normally prohibited.
(d) Pot life of mixed product
(e) Minimum and maximum recommended dry film thickness per coat
(f) Recommended time intervals between coats, unless a single coat is specified.
(g) Recommended minimum and maximum steel surface temperatures during application
(h) Time for complete drying and curing on steel surfaces
(i) All relevant information the Manufacturer wishes to submit on his product
(k) Recommended method of coating application

Verbal information by the manufacturer's representative will not be accepted unless confirmed in writing by the manufacturer.

13.5. COATING APPLICATION

13.5.1. ENVIRONMENTAL CONDITIONS

13.5.1.1. DUSTY CONDITIONS

Coatings shall not be applied in dusty or contaminated conditions.

13.5.1.2. SURFACE TEMPERATURE

(a) Coatings shall not be applied if the surface temperature of the steelwork is less than 3°C above dew point or stated differently may only be applied if the steel surface is at least 3°C warmer than dew point or condensation temperature of the air.

(b) Epoxy Glass-flake and epoxy coating should not be applied under cold condition below 7°C because of material doesn't cure properly and risks amine bloom.

(c) Polyester and vinyl ester Glass-flake coating can be applied under freezing cold conditions (sub-zero temperature) and the material will still cure properly, with consideration that curing times will become longer. When applying coating in freezing conditions, care must be taken that the steel is warm or air is very dry to prevent condensation.

(d) For very hot conditions above 40°C solvent free and high solids Glass-flake coatings may be used with consideration that pot life and curing time will decrease.

(e) When-ever coatings are to be applied under extreme conditions outside the range 7-40°C, the coating manufacturer shall be consulted and requested to confirm product suitability.

13.5.1.3. RELATIVE HUMIDITY AND TIME OF APPLICATION

The first coat shall be applied as soon as possible after blast cleaning, but not exceeding four (4) hours if the relative humidity (RH) is below 70% or two (2) hours if the RH is between 70% and 85%. Refer to paragraph 7.2.7.1 (Humidity And Temperature) for the conditions under which the Corrosion Engineer may in his discretion relax these requirements for project specific requirements.

No coating or lining application is permissible if the dew point temperature of the air is not at least 3ºC above or warmer than the steel substrate.

13.5.1.4. AMBIENT TEMPERATURE

Coatings shall not be applied when the ambient temperature is less than the minimum or greater than the maximum specified by the manufacturer of the coating material, read together with Section 13.5.1.2 (Surface Temperature).

13.5.2. MIXING GLASS-FLAKE MATERIAL

Epoxy glass-flake materials have a base to activator mix ratio which is critical and must be adhered to. Example 70:30.

Polyester and vinyl ester glass-flake materials have a base to catalyst mix ratio that must be adhered to within a range allowed by the manufacturer's data sheet. Example 98:2 or 99:1.
Curing time and pot life of polyester and vinyl ester glass-flake materials may be varied with in manufacturer's allowable range to speed up or slow down polymerization and curing time.

For two pack materials, the use of part of the contents (split packs) is strictly forbidden unless written authorisation by the Corrosion Engineer is obtained.

All coating components, particularly two- or multi-component materials, shall be thoroughly mixed until a homogeneous mixture is achieved.

In the case of two-pack materials, each component base or activator shall be separately mixed. The two components shall then be mixed together in the proportions supplied by the Manufacturer until the mixture is completely homogeneous.

The use of plural spray equipment is permitted using one of two methods: at gun catalysation, or mixing block with inline mixing tube.

The plural spray mixing method statement and method of mix ratio quality control shall be pre-approved by the Corrosion Engineer. The contractor shall be required to demonstrate the effectiveness of the proposed methods over the spray hose distances required, before the relevant commencement of work on site.

13.5.3. MIXER

Power mixing must be used for all spray applications. Any deviation from mixing procedures shall be at the written discretion of the Corrosion Engineer.

For external coating patch repairs, touch ups and field joints mixing with a flat paddle by hand is only permissible for small volumes below 5 litres. The mixing with a round rod is not allowed.

For internal lining patch repairs, touch ups and field joints where man access is possible, squish packs, cartridge guns or twin pack aerosol cans, shall be used.

Where power mixers are required, a low speed power mixer, which does not introduce air into the coating material being mixed, shall be utilised. For pipeline lining application and field joints where man access for spray is possible, the use of power mixers is mandatory.

13.5.4. APPLICATION METHODS AND REQUIREMENTS

Application methods and requirements shall be as prescribed in the relevant product chapter, read in conjunction with the manufacture's procedure sheets, whichever is the more stringent.

13.5.4.1. EQUIPMENT

Application equipment shall be maintained in a clean condition and in good working order. Glass-flake coatings and lining may require large spray tips sizes and higher airless spray pump pressure. Worn out equipment may led to rough coating spray finish. The use of equipment not maintained in good condition may lead to rejection of the applied coating and lining.

13.5.4.2. COMPATIBILITY OF COATS

All primer, intermediate and finishing coats shall be mutually compatible with proper intercoat adhesion.

Likewise mainline coating, lining and field joints shall be mutually compatible with proper intercoat adhesion.

13.5.5. SURFACE RESTORATION OF SUBSTRATE

Should immediate lining/coating after blasting not be possible, or should any atmospheric oxidisation take place between the completion of blast cleaning and commencement of lining/coating, such oxidisation shall be removed by flash blasting to restore the specified surface finish. Removal of dust and debris shall be in accordance with Section 7.5.4.3 (Dust And Debris).

13.5.6. METHOD OF APPLICATION

13.5.6.1. APPLICATION

Coatings and Linings shall be applied by any appropriate method recommended by the manufacturer thereof, and approved by the Corrosion Engineer.

13.5.6.2. CLEANLINESS DURING APPLICATION

During application and curing of the coating layers, the items shall be protected against contamination by dust or other foreign matter and shall be kept dry and shaded from direct sunlight.

If the environmental conditions such as dust and moisture are not able to be controlled on the site, the Corrosion Engineer shall have the discretion to specify an appropriate single coat system to avoid the risk of inter-coat bond contamination and subsequent bond failures.

All coats shall be clean and free from dust, oil, moisture and perspiration before over-coating. Care must be taken overnight as dew or frost may form on the previous layer and have a detrimental effect on intercoat bond strength.

Operators handling blast-cleaned or partially painted surfaces shall wear clean gloves to avoid contamination of the surface.

13.5.6.3. COAT COLOURS

The colour of each subsequent coat shall be different to that of the previous coat except where two finishing coats of the same colour are necessary for aesthetics to achieve colour uniformity.

The first coat is not permitted to be grey as it does not give adequate contrast to the grit blasted substrate.

The final coat colour is not permitted to be similar to that of rust or corrosion product (brown, orange and red).

13.5.6.4. OVER-COATING TIMES

Over-coating times shall be not less than the minimum nor greater than the maximum specified by the manufacturer relevant to the ambient temperature.

Strict adherence to over-coating time is particularly important for coatings which are subsequently immersed.

13.5.7. PIPE END QUALITY INSPECTION

(a) Extension of Lining

For flanged pipes or specials and pipes or specials intended for joining with flexible couplings or for site welding by means of double sleeve weld-on couplings, the lining shall extend to the ends of pipes and specials including edges and shall extend by at least 300 mm on the outside of the pipe. Coatings shall overlap lining surfaces on the outside by at least 50 mm.

(b) Butt Weld Edges

For pipes and specials intended for site butt welding, lining and coating shall extend up to a distance of 100 mm from the pipe ends.

The unlined circumferential strip of grit blasted surface shall be temporarily protected between the works and the site with a coat of (red or a different colour to the lining/coating) weldable primer.

13.5.8. WELDING AFTER APPLICATION

No welding whatsoever shall be performed on any pipe or special on which the lining or coating has been completed, without Approval of procedure in writing by the Corrosion Engineer. Where applicable the temporary protected surfaces shall be blast cleaned before coating with the specified system.

Different coating and lining systems for in-situ applications may require specialized procedures and quality control methods.

The Approval shall only be considered by the Corrosion Engineer after submission by the Contractor of acceptable proposals.

13.5.9. OVER-COATING WITH POLYURETHANE

For colour coding or aesthetics, glass-flake coating may be over coated subject to confirmation of compatibility by the manufacturer.

13.5.10. QUALITY AND TESTING OF COATING AND LINING

Each specific material type shall have detailed quality and testing requirements in the particular chapters and in general these requirements include but are not limited to:

Finish/Visual Inspection
Adhesion
Coating Thickness
Electrical Insulation Defects/ Holiday Inspection
Material Defects
Curing

13.6. CONTRACTOR'S AND ENGINEER'S INSPECTIONS

13.6.1. INSPECTION BY THE ENGINEER

Inspection of equipment, pipes, process plant etc. shall be carried out by the Corrosion Engineer, his appointed representative or a nominated and approved inspection authority at the manufacturer's and corrosion applicator's works. For site applied corrosion protection, inspection shall occur at the work site.

The Corrosion Engineer's inspection shall in no way relieve the Contractor or Sub-contractors of any of their obligations to design, manufacture and supply superior quality and workmanship in accordance with the specification.

13.6.2. INDEPENDENT SURVEILLANCE

The Corrosion Engineer may employ an independent, technically qualified organisation to carry out quality surveillance of the work on his behalf.

The inspection authority has the right to inspect any item covered in the Contract at any stage of execution of the Contract.

Where imported supplies are to be inspected before shipment, the Contractor shall notify his suppliers abroad of the conditions applicable to inspections and also request them to notify the Department's representative abroad when consignments are ready so that arrangements for inspection may be made.

13.6.3. MATERIAL TESTS

The Manufacturer's material test data certification and the Contractor's quality records shall be subject to examination by the Corrosion Engineer or his representative. Reasonable samples of the cleaning and coating materials to be used may be removed for testing.

Rejection of the samples shall place a hold on the use of materials of the same batch number and any components that have already been cleaned / coated with rejected material shall be reworked.

13.6.4. DESTRUCTIVE TESTING

The Corrosion Engineer or his representative may carry out reasonable destructive tests to ascertain compliance with the Specification. Areas thus damaged shall be repaired by the Contractor to the satisfaction of the Corrosion Engineer at no additional cost.

13.6.5. HOLIDAY INSPECTION

100 % percent of the glass-flake lining and coating of all pipes and equipment shall be tested and there shall be no holiday, electrical insulation defects, on any area inspected.

For films exceeding 500 µm thicknesses, the high voltage, sparking electrical insulation defects detector is used in accordance with this standard specification and approved QCP document.

Use of the wet sponge test method is not acceptable for glass-flake coatings.

13.7. DRY FILM THICKNESS (DFT)

The default method of measuring and evaluating coating and lining thickness shall be a minimum thickness which shall mean that no readings are allowed below the minimum thickness.

The Corrosion Engineer shall consider the variability associated with hand spraying versus the consistency that can be obtained with automated machine spray.

(a) Measurements shall be taken in accordance with SANS ISO 2808, unless the frequency of readings is specified in the Project Specification.

(b) 100% percent of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(c) In the case of coats applied after the erection of steel work on Site, the frequency at which measurements of the DFT are taken shall be at the discretion of the Engineer's Inspector or the Engineers Representatives and may be dictated by accessibility.

(d) DFT in excess of the prescribed maxima shall not necessarily constitute reason for rejection, if the coating film is demonstrated to be sound in all respects. Over thickness for solvent free glass-flake coatings is not detrimental.

(e) The default method of DFT measurement shall be in accordance with SSPC PA - 2 Procedure for the determining conformance to dry coating thickness requirements, with specific reference to Section 9 of SSPC PA - 2 and a restriction level of 1.

The method of measuring and evaluating coating and lining thickness shall be a minimum thickness which shall mean that no readings below the minimum thickness are allowed to be accepted.

13.7.1. AUTOMATED SHOP APPLIED GLASS-FLAKE LINING AND COATING

The film thickness on the first five pipes and thereafter on at least one pipe selected at random from every day's production, but not less than one pipe out of every ten pipes, shall be measured non- destructively by an approved eddy current instrument.

(a) Pipes smaller than 600mm in diameter at least four readings at equally spaced intervals around the circumference, approximately 300 mm from each end of the pipe, shall be taken. The first reading shall be over the weld bead. When practicable an additional four readings at equally spaced intervals around the circumference in the centre of the pipe shall be taken. The thickness shall not be less than the minimum specified over 100 percent of the area including weld beads. The Inspectorate may at their discretion supplement the above test by checking wet film thickness on any or all pipes during application of the glass-flake coatings & linings resin.

(b) Pipes of 600mm in diameter and above 8 readings equally spaced around the circumference shall be taken at 300mm at each end of the pipe and at two other equally spaced positions along the length of the pipe.

13.7.2. HAND AND IN-SITU APPLIED GLASS-FLAKE LINING AND COATING

For pipes above 600mm in diameter 8 readings equally spaced around the circumference shall be taken at positions not more than 10 metres apart along the length of the pipe. All the applied lining and coating thicknesses shall be tested by means of an approved eddy current or magnetic instrument. The first reading shall be over the weld bead. The thickness shall not be less than the minimum specified over 100 percent of the area including weld beads.

13.7.3. DEGREE OF CURE OF TWO-COMPONENT MATERIALS

The degree of cure of a two-component material will vary with time, temperature and ventilation and shall be assessed by solvent wiping in accordance with the method given in SANS 1217 (methyl ethyl ketone resistance rub test)

Alternatively, the degree of cure can also be determined by measuring the hardness of the polymer in Barcol, IRHD Shore A or D or other method as described by the manufacturer in the material data sheet.

13.8. DAMAGED COATINGS

Evaluation of glass-flake coatings & linings to determine extent of damage and if repair or refurbishment is possible.

(a) All repairs and procedures shall be approved by the Corrosion Engineer and subject to inspection procedures.

Where the damage is extensive, the inspection procedures and repair method shall be agreed upon in writing with the Corrosion Engineer.

(b) All repairs shall comply with the requirements of the repair-product manufacturer's data sheet. The Corrosion Engineer may at his discretion request that repaired coating areas undergo adhesion tests.

(c) Any damage occurring during transit from the Contractor's premises to the site shall be the responsibility of the Contractor. The Contractor responsible for installation of equipment at site, shall repair any damage occurring on site during handling, assembly, storage, transport, and erection.

(d) The repaired area shall be tested for compliance with the relevant requirements for thickness, full cure, and electrical insulation defects respectively.

(e) Any item showing electrical insulation defects exceeding an average of five per square metre (a cluster of pinholes within a radius of 25 mm being regarded as a single defective area), or flaking or other signs of loss of adhesion, shall not be repaired. The item shall be blast cleaned and re-coated in accordance with the relevant requirements of the specification.

13.9. REPAIR METHODS FOR MINOR DEFECTS

The repair of areas showing electrical insulation defects, lack of full cure or low film thickness shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with a minimum roughness grade 100 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with SANS 5769 and paragraph 7.4.1.

(d) Wipe the abraded paint surface with methyl ethyl ketone and allow to dry

(e) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE:

1. When glass-flake coatings contain solvent, the curing time between coats, as specified by the coating material manufacturer shall be adhered to.

2. Apply a final topcoat over the repaired area to achieve uniform finish of the item.

13.10. REPAIR METHODS FOR MAJOR DEFECTS

The repair of areas showing damage down to the steel surface shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Blast-clean all damaged areas to Sa 3 (SANS 8501-1).

(c) Feather the surrounding paint for a distance of 50 mm beyond the damaged areas with a minimum roughness grade 100 abrasive paper.

(d) Vacuum-clean the surface to remove dust and debris in accordance with SANS 5769 and Section 7.5.2.3 (Dust And Debris).

(e) Wipe only the abraded paint surface with methyl ethyl ketone and allow to dry.

(f) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

14. FUSION BONDED POWDER COATING SYSTEMS

STANDARDS

Equipment, materials, and operational methods shall comply with the relevant SANS or equivalent Standard.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification. Reference is made to the latest issues of the following Standard.

Specifications:

SANS	2808	Determination of film thickness.
SANS	5772	Preparation of steel substrate before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces - Profile of blast-cleaned steel surfaces by a micrometre profile gauge.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
SANS	8502-3	Preparation of steel substrates before application of paints and related products – Test for the assessment of cleanliness Part 3: - Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method).
SANS	9000	Model for quality assurance in production and installation.
BSS	5493	Protective coating of iron and steel structures against corrosion.

14.1. POWDER COATING MATERIAL

Shall conform to the Type 2 materials as referenced in Section 10.5 SPECIAL REQUIREMENTS FOR LININGS AND FIELD JOINT SYSTEMS) of this specification relating to powder coating.

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warrantied by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

14.2. APPLICATION

14.2.1. SURFACE PREPARATION

Pre- and surface preparation shall conform to Chapters 6 (MANUFACTURE AND PRE-PREPARATION) and 7 (SURFACE PREPARATION) respectively.

14.2.2. COATING THICKNESSES

Fusion bonded powder coating shall have minimum thicknesses as given below unless otherwise specified in the Project Specification.

The epoxy coating shall be evenly applied to the minimum final film thickness and shall be tested in accordance with this specification.

Heavy duty fusion bonded epoxy is suitable for full immersion under water and shall have a minimum dry film thickness of 325 microns. Heavy duty fusion bonded epoxy shall have the same thickness both internally and externally on small components such as valves and flow meters etc.

Light duty fusion bonded epoxy is suitable corrosion protection in atmospheric conditions for components such as electrical control boxes and electric motors shall have a dry film thickness of no less than 200 microns plus a further 50 microns minimum re-coatable Polyurethane if exposed to UV.

Buried in soil conditions the fusion bonded epoxy thickness shall be a minimum dry film thickness of 400 microns with an additional 800 microns of ARO (Abrasion Resistant Overcoat).

14.2.3. COATING APPLICATION

Powder coating materials are generally applied by introducing electrostatic voltage differential between the steel substrate and the powder material. The powder materials are then generally blown onto the steel surface by a powder coating gun.

Powders can also be applied by immersing the component into a fluidised bed.

After application of the powder the substrate is heated until the melt fusion temperature is reached where after a film of liquid covers the surface. The liquid solidifies and cools down to form the powder coated surface. Different types of powder coating materials have different melting temperatures and also require different sinter cycles for controlled heating and cooling rates.

Some of the powder coating materials are re-coatable and the film thickness can be built up progressively refer relevant material data sheets for more information.

Items shall be heated to a temperature range specified in the data sheet (only applicable to heavy items) and coated with fusion bonded epoxy by means of an electrostatic powder gun.

On completion of the powder coating, items shall be cured at a temperature range and time period specified in the data sheet (mean temperature). For epoxy powder coating the curing time shall be a minimum of 60 minutes, unless specified differently in the data sheet.

14.2.4. QUALITY OF POWDER COATING

- Finish
  The fully cured coating shall have a uniform, smooth, gloss finish with required adhesion.

- Electrical Insulation Defects
  All coated surfaces intended for water immersion or where likely to be frequently wetted under normal service conditions shall show no electrical insulation defects when tested in accordance with this specification.

- Finishing Coat Colours (finishing coat colour)
  The finishing coat colours shall be as specified in the Project Specification in accordance with the Specification Colour Code.

  A guideline of colour codes is given in SANS 1091.

  Where not specified, the selection of final colours shall be approved by the Engineer.

14.3. TESTING

To be read in conjunction with Chapter 8 (APPLICATION AND QUALITY CONTROL).

For powder coating that will be subject to buried conditions and or intermittent immersion, the powder coating shall be spark tested as per the requirements of Section 8.4.2 (HOLIDAY INSPECTION). Furthermore, Epoxy powder coating that is used for mainline coating under a three-layer 3LPE system shall be subject to hot water soak test.

14.3.1. CONTRACTOR'S AND ENGINEER'S INSPECTIONS

Refer to Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES) and ANNEX F: QUALITY CONTROL PLAN TEMPLATES)

14.3.2. VISUAL INSPECTION

All surfaces shall be inspected visually and shall be free from tears, runs, sags, wrinkles, blisters, change in colour or gloss, orange peel, dirt, visible pinholes, dust or fluff occlusions or any other visible defects.

All epoxy coating systems exposed to UV light are subject to chalking and a gradual loss of coating thickness. For prolonged UV exposure epoxy should be over coated with UV resistant coatings. Spare pipes and specials shall be protected against UV exposure during storage.

14.3.3. HOLIDAY INSPECTION

100 percent of the lining and coating of all pipes shall be tested and there shall be no holiday on any area inspected.

Wet sponge testing is only permissible on coatings that will be subject to atmospheric corrosion service. High voltage spark testing is mandatory for linings as well as coatings for buried and / or immersed structures. The spark test voltages shall be determined in accordance with Section 8.4.2 (HOLIDAY INSPECTION).

For films not exceeding 500 µm thickness, low-voltage wet sponge electrical insulation defects inspection shall be carried out in accordance with Section 8.4.2.1 (Test Method A (Wet Sponge) for coatings. The inspection procedure shall ensure that sufficient moisture is present at all times.

14.3.4. FILM THICKNESS

(a) Measurements shall be taken in accordance with SANS ISO 2808 unless the frequency of readings is specified in the project specification.

(b) 100 percent of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(c) Film thickness in excess of the prescribed maxima shall not necessarily constitute reason for rejection if the coating is demonstrated to be sound in all respects.

(d) The method used to measure film thickness, and the significance of the readings for each particular project shall be agreed upon by all parties prior to commencement of the work.

(e) Should the standard deviation and mean thickness reading indicate that there may be areas of coatings thinner than specified, then additional testing is necessary.

(f) The method used to measure DFT, and the significance of the readings for each particular project, shall be agreed upon by all parties prior to commencement of the work.

14.3.5. DEGREE OF CURE OF FUSION-BONDED MATERIALS

The degree of cure of fusion-bonded material shall be assessed by solvent wiping in accordance with the method given in Section 8.4.4.1 (Methyl Ethyl Ketone Resistance).

14.4. DAMAGED COATINGS

(a) All repairs and procedures shall be approved by the Corrosion Engineer and subject to inspection procedures as set out in Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES).

Where the damage is extensive the remedial procedures shall be agreed in writing with the Corrosion Engineer.

(b) All repairs shall comply with the requirements of the repair-product manufacturer's data sheet. The Engineer may at his discretion request that repaired coating areas undergo adhesion tests.

(c) Any damage occurring during transit from the Contractor's premises to site, shall be the responsibility of the Contractor. The Contractor responsible for installation of equipment on site shall repair any damage occurring on site during handling, assembly, storage, transport and erection.

(d) The repaired area shall be tested in accordance with Sections 8.3.3 (Methyl Ethyl Ketone Resistance), 8.4.4.1 (Methyl Ethyl Ketone Resistance), 8.4.2 (HOLIDAY INSPECTION) for compliance with the relevant requirements for thickness, full cure and electrical insulation defects respectively.

(e) Any item showing electrical insulation defects exceeding an average of five per square metre (a cluster of pinholes within a radius of 25 mm being regarded as a single defective area), or flaking or other signs of loss of adhesion, shall be repaired by blast cleaning and re-coating in accordance with the relevant requirements of the specification.

14.4.1. REPAIR METHODS FOR MINOR DEFECTS

The repair of areas showing electrical insulation defects or low film thickness shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with a minimum roughness grade 100 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with Section 7.2.7.5 (Residual Dust And Debris).

(d) Wipe the abraded paint surface with methyl ethyl ketone and allow to dry.

(e) Apply as many coats of the following repair material as necessary to achieve the specified thickness and finish:

(i) Solvent-free epoxy, or
(ii) Preheat the item to the required temperature (ensuring that the existing material is not damaged) and repair with the original powder material.

NOTE: Apply a final topcoat over the repaired area to achieve a uniform finish to the item.

14.4.2. REPAIR METHODS FOR MAJOR DEFECTS

The total un-coated areas for renovation by the applicator shall not exceed 0,5 percent of the total surface area of a component. Each un-coated area for renovation shall not exceed 2 500 mm². If damaged areas are larger, the items containing such areas shall be re-coated.
The repair of areas showing damage down to the steel surface shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).

(b) Blast-clean all damaged areas to Sa 3 (SANS 8501-1).

(c) Feather the surrounding paint for a distance of 50 mm beyond the damaged areas with a minimum roughness grade 100 abrasive paper.

(d) Vacuum-clean the surface to remove dust and debris in accordance with SANS 8502-3 and Section 7.2.7.5 (Residual Dust And Debris).

(e) Wipe only the abraded paint surface with methyl ethyl ketone and allow to dry.

(f) Apply as many coats of the following repair material as necessary to achieve the specified thickness and finish.

  (i) Solvent-free epoxy, or
  (ii) Preheat the item to the required temperature (ensuring that the existing material is not damaged) and repair with the original powder material.

NOTE: Apply a final topcoat over the repaired area to achieve a uniform finish of the item.

14.5. REFURBISHMENT OF AGED OR DEGRADED FUSION BONDED EPOXY COATING SYSTEM

The repair methods depend on the type of damage and are very similar to the repair methods for newly applied fusion bonded epoxy. For more information refer to Sections 14.4.1 (REPAIR METHODS FOR MINOR DEFECTS) and 14.4.2 (REPAIR METHODS FOR MAJOR DEFECTS).

14.6. OTHER FUSION BONDED COATING SYSTEMS

Other fusion bonded systems that may be used are as follows:

Polyester powder coating is often used where superior UV resistance and scratch resistance, compared to epoxy powder coating, is required.

Polyester powder coating is applied and tested in a similar manner to epoxy powder coating.

Fluoro-polymer powder coating is generally known as the PTFE type materials of which the most well-known brand names are Hylar and Teflon. They have exceptionally good immersed chemical resistance and very low co-efficient of friction.

Plastic materials such as HDPE and MDPE can also be applied with electrostatic powder coating.

All of the above types of other powder coatings must be applied to grit blasted surfaces with steel preparation as specified in this document. The patch repairs for PTFE type materials and for other plastics is by plastic welding.

14.7. REFURBISHMENT OF AGED OR DEGRADED OTHER FUSION BONDED COATING SYSTEMS

The repair methods depend on the type of damage and for polyester powder coating are very similar to the repair methods for newly applied fusion bonded epoxy. For more information refer to Sections 14.4.1(REPAIR METHODS FOR MINOR DEFECTS) and 14.4.2 (REPAIR METHODS FOR MAJOR DEFECTS).

For repair and refurbishment other powder coatings must be applied to grit blasted surfaces with

preparation of steel as specified in this document.

The refurbishment of other powder coating type materials shall be as per the manufacturers data sheets and procedures.

The patch repairs for PTFE type materials and for other powder coated plastics is by plastic welding.

15. POLYMER MODIFIED BITUMEN COATING SYSTEM

This specification relates to factory applied pipe coating operations based on hot applied polymer modified bitumen.

STANDARDS

This Section of the Standard makes reference to the documents listed below. Unless otherwise specified the latest editions of these documents, including all addenda and revisions, shall apply.

British Standards

BS	410	Specification for test sieves.
BS	1796	Methods using test sieves of woven wire cloth and perforated metal plate.
BS	2000	Methods of test for petroleum and its products.
BS	3900	Methods of test for paints:
		Part A 6 (replaced by EN 535) – Determination of flow time of paints.
		Part B 2 (replaced by ISO/DR 1515) – Determination of volatile matter and non-volatile matter.
BS EN	10300	Steel tubes and fittings for onshore and offshore pipelines – Bituminous hot applied materials for external coating.

South African National Standards

SANS	1178	The production of coated steel pipe using fibre reinforced bituminous material.

American Standard

ASTM	D113-86	Ductility of bituminous materials.
ANSII AWWA	C203-91	Coal-tar Protective Coatings and linings for steel water pipelines – enamel and tape-hot applied.

15.1. MATERIALS

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warranted by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture

- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

15.1.1. PRIMER

The primer shall be of synthetic composition, designed to be used with specific polymer modified bitumen. The drying rate of the primer shall be suited to the application conditions. The primer shall be supplied in new sealed steel drums.

The primer shall have the characteristics shown in the table below. In addition, when stored in original sealed containers at ambient temperature, the primer shall retain the properties as set out in the table below for not less than 6 months from the date of delivery.

CHARACTERISTICS OF PRIMER

Characteristic	Requirements	Method of Test
Viscosity at 23°C	35-60 seconds	Flow cup No 4
		BS 3900: Part A6 = EN 535
Volatile matter	75	BS3900: Part B2 = ISO/DR
	(max. % loss by mass)	1515 (1050C for 3 hours)

15.1.2. POLYMER MODIFIED BITUMEN

15.1.2.1. COMPOSITION:

The polymer modified bitumen shall consist of a uniform mixture of the following:

- A formulated blend of polymer modified bitumen, as specified in (15.1.2.3) and (15.1.2.4).
- A proportion of approved filler (limestone or asbestos shall not be used).
- Characteristics of the filler shall be as specified in (15.1.2.2)

15.1.2.2. FILLER GRADING:

- Method of test to BS 1796 modified to use the metric sieves specified in BS 410.
- Passing 90 microns – not less than 93%.
- Passing 250 microns – not less than 99%.

15.1.2.3. CHARACTERISTICS OF THE POLYMER MODIFIED BITUMEN:

The material shall conform to the requirements given in the table below when tested in accordance with the methods specified.

15.1.2.4. PERFORMANCE TESTS OF THE POLYMER MODIFIED BITUMEN SYSTEM:

The polymer modified bitumen shall be thermoplastic and shall conform to the performance requirements.

The polymer modified bitumen containing mineral filler with the characteristics detailed above shall pass the performance test specified in the table below:

CHARACTERISTICS AND PERFORMANCE TEST FOR POLYMER MODIFIED BITUMEN

Properties	Method	Unit	Requirements
Softening Point	ASTM D36	°C	115-130
Penetration @ 25°C	ASTM D5	1/10mm	15-30
Density @ 25°C	BS 4147	g/cm³	1,1-1,4
Viscosity @ 170°C	Brookfield	Cp	7000-12000
Viscosity @ 190°C	Brookfield	Cp	3000-6000
Filler Content	BS 4147	%	20-30
Impact @ -10°C	BS 4147	mm²	Max. 6500
Peel Initial / Delayed	BS 4147	mm	Max:
@ 25°C			3,0/3,0
@ 40°C			3,0/3,0
@ 50°C			3,0/3,0
@ 60°C			3,0/3,0
Sag @ 80°C	BS 4147	mm	Max. 1,5
Aging Test @ 190°C	Phoenix	hours	Min. 72
Bend	BS 4147	mm	Min. 15

NOTES:

- The test plates shall be cleaned by abrasive blasting to grade Sa 3 of SANS 8501-1 and with a profile of 50 – 70 microns (SANS Method 772). They shall be coated with primer at a rate of 100g per m2.
- For the impact test a plate 12, 7 mm thick shall be used and a single impact made in each quarter of the plate. The average of the four areas disbanded shall not exceed the permitted value shown above.
- The peel test at 25ºC is equivalent to / replaces the preliminary adhesion test in the original Specification.

- Outerwrap

The outerwrap consists of a combination of polyester and glass fibres to ensure the required strength and elasticity. This is combined with a glass fabric of uniform quality and amount to control the best application and the required amount of bleed through, in order for the outerwrap to provide maximum protection.

The outerwrap shall be impregnated with the polymer modified bitumen compatible material to fulfil the characteristics shown in the table below:

CHARACTERISTICS OF OUTERWRAP SATURANT

Characteristic	Requirement	Method of Test
Softening Point	Min 100°C	BS 2000
Penetration @ 25°C	60-85 1/10 mm	BS 2000
Saturant	Polymer Modified Bitumen	

- The characteristics of the outerwrap shall comply with the requirements of the table below and shall be determined in accordance with the test procedure.

PHYSICAL CHARACTERISTICS OF OUTERWRAP

Characteristic	Type A	Type B	Method of Test
Minimum Thickness (mm)	0,6	0,6	AWWA C203-91
Weight (g) per m²	500 – 700	500 – 700	AWWA C203-91
Tensile strength (N/50 mm)			
Longitudinal	>800	>400	AWWA C203-91
Transverse	>800	>200	AWWA C203-91

15.2. APPLICATION

15.2.1. CARE OF WRAPPING MATERIALS

All wrapping materials consigned to the coating yard or factory shall be properly stored to prevent damage or deterioration.

15.2.2. CARE OF PIPE

Throughout the wrapping process pipe and coating materials shall be kept clean and away from all foreign matter.

15.2.3. MARKING

Any pipe manufacturer's identifying marks shall be removed before the start of the wrapping process and shall be permanently marked on the side of each pipe at both ends with a weatherproof paint. Metallic dye stamping shall only be permitted using approved stamps and only on the pipe bevel.

15.2.4. SURFACE PREPARATION

The pipes shall be degreased, and blast cleaned in accordance with Chapters 10 (COMPARATIVE EVALUATION CRITERIA FOR MATERIAL SELECTION) and 11 (**REHABILITATION)** to grade Sa 3 of ISO 8501-1

15.2.5. PRIMING

(a) Following blast cleaning and within 4 hours, the pipe exterior shall be coated with the primer applied at a controlled rate to the manufacturer's recommendations. Pipes shall be coated within 24 hours of being primed.

(b) The primer shall be applied to a dry, clean and dust free pipe and thereafter the primed pipe shall be kept free from moisture, dust or any other contaminant. The primed pipe shall be uniform and free from runs, drips, flooded or bare areas. Particular care shall be taken to ensure complete coverage of weld areas.

(c) The primer should be applied to a pipe having a temperature of at least 15°C and 3°C above the dew point. The optimum substrate temperature is between 30 and 50°C.

(d) The Corrosion Engineer shall see that adequate measures are put in place for working under South African winter conditions where temperatures can be freezing conditions. Example induction pipe heaters to warm the steel surface.

(e) Deteriorated or contaminated primer shall not be applied to the pipe. Primer that has deteriorated or become contaminated after its application shall be removed to the satisfaction of the Employer or his representative, at the Contractor's expense. The cleaned area shall then be re-primed.

15.2.6. EXTERNAL COATING AND WRAPPING APPLICATION

(a) The pipe, after priming and when the primer is no longer tacky, shall be passed through coating facilities of a type approved by the coating supplier. The machine shall coat the pipe weld (longitudinal or spiral) with a 50 mm wide strip of extruded polymer modified bitumen and thereafter the entire pipe with an extruded coating of polymer modified bitumen and shall simultaneously apply the outerwrap.

(b) All primed surfaces shall be clean and dust free immediately prior to coating.

(c) The coating (including outerwrap) shall have an average thickness of not less than 5.5 mm, with an absolute minimum thickness of 5 mm. The coating shall be reinforced by a spirally wound layer of outer-wrap pulled into the polymer modified bitumen with an overlap of 20 mm, such that the outer-wrap is wetted by the polymer modified bitumen. Particular attention shall be paid to the location of the reinforcement and thickness of the wrapping over the weld. The average thickness shall be determined in the following manner: At least four thickness measurements at approximately the pipe quarter points per lineal metre of pipe length shall be taken. At least 25% of the measurements shall be taken at the weld bead. The average thickness shall be the arithmetic average of all measurements.

(d) The completed coating shall be well bonded to the pipe metal: uniform, smooth and free from holidays, laminations, voids or other defects.

(e) The wrapping shall be carefully trimmed off 100 mm from the ends of each pipe and bevelled throughout its thickness over a minimum length of ±5 mm, unless otherwise specified by the Employer or his representative.

(f) Solar protection paint shall be applied to the coated pipe while the coating is still warm. It shall be white in colour, water resistant, continuous and shall cover the wrapping sufficiently to form an effective barrier to solar radiation. The solar protection shall be terminated approximately 100 mm from each end of the wrapping (i.e. 200 mm from each end of the pipe).

15.2.7. INSPECTION AND TESTING

The Contractor shall be responsible for and shall bear the cost of a system of inspection and repair of the wrapped pipe approved by the Engineer. The system shall meet all relevant requirements in this Section and in addition the following requirements:

(a) Monitoring of grit size and the finish of blast cleaned pipe.

(b) Viscosity measurement and control of film thickness of external primer at least once for every batch of primer, in addition to visual checks of the applied prime coating.

(c) Adequate temperature control, the polymer modified bitumen at the application head. In order to ensure that the polymer modified bitumen applied to the pipe has the characteristics specified in samples of the polymer modified bitumen shall then be taken from the application head and subjected to the following test and frequently of testing shown in the table below.

(d) Visual and non-destructive tests on each coated pipe shall be carried out in accordance with Section 6.3 of SANS 1178.

(e) Test of bond strength and thickness of the wrapping including removal of samples of the wrapping for inspection.

(f) Adequate and proper repair of any defects to ensure compliance with this specification. A need to repair more than 1 defect per m2 of pipe coating shall be sufficient grounds to reject the pipe and cause the Contractor to adjust his process to reduce the number of defects to an acceptable level.

Any necessary repairs of tested pipes shall be carried out by the Contractor at no additional cost to the Employer.

One pipe from every day's production shall be held back for examination on the following day. This examination shall include bond testing, thickness testing and examination for laminations, voids or any other defects.

If, in the opinion of the Engineer, there is a signification number of a defect on the test pipe, then a back-check procedure will be invoked. This will involve checking the ten pipes immediately preceding and the ten pipes immediately following the faulty test pipe (the pipe numbers shall be available from the final inspection). These twenty pipes shall be subjected to an examination similar to that carried out on the test pipe. Should the number of defects detected be, in the opinion of the Engineer, significant, then the entire production for that week shall be quarantined and jointly investigated by the Contractor and the Engineer.

Should tests in any production batch show a defect rate of more than 10%, the Engineer may reject the whole batch. In such cases the Contractor shall conduct an investigation to establish the cause of the defects.

IN PLANT TESTING

Test	Frequency of Testing
Softening Point	Twice per working shift
Penetration at 25°C	Twice per working shift
Bond test for coated pipes	One pipe per working shift

These tests should be conducted at the coating plant by the Contractor and monitored by the Approved Inspection Authority (AIA), who would be trained in the procedures by the coating material supplier.

At least once during the contract or when the method of surface preparation is changed, a sample wrapped pipe shall be tested for resistance to cathodic disbonding.

When tested, the wrapping shall not be disbonded from the pre-damaged area by more than a 5 mm radius after exposure for 28 days at the specified potential, i.e. -1500 mV (BS 3900: F1 1).

The inspection activities shall be coordinated with the Contractor's operations so as to delay or interfere with the operations as little as possible. The Contractor's methods shall, nevertheless, always permit inspection to be made and allow adequate repair of imperfections.

Prior to despatch from his plant, the Contractor shall ensure that the wrapped pipe is correctly marked on the internal painted surface of the pipe at each end with approved paint, with sufficient information to enable subsequent identification of the pipe to be made. Documentation shall be supplied to the Engineer to enable the history of the processing of each pipe to be traced.

15.3. METHODS OF TESTING

15.3.1. TESTING OF WRAP CHARACTERISTICS

15.3.1.1. GENERAL

The procedures given below are reference methods of test, which shall be used to establish conformity to the specification in cases of dispute. Other similar methods, such as those detailed in SANS 1178, may be used by manufacturers for routine quality control purposes with the Approval of the Engineer.

15.3.1.2. THICKNESS

The thickness shall be determined by means of a suitable instrument fitted with a micrometre dial gauge, a cylindrical brass block 57 mm in diameter and giving a nominal loading of 3,45kN/m² and a surface plate.

The thickness shall be measured by interposing the outer wrap between the cylinder and the surface plate. Measurements shall be made by marking 75 mm square across the effective width of the mat and making a measurement within each square. No single reading across the width of the mat shall be less than the specified minimum thickness.

15.3.1.3. WEIGHT PER SQUARE METRE

The weight per square metre shall be determined by cutting representative samples from the effective width of the outer wrap. The samples shall be of such a size, that the weight per square metre may be determined to an accuracy of ±2%.

15.3.1.4. TENSILE STRENGTH

The tensile strength shall be measured with approved equipment. The size of the samples cut from the roll shall be 520 mm long and shall have the required width.

When mounted in the equipment, the distance between the jaws shall be 320 mm. The constant rate of separation of the jaws shall be in the range of 100 mm to 610 mm/minute and the tensile strength at breaking point shall be determined. For reference purposes the rate of separation of the jaws shall be 200 mm/minute. At least four samples shall be tested, and an average figure obtained.

The test may be carried out on narrower samples if required, provided that at least two of the reinforcing strands are included in the specimen. Sealing of the ends is recommended.

The value for tensile strength obtained from a narrower sample shall be extrapolated to 150 mm width.

15.3.2. BOND TEST FOR COATED PIPES

(a) Measure the temperature of the coating with a surface thermometer.

(b) If the temperature of the coating is not between 10^{o}C and 25^{o}C, cool or warm the pipe in the test area to bring the temperature within this range.

(c) Using a knife, heated if necessary, make two parallel cuts, through the coating down to the pipe surface. The cuts shall be 100 mm long and 30 mm apart.

(d) With a stiff flat blade, loosen the coating the full width between the two cuts and lift the wrap upward in a direction at right angles to the pipe surface.

(e) The bond shall be considered satisfactory if the coating does not peel cleanly from the primer or the pipe surface but is removed with difficulty.

(f) This bond test should be carried out at the start of each shift or change in production and thereafter at a frequency approved by the Engineer.

15.4. HANDLING

At all times the pipe, unwrapped as well as wrapped, shall be handled with the aid of slings, lifting yokes and protected hooks to the Approval of the Engineer.

At all times the coated pipe shall be handled and stacked in such a manner as to prevent damage to the coating. Particular care shall be taken immediately after coating to avoid damage while the enamel is above ambient temperature. No stacking or loading shall be undertaken until the coating has cooled sufficiently to avoid marking.

The coated pipe shall be stored at all times clear of the ground and in such a way that either water or mud cannot accumulate on the inside or outside of the pipe. Storage shall be affected by the use of wooden bearers, suitably covered, or mounds of gravel-free sand, covered with polyethylene sheets.

The pipe shall only be stacked to a height such that no flattening of the wrapping occurs.

The pipes shall be separated from each other with approved polyethylene covered pads.

15.5. REPAIRS

Although the polymer modified bitumen has excellent self-healing properties, damage caused by transportation or laying of the coated pipe may occur. This shall be repaired using torch-on membrane.

Damage shall be repaired by removing the existing coating to at least 10 mm beyond the area of damage. The repair area shall then be cleaned of all deleterious matter to 100 mm beyond the proposed repair area. Exposed metal shall be re-primed in accordance with this specification. The repair patch, which shall lap at least 50 mm onto sound coating, shall be applied by gently heating with a gas torch and applying it to the pipe in a manner, which prevents the entrapment of air bubbles. All air bubbles shall be removed using a wooden roller or by other means and the perimeter of the repair patch shall be neatly finished off. The patched area shall then be holiday tested in accordance with the specification.

15.6. FIELD JOINT COATINGS

Remove the whitewash for a distance of 150mm from the edge of the factory applied coating. Ensure the end of the factory coating is firmly adhered. Cut back any areas of loose or damaged coating to 10mm beyond the area of damage. Ensure the edge of the factory applied coating is bevelled at 30° or less.

Prepare the exposed steel surface of the joint in accordance with Chapters 10 (COMPARATIVE EVALUATION CRITERIA FOR MATERIAL SELECTION) and 11 (**REHABILITATION**) and apply the bitumen primer.

Using hot air or gas torches, apply the custom sized rolls of membrane material to achieve the same minimum thickness as the factory applied coating. The membrane shall overlap onto the factory coating by a minimum of 100mm.

Ensure a liquid bead of coating is maintained in contact with the steel at all times to prevent air entrapment. The perimeter of the field joint shall be neatly finished off and blended into the factory coating.

The finished joint shall be free of air bubbles and shall exhibit the same bond to steel as the factory coated pipe.

The finished joint shall be holiday tested at 15kV and any holidays repaired in accordance with Section 8.4.2.2 (Test Method B (High Voltage)).

16. BITUMEN TAPE WRAPPING SYSTEM (Torch on)

Torch on Bitumen Tape Wrapping Systems are generally used for Field Joint Repairs.

This specification does not allow for use of cold applied bitumen tape wrap.

Refer Field Joint Coating in Section 9.6 (FIELD JOINT CORROSION PROTECTION) and Section 9.7 (CORROSION PROTECTION OF DIFFERENT JOINT SYSTEMS).

16.1. General

The torch on bitumen tape wrapping should not be used as a mainline coating. Steel pipes, fittings, and specials, protected by means of bitumen tape, shall be wrapped in accordance with SANS 10129 as amended and extended by this Specification.

This method statement will cover the proper application and installation of the Bitumen Tape Wrapping System for the external protection of welded field joints.

The joint coating system will be applied in accordance with the manufacturer's specification. The size of the coating systems to be used shall be in accordance with the manufacturer's specification.

The pipeline contractor responsible for the application of the coating system will furnish all equipment and properly trained and supervised labour and service required for the specified application of the coating system. All equipment and tools required for the application of the coating system will be subject to the Approval of the end-user company. The pipeline contractor will follow the manufacturer's application specifications and work in harmony with representatives of manufacturer's and the end-user to alleviate any difficulties during the application and installation.

The contractor will be responsible for verifying the integrity of the coated field joint. Damaged coating will be repaired at the contractor's expense. The pipeline contractor will supply all repair material.

The manufacturer will supply a Technical Representative to assist or instruct the contractor and/or the end-user coating inspector with the proper application of the coating system.

The Manufacturer's Technical Representative will have the authority, through the end-user representative, to suspend the application of the coating system, until such time as the application satisfies manufacturer's application and quality control standards for the coating system.

Inspection of coated Field Joint will be performed by qualified coating inspectors appointed by the end-user. The coating system will be applied by manufacturer's certified trained personnel in the application of the joint coating system and meet the Approval of the manufacturer.

16.2. Material Storage

All coating material will be stored, handled and transported in such a manner as to prevent damage to individual carton containers. Cartons, tape rolls or individual repair rolls removed from the storage pallets will not be dropped, rolled, or thrown in any manner as to damage the coating material.

Cartons or tape rolls will not be handled with hooks, ropes, cables or any other mechanical devices that could damage the coating materials.

The coating material will be stored and/or transported in a dry, ventilated location. Storage temperature will be a minimum of 10°C and not exceed 60°C.

Coating materials that have been damaged or show signs of deterioration will be inspected by representatives of manufacturer and at the discretion of the end-user, be rejected.

Primer will be stored in accordance with regulations that govern hazardous material storage. Primer

inventory will rotate on a first in - first out basis. Primer containers will be marked with receiving dates.

Coating system waste material, primer containers, stub rolls, empty cartons, release liners, separator papers and related waste materials WILL NOT be discarded along the pipeline right-of-way or in the pipeline trench.

All cartons and rolls are marked with batch numbers, these batch numbers must be recorded by the applicator, each field joint that is wrapped must have the batch number of the Bitumen Tape Wrapping System and Primer recorded to the Tee number for easy reference.

16.3. Surface Preparation

The surface preparation requirements of SANS 10129 shall not be applicable in terms of this specification and shall be superseded by Chapter 7 (SURFACE PREPARATION) of this specification which are considerably more stringent and comprehensive. For the avoidance of doubt, surface preparation will be by abrasive grit blasting.

Factory applied mainline coating systems should be bevelled at the cut back area with a power wire brush. Abraded coating will be removed from the cut back area.

The bare Field Joint Surface shall be grit blasted and in terms of this specification wire brushing is not accepted.

16.3.1. SURFACE PREPARATION FOR EMERGENCY REPAIRS

For emergency repair work where blast cleaning is not possible, the surface preparation shall be to minimum standard of St2 wire brushing as specified by SANS 8501.

Wire brushing shall only be acceptable with the written permission of the Corrosion Engineer.

St2: Hand Tool Cleaning
Removal of all rust scale, mill scale, loose rust and loose paint to the degree specified by hand wire brushing, hand sanding, hand scraping, hand chipping or other hand impact tools or by a combination of these methods. The substrate should have a faint metallic sheen and also be free of oil, grease, dust, soil, salts and other contaminants.

16.4. Primer Application

The Field Joint will be primed with a Primer.

The primer is applied to the pipe steel surface with a brush or paint roller to a wet thickness of no less than 75 microns and no greater than 100 microns. The primer will be thoroughly mixed prior to application on pipe. Primer container will remain covered when not in use. Primer coverage should be 6m²/lt.

The primer will cover the entire exposed steel surface including the raised circumferential weld bead and overlap onto the mill applied primary coating system by a minimum of 200mm.

The primer shall be dry (20min @ 23°C) to "tacky to touch" prior to the application of the joint wraps.

The primer may not be diluted. Primer cans must remain covered when not in use to avoid solvent evaporation and contamination.

16.5. Butyl Putty Application

All sharp angles are to be filled with the Butyl Putty to form a “fillet” care must be taken to ensure that there is no air entrapment and that the Butyl Putty is packed firmly into the angles.

16.6. Bitumen Tape Application

a) Pre-cut Strips

The strip is applied circumferentially in a cigarette wrap fashion across the whole width of the joint and a minimum distance of 50mm onto the shop applied coating either side of the joint.

Where more than one strip is required, overlaps should be a minimum of 100mm and the joints should face downwards, weatherboard fashion. Commencing at the lowest point, peel back the release interleaving and gently heat the face of the section by means of a butane/propane gas torch, until the surface has a glossy appearance, 100-125˚C (Do not overheat or allow to run or drip). Press the heated section firmly into place with gloved hands, ensuring intimate contact with the substrates and the elimination of entrapped air, and fuse in an upward direction. Distribute the gas flame evenly between the tape and the pipe surface. Continue in this manner until the whole of the joint has been covered. After completion of the joint, the side seams and end laps should be consolidated by tooling with a hot, round nosed trowel. These overlaps should be consistent around the entire pipe circumference.

NB: To achieve a neat, even appearance the whole exterior of the completed joint can be lightly brushed with a low torch flame.

b) Pre-Sized Rolls proceed exactly as in (a) but commence the application 100mm beyond the centre line on top of the pipe. Continue around the full circumference of the pipe ending 200mm beyond the starting point. This will provide the benefit of a reinforced crown.

c) If the sealed joint is to remain exposed for any prolonged length of time, it is advisable to protect them by applying one or two coats of a suitable acrylic or an aluminium coating.

16.7. Safety Data

Storage:	Ambient conditions. Use Class 3 dangerous goods storage for the primer. Store away from direct sunlight.
Transport:	Avoid prolonged exposure to high temperatures during transit, preferably in an enclosed vehicle.
Handling:	This material is not a static accumulator. It is still advisable to use proper bonding and/or grounding procedures. The bitumen primers are flammable liquids, please refer to safety data sheet for further details
Action in case of fire:	Extinguish with water fog, dry powder, carbon dioxide or chemical foam. Self-contained breathing apparatus required.
Protective Clothing:	Eye Protection, Hearing Protection, Dust Masks, Gloves.
Skin Contact:	Wash with warm water and mild soap. Pumiced heavy duty hand cleaner for stubborn stains.
Swallowing:	If feeling unwell, seek medical advice
Inhalation:	In a fire situation avoid inhaling fumes. Negligible hazard at ambient temperatures (-18°C to 38°C)
Spillage:	Bitumen tapes are generally not hazardous. Pick up and collect material by hand.
Disposal:	Incineration or landfill in accordance with local regulations.

17. PLASTIC TAPE WRAPPING SYSTEM

STANDARDS

Reference is made to the latest issues of the following Standard Specifications:

SANS	1117	Plastic wrappings for the protection of steel pipelines.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
SANS	9000	Model for quality assurance in production and installation.
SANS	10129	Plastics tape wrapping of steel pipelines.
SANS	12068	Cathodic protection – External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathode protection – Tapes and shrinkable materials.

17.1. GENERAL

Plastic tape wrapping is not recommended be used as a mainline coating on longitudinal or spiral SAW pipe, due to the risk of spiral corrosion from the triangular shape void (tenting) that arises under the tape at the overlap. The corrosive environment has significant bearing on the risk of future corrosion failures that can arise from using this system.

Note: max weld bead height (0mm) to be as per Section 6.2.4.4 (Weld Finish)
Plastic tape wrapping shall only be applied to mainline pipe by machine.
Hand wrapping may be used for field joints and specials.
Pipes must be sand padded. Bedding and backfill must be fine grained sand with a maximum particle size of minimum 80% less than 0,425mm and 100% less than 1,5mm.

Steel fittings and specials, protected by means of polyethylene pressure-sensitive or polyethylene laminated to an elastomeric layer of butyl rubber tapes, shall be wrapped in accordance with SANS 10129 as amended and extended by this Specification. All pipes shall be wrapped outside the trench in accordance with acceptable factory applications.

This plastic tape wrapping system shall not be used when subject to wet soil conditions such as a marsh, or river crossing, or in the vicinity of high electrical fields, close to a railway line, or overhead electrical power lines. Furthermore, it may not be used in clay soils or any soils deemed to be corrosive.

If in the opinion of the Corrosion Engineer adverse weather conditions are such as to interfere with the successful application of an efficient corrosion protective wrapping, he shall order a stoppage of work. It shall be regarded that the Contractor has accepted this risk and made provision for it in his tender.

The production and application of the tapes shall be controlled by SANS 9000, Quality System.

17.2. MATERIAL

Tapes shall conform to SANS 1117 for polyethylene (PE) and polyvinylchloride (PVC) and EN 12068 for all other types of tapes.

A plastic tape wrapping system may not be exposed to direct UV light for more than seven days.

17.3. APPLICATION

17.3.1. SURFACE PREPARATION

The surface preparation requirements of SANS 10129 shall not be applicable in terms of this specification and shall be superseded by Chapter 7 (SURFACE PREPARATION) of this specification which are considerably more stringent and comprehensive. For the avoidance of doubt, surface preparation will be by abrasive grit blasting.

If blast cleaning is not possible, wire brushing shall only be acceptable with the written permission of the Corrosion Engineer.

17.3.2. PRIMING

Primer shall be a fast-drying compound, compatible with the laminated tape suitably compound to produce a liquid coating material that can be readily applied cold by brushing or spraying to produce an effective bond between the bare pipe surface and the subsequent coat of laminated tape. It shall be free flowing at the application temperature ranges and have the ability to cover voids, pits, and welds, and shall be resistive to fungi bacteria.

The physical properties of primer shall be that the adhesion to pipe and tape are inseparable.

After surface preparation in accordance with Chapter 7 (SURFACE PREPARATION), the primer shall be applied provided pipe surfaces are kept dry and free from dust. Drying time of primer is a minimum of 15 minutes at 25°C and a maximum of 8 hours irrespective of environmental conditions. Shall be applied according to sub-clause 4.2.1 of SANS 10129

17.3.3. WRAPPING

The protective wrapping shall consist of a coating system employing primer, laminated inner tape wrap and outer wrap.

The laminated inner tape wrap shall be butyl backed on polyvinyl chloride plastic tape.

The outer tape wrap shall be a second layer of polyvinyl chloride plastic tape complete with adhesive backing. For normal application, this specification calls for a minimum of 2 layers of wrap and for rocky ground there shall be a third layer of wrap as armouring.

Tape wrapping shall be applied with sufficient pre-tensioning after priming within the above specified period in accordance with sub-clause 4.2.2 of SANS 10129, and shall ensure a smooth wrap free from wrinkles, blisters, frayed or torn edges, cracks or other defects even at temperatures up to 65°C. For normal wrap, tape shall be applied in two layers with a minimum overlap of 50% on both the inner and outer wraps.

Tape joints and repairs shall be done in accordance with sub-clause 4.2.3 of SANS 10129.

Hand wrapping shall only be allowed for short lengths that are inaccessible to a wrapping machine, specials, joints, small diameter pipes and small repairs – refer Section 17.7 (REFURBISHMENT OF AGED OR DEGRADED PLASTIC SYSTEMS).

17.3.4. ARMOURING

Where required the wrapping shall be armoured by the application of a third layer of pressure-sensitive polyethylene or polypropylene tape, with a carrier thickness of 750 micrometres (**µm**) and a minimum overlap of 50%.

Inner wrap shall overlap by half the tape width plus 25 mm and the outer wrap shall overlap by not less than 50 mm.

Armoured wrappings shall generally be applied at the following positions:

(a) road crossings through sleeves and culverts;
(b) for poor soil conditions with stones that may cause mechanical conditions to the tape; and
(c) wherever the Corrosion Engineer may consider that special conditions warrant such measures.

17.3.5. WRAPPING OF SPECIALS

Plastic tape wrapping of bends and specials is not practical and not good corrosion practice. Therefore, the Corrosion Engineer has the responsibility to separately specify the corrosion protection for these items.

The corrosion protection that is specified for bends and specials must be compatible with the mainline plastic wrap system.

Either the special is workshop coated and then installed and then you have to do a field repair or the special is manufactured on site.

In the case of specials or pipe lengths where length and/or shape preclude the application of a protective wrapping system, the protection shall be carried out by other suitable systems as specified by the Corrosion Engineer. As specified in the Field Joint Coating Section. (note; see also 9.6)

In the case of access, scour, air valve and off-take tee's the special shall be deemed to incorporate at least two (2) diameter lengths or one (1) meter minimum either side of the main tee barrel.

Where buried pipes are corrosion protected using a tape wrap system, the specials to be encased in concrete shall be corrosion protected by rigid coating material such as epoxy or rigid polyurethane without tape wrapping. Adjacent to the encased section, the epoxy or rigid polyurethane shall extend for at least 100mm under the tape wrap.

17.4. TOLERANCES

17.4.1. PRESSURE SENSITIVE TAPE WRAPPING

The minimum thickness of the inner medium-density polyethylene or PVC tape carrier component shall be 300 µm and the maximum thickness of the outer high-density tape carrier shall be 1000 µm. Total minimum polyethylene or PVC thickness of 1450 µm.

The adhesive part of the inner layer shall be a minimum thickness of 1.5 times the polyethylene tape carrier thickness. For the outer layer the adhesive layer shall be at least equal to the thickness of the polyethylene or PVC tape carrier thickness.

17.4.2. BUTYL RUBBER LAMINATES

The minimum thickness of the completed wrapping shall be 750 µm. The inner layer shall be a butyl rubber laminate of 450 µm minimum thickness of which the butyl rubber film shall not be less than 200 µm thick and the polyethylene or PVC film shall not be less than 200 µm thick.

The outer layer shall be high density pressure tape of 300 µm minimum thickness.

This product can be supplied in a two or three-layer system.

17.5. TESTING

To be read in conjunction with Section 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES).

17.5.1. VISUAL INSPECTION

The wrapping shall have a smooth appearance, free from wrinkles, blisters, bridging across weld beads, frayed edges, cracks, dis-bonding and any signs of physical damage.

17.5.2. NON-DESTRUCTIVE TESTING

(a) Holiday Testing

The entire wrapping of the pipeline shall be tested with an approved holiday detector equipped with a rolling ring detector around the pipe by the Contractor to the Engineer's satisfaction. The ring shall be in close contact with the surface of the wrapping along the pipe circumference. The test shall be carried out immediately prior to lowering the pipe into the trench. The wrapping on specials or short pipe lengths shall be tested with an approved holiday detector fitted with a copper bristle brush detector of suitable form. The wrapping shall exhibit no holidays when tested in accordance with Section 8.4.2 (HOLIDAY INSPECTION).

The Engineer may instruct any length of pipe or any number of specials to be re-tested using a holiday detector with a copper bristle brush detector.

(b) Coating Insulation Test

The Engineer shall carry out a conductance test on the wrapping over any section of pipeline between valves when the pipeline has been wrapped and installed in the trench with padding and back filling completed. The test shall be conducted with the valves temporarily removed from the line, at the Contractor's expense, to ensure complete isolation of the pipeline section under test or between gaps left for tie-ins.

The length of the section of pipeline under test shall be carefully measured and the conductance over the section tested shall not exceed 180 micro-Siemens per square metre of pipe surface under all conditions of test. If the results of the test for the section of pipeline tested are not satisfactory, two sections immediately adjacent to the testing section will be tested. If the results on one or both of these sections tested are not satisfactory, all sections of wrapped pipeline shall be tested.

17.5.3. DESTRUCTIVE TESTING

The Engineer may from time to time collect samples of 10 metres of each type of tape and one litre of primer for testing, for compliance with the specification, by any independent laboratory appointed by the Engineer. The supply of samples shall be for the Contractor's account. The Engineer reserves the right to reject the whole batch of materials from which unsatisfactory samples were obtained.

17.5.4. REPAIRS

The Contractor shall be required to locate areas of faulty protection on all sections on which unsatisfactory results are obtained and to affect the necessary repairs. The cost of this work and all additional materials provided or supplied, including the reinstatement of the trench and the retest shall be for the Contractor's account.

17.6. REPAIR METHODS

Tape wrapping is done under tension and any damage that reduces the tension in the tape shall be removed and repaired in accordance with large damage areas below.

Where damage to the wrapping on a pipeline has occurred and where there are creases, wrinkles, and folds in the wrapping, proceed as follows:

17.6.1. SMALL DAMAGED AREAS

A small damage area is less than the width of the tape. The width of the tape being used for the repair shall exceed by at least 100 mm the width of the section affected.

The repair procedure is to cut the area of damaged wrapping away to bare metal leaving no raised edges or protrusions. Thereafter, clean and prime the exposed area in accordance with Sections 17.4.1 (PRESSURE SENSITIVE TAPE WRAPPING) and 17.4.2 (BUTYL RUBBER LAMINATES) and apply a patch of tape, ensuring an overlap of not less than 50 mm on all sides onto the surrounding wrap. Thereafter, apply full circumferential hand-wrapping with a minimum of fifty (50) percent over-lap, a further layer of tape commencing two turns before and continuing for two turns beyond the patch.

17.6.2. LARGE DAMAGED AREAS

Where the extent of damaged or faulty wrapping is such that the tape width cannot span the affected area and provide a 50 mm overlap on all sides, the damaged wrapping must be completely removed from the pipe over the affected section. The area must be cleaned and primed in accordance with Sections 17.4.1 (PRESSURE SENSITIVE TAPE WRAPPING) and 17.4.2 (BUTYL RUBBER LAMINATES). The pipe must be re-wrapped with a minimum of fifty (50) percent overlap, commencing two turns before and finishing two turns beyond the bared section.

17.6.3. TIE-IN AND WELD REPAIRS

When the pipe has already been tape wrapped and installed and it is required to retrofit the air valves, off takes, manhole access, it is necessary to take special precautions as follows:

Remove the wrapping 300mm either side of the cut edge of the weld area. The outer wrap shall be removed for a further distance equal to three (3) times the width of the inner wrap tape on each side of the damaged area. The area must be cleaned and primed in accordance with Sections 17.4.1 (PRESSURE SENSITIVE TAPE WRAPPING) and 17.4.2 (BUTYL RUBBER LAMINATES). The pipe must be re-wrapped with a minimum of fifty (50) percent overlap, commencing two turns before and finishing two turns beyond the bared section.

17.6.4. DAMAGE ON DOUBLE WRAP

Where damage or a defect has occurred in a section that has been double wrapped and in the case of small holidays, the outer wrap shall be removed for a distance equal to three (3) times the width of the inner wrap tape on each side of the damaged area.

The appropriate procedure given in Sections 17.6.1 (SMALL DAMAGED AREAS) or 17.6.2 (LARGE DAMAGED AREAS) shall be used to effect the repair of the inner wrap.

The outer wrap shall be re-instated in accordance with Section 17.3.3 (WRAPPING).

17.6.5. OUTER WRAP DAMAGE

Where damage extends through an outer wrap/rockshield (see Section 6 of SANS 10129), this should be carefully removed for a distance equal to three (3) times the width of the inner wrap tape on each side of the damaged area without damaging the inner wrapping.

The repair shall be carried out by the appropriate method given in Sections 17.6.1 (SMALL DAMAGED AREAS) or 17.6.2 (LARGE DAMAGED AREAS) and the outer wrap/rockshield re-instated in accordance with Section 17.3.4 (ARMOURING).

17.7. REFURBISHMENT OF AGED OR DEGRADED PLASTIC SYSTEMS

It is generally not recommended to refurbish aged or degraded plastic tape wrapped systems. It is preferable to remove the aged or degraded system and replace it with a suitable corrosion protection system as recommended by the Corrosion Engineer.

18. PETROLATUM WRAPPING SYSTEM

STANDARDS

Reference is made to the latest issues of the following Standard Specifications:

SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
SANS	9000	Model for quality assurance in production and installation.
SANS	10129	Plastics tape wrapping of steel pipelines.

18.1. GENERAL

The use of petrolatum tape and mastic is only permitted for the wrapping of flanges and couplings used in valve chambers, galleries in dam walls, intake, and discharge tower pipe work as well as buried flanges.

For new works, petrolatum tape and mastic can only be used provided the flanges and couplings are first corrosion protected with the mainline system and then overwrapped with the tape.

Under maintenance conditions, where the conventional grit blasting and the application of liquid protective coatings is impractical, petrolatum tape and mastic may be used in accordance with SANS 10129 as amended and extended by this Specification.

NOTE: Use of petrolatum tape under direct sun and hot conditions is not permitted because it may result in changes of viscosity and draining out of the grease from the bandage. Maximum short-term direct sun exposure is 14 days.

The use of petrolatum tape wrapping of above ground couplings is not allowed.

Bends and T sections shall not be wrapped as part of a new works specification.

Profiling mastic and mastic blankets are used for corrosion protection of couplings and flanges in chambers with high humidity and buried in soil.

If in the opinion of the Corrosion Engineer adverse weather conditions are such as to interfere with the successful application of an efficient corrosion protective wrapping, he shall order a stoppage of work. It shall be regarded that the Contractor has accepted this risk and made provision for it in his tender.

The production and application of the tapes shall be controlled by SANS 9000, Quality System.

18.2. SURFACE PREPARATION

Abrasive blast-clean the joint to remove all rust, scale, old coating, and foreign matter to a cleanliness standard equivalent to Sa 2 (SANS 8501-1). Where abrasive blast-cleaning is not possible, mechanical cleaning to St 2 (SANS 8501-1) shall be done.

Areas subjected to chemical attack, salt spray, fungus or bacteria shall be neutralised, rinsed with clean potable water, and mechanically cleaned before mechanical or abrasive blast-cleaning as specified above.

18.3. PRIMING

Brush priming solution well over the entire joint area, leaving a thin film (at a nominal coverage rate of 0,8 m²/litre). Apply a liberal amount around the bolt threads, narrow cavities, and crevices.

Use paste primer where excessive surface corrosion has occurred to fill pit marks and smooth rough surface areas.

18.4. APPLICATION OF MASTIC AND TAPE

(a) Use profiling mastic and/or strips to fill all voids, crevices and sharp or irregular contours or to smooth out raised weld beads.

(b) Apply mastic tape circumferentially over the area to be coated with a 25 mm overlap on either side of the mastic with a 75 mm end overlap.

(c) Pre-formed petrolatum mastic blanket system (10 mm thick), supported by a coated tape backing, is available to provide a quick and easy method to apply this system.

(d) Eliminate all air pockets, wrinkles, and creases.

18.5. OUTER PROTECTION

18.5.1. BURIED CONDITIONS

On top of the petrolatum tape and profiling mastic apply as the final outer protection two complete turns of the polyethylene sheeting circumferentially, alternatively, 180 microns of PVC tape should be used as a final protective layer. If using the PE sheeting, the ends are to be secured to the pipe barrels with 48 mm wide bands of PVC adhesive tape. This applies to the outside diameter of couplings and bolted joints.

18.5.2. HIGH HUMIDITY CONDITIONS

Areas subjected to high humidity should be over-coated with a synthetic coating mixed with a cementitious filler to give a tough, flexible coating.

The cementitious base coat under wet conditions may be over-coated with water-based Acrylics or over-coated with Epoxies.

Areas subjected to fungus or bacteria growth shall be over-coated with a synthetic coating mixed with a cementitious filler.

NOTE: Detail of application shall be in accordance with the manufacturer's data sheets and approved by the Corrosion Engineer.

18.6. TESTING

18.6.1. VISUAL INSPECTION

The wrapping shall have a smooth appearance, free from wrinkles, blisters, bridging across weld beads, frayed edges, cracks, dis-bonding, and any signs of physical damage.

18.7. REPAIR METHODS

Damaged sections should be removed and repaired/replaced in accordance with Sections 18.2 (SURFACE PREPARATION), 18.3 (PRIMING) and 18.4 (APPLICATION OF MASTIC AND TAPE).

19. THREE LAYER POLYETHYLENE (3LPE) PIPE COATING

ENHANCED SPECIFICATION

19.1. GENERAL

3LPE coating system comprises a layer of fusion bonded epoxy (FBE), overlaid with adhesive, with an outer layer of plastic high-density polyethylene (PE).

The 3LPE coating operation generally comprises the following stages:

- Solvent cleaning followed by steam or hot bath cleaning alternatively mandatory inspections for oil and grease.
- Abrasive blasting.
- Phosphoric acid wash and de-mineralised water rinse.
- Application of fusion bond epoxy (FBE) layer.
- Application of adhesive layer.
- Application of polyethylene layer.

The FBE layer is applied to the steel and provides the majority of the corrosion protection and cathodic disbondment resistance. The adhesive and high-density polyethylene outer layer provide mechanical protection to the FBE and increase the di-electric insulation properties of the system. 3LPE resistance to cathodic disbondment and cathodic over potential improves with increasing system thickness. The Corrosion Engineer shall consult with the Cathodic Protection Specialist before considering 3LPE specifications.

3LPE is to be used for external coating of long straight pipes on a production line only. 3LPE is not suitable for pipes with flanges and external stiffeners. NB. Repairs of damages are challenging.

NOTE: The outer wrap may also be polypropylene (PP) in which case the system is called 3LPP.

This section of the Specification shall be used for the external 3LPE coating of the pipe. The pipeline will be buried and will be protected against external corrosion by external coating and cathodic protection systems. The Corrosion Engineer shall confirm that the external 3LPE coating shall be suitable for the applicable operating conditions.

The outer PE layer is applied by co-extrusion in either a wrapping process or a longitudinal sleeve extrusion process, each with different benefits and risks.

This section of the Particular Specifications defines the minimum technical requirements for a shop applied enhanced three-layer high density polyethylene coating system.

19.2. STANDARDS AND CODES

Coatings shall be applied in accordance with the requirements of this Specification. These requirements are significantly more stringent than the Canadian Standard CSA Z245 20 - 21.

The order of precedence between this specification and industry documents is:

- Project Specifications
- Project Datasheet
- Manufacturer's Specifications
- Standards and Drawings
- Industry Codes and Standards

ISO – INTERNATIONAL ORGANIZATION FOR STANDARDIZATION

ISO 178	Plastics-determination of Flexural properties
ISO 527-2	Plastics - Determination of Tensile Properties Part 2: Test Conditions for Moulding and Extrusion Plastics
ISO 1133	Plastics - Determination of the Melt Mass-Flow Rate (MFR) and the Melt Volume-flow Rate (MVR) of Thermoplastics.
ISO 3061A	Plastics-thermoplastic Materials. Determination of Vicat Softening Temperature.
ISO 11831A	Plastics Methods for Determining the Density of Non- cellular Plastics
ISO 3146	Plastics -- Determination of Melting Behaviour (Melting temperature or melting range) of Semi-crystalline Polymers by Capillary Tube and Polarizing -microscope Methods.
ISO 6964	Determination of Carbon Black content by Calcination and Pyrolysis - Test Method and Basic Specification.
ISO 11420	Method for the Assessment of the Degree of Carbon Black Dispersion in Polyolefin Pipes, Fittings and Compounds
ISO 1514	Paints and varnishes -- Standard panels for testing
ISO 2808	Paints and varnishes – Determination of film thickness
ISO 4624	Paints and varnishes – Pull off test for adhesion
SANS 8503	Preparation of Steel Substrates Before Application of Paints and Related Products - Surface Roughness Characteristics of Blast-Cleaned Steel Substrates Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces. Part 2: Method of grading of surface profile of abrasive blast-cleaned steel- comparator procedure. Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile - Stylus instrument procedure. Part 5: Replica tape method for the determination of surface profile.
ISO 11124-1	Preparation of Steel Substrates Before Application of Paints and Related Products - Specifications for Metallic Blast Cleaning Abrasives – Part 1: General introduction and classification Part 2: Chilled iron grit Part 3: High-carbon cast-steel shot and grit Part 4: Low-carbon cast-steel shot
ISO 21809-1	Petroleum and natural gas industries external coatings for buried or submerged pipelines used in pipeline transportation systems – Part 1: Polyolefin coatings (3-Layer PE and 3-Layer PP)
ISO 21809-2	Petroleum and natural gas industries external coatings for buried or submerged pipelines used in pipeline transportation systems – Part 2: Single layer fusion-bonded epoxy coating
DIN 30670	Polyethylene coatings on steel pipes and fittings – Requirements and testing

19.3. MATERIALS

The required coating shall be a shop applied three-layer high density polyethylene coating system.

The coating system shall comprise a layer of fusion bonded epoxy (FBE), overlaid with adhesive with an outer layer of high-density polyethylene (PE).

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warrantied by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

19.3.1. FBE POWDER

The FBE powder selected shall be suitable for use at the design temperatures in the proposed environment and be suitable for a three-layer polyethylene coating system. The FBE shall be endorsed by the Manufacturer of the adhesive and polyethylene as being compatible with these products under the specified service conditions.

Each FBE batch shall be accompanied by a certificate (BS EN 10204:1991 or equivalent) stating the following tests have been carried out on every batch, and results are in accordance with the Manufacturer's product specifications:

- Gel and cure times
- Moisture content
- Particle size distribution
- Density
- Infrared scan
- Thermal analysis, including glass transition temperature
- Shelf life
- Water Absorption

The proposal for the specific FBE powder shall be accompanied by test data demonstrating its satisfactory performance in a 3LPE pipe coating system.

19.3.2. ADHESIVE

The adhesive(s) selected shall be completely suitable for use at the design temperatures in the proposed environment and be suitable for a 3LPE coating system.

Each adhesive batch shall be accompanied by a certificate (BS EN 10204 or equivalent) stating the following tests have been carried out on every batch, and results are in accordance with the Manufacturer's product specifications:

- Adhesion
- Density
- Melt flow index
- Tensile strength
- Elongation

The proposed PE adhesive shall be accompanied by test data demonstrating equivalent performance in 3LPE coating systems.

19.3.3. POLYETHYLENE

The polyethylene selected shall be of high density, shall contain additives as required to provide ultra-violet protection. The polyethylene shall be completely suitable for use at the design temperatures in the proposed environment. The polyethylene shall be suitable for the three-layer polyethylene coating systems specified herein.

The carbon black requirements for the PE shall as follows:

- Carbon black content: 2 to 2.6% (ISO 6964)
- Carbon black dispersion: ≤3.0 (ISO 11420)

Each polyethylene batch shall be accompanied by a certificate (BS EN 10204 or equivalent) stating the following tests have been carried out on every batch, and results are in accordance with the Manufacturer's product specification:

- Density
- Melt flow index
- Melting point
- Shore hardness
- Tensile strength
- Elongation
- Moisture content
- Carbon black content
- Carbon black dispersion
- Oxidation induction time

Current technical and health & safety data sheets from the proposed Manufacturer of the PE outer layer for the proposed material shall be submitted to the Corrosion Engineer.

19.3.4. SAMPLES FOR RETENTION

Samples of the material to be retained by the contractor. The Contractor shall request, in writing to the Corrosion Engineer, permission to dispose of the samples.

19.4. SURFACE PREPARATION

The surface preparation shall be in accordance with Chapters 6 (MANUFACTURE AND PRE-PREPARATION) and 7 (SURFACE PREPARATION) and in addition:

- The weld bead height shall be in accordance with Section 6.2.4(SHAPE IMPERFECTIONS).
- The weld bead height and contour shall be an inspection hold point.
- Chloride contamination shall not be in excess of 50mg/m^2 (5µg/cm^2) as determined in accordance with SANS 8502-6 and SANS 8502-9 which is a lower level than specified in Section 7.6.29 (WATER SOLUBLE SALT TEST METHODS), but all other requirements of Chapter 7 (SURFACE PREPARATION) shall apply.

Any instrumentation used for determination of surface chloride contamination, shall be calibrated and used in accordance with the Manufacturer's instructions.

The surfaces of the pipes shall be blasted until a finish of Grade Sa 3 to ISO 8501-Part 1 (steel condition A or B) is attained. The surface profile (anchor pattern) shall be 75 ± 25microns measured in accordance with ISO 8503-Part 5. Profile measurements shall be made with Testex Press-O-Film or other approved method suitable for the abrasive being used.

19.4.1. PREPARATION FOR APPLICATION OF COATING

Blasting and other dust producing areas shall be separate from coating application areas.

After cleaning and prior to abrasive blasting-cleaning the pipe lengths shall be uniformly heated to between 60°C and 85°C to remove all moisture, and to preclude any moisture condensation on the pipe after blast cleaning. The heating method employed shall not cause hydrocarbon contamination of the blasted steel surface.

The ends of the pipe shall be fitted with non-metallic plugs to prevent entry of abrasive into the pipe during the blast cleaning operation. Alternatively, the Contractor may link the pipes together to prevent entry of abrasive. If the latter method is used, the Contractor shall submit his procedure to the Corrosion Engineer for review and Approval. In any event all spent grit etc. shall be removed completely from the pipe internals prior to coating application. Pipes with machined weld bevels shall not be linked together at any stage of production, so as to prevent contact of the prepared weld faces.

The total elapsed time between the start of blasting of any pipe and the heating of that pipe to the specified temperature shall not exceed the following time-humidity table.

TIME – HUMIDITY TABLE FOR BLAST CLEANING – HEATING DELAY

Percent Relative Humidity	Elapsed Time (Hours)
85	0.5
80	1.0
70	1.5
60	1.75
50	2.0

Any pipe surface not processed within the above time-humidity table shall be completely re-cleaned and re-blasted before coating.

19.4.2. ACID WASH PRE-TREATMENT

Acid wash pre-treatment for 3LPE pipes substantially improves the resistance to long term cathodic dis-bondment. Acid wash pre-treatment for 3LPE pipes shall be used in addition to grit blasting. The procedure for acid wash pre-treatment shall be proven in the PQT to the satisfaction of the Corrosion Engineer.

Pipe surface pre-treatment shall be performed using a propriety brand of a 10% solution (or as otherwise proven in the PQT) of phosphoric acid wash, e.g., Oakite 31 or 33. This shall be used to remove soluble salts and other soluble contaminants. This process shall be followed immediately by washing with de-mineralised water. (Alternative concentrations may be used subject to verification during the PQT). This process shall be followed immediately by washing with de-mineralised water.

The pipe temperature immediately before the phosphoric acid treatment shall be in the range 45°C to 65°C or as proven appropriate during PQT.

If two abrasive blast cleaning machines are utilised, the phosphoric acid pre-treatment shall be carried out between the two blast cleaning operations. If only a single abrasive blast cleaning unit is used, phosphoric acid treatment shall take place after blast cleaning. Alternatively, and only with Engineer Approval, phosphoric acid treatment may take place before surface preparation.

The pH of the pipe shall be determined both before and after the de-mineralised water wash at a minimum frequency of once per hour.

The measured pH shall be as follows:

- Before the de-mineralised water rinse: pH 1 to 2.
- Following the de-mineralised water rinse: pH 6 to 7.

Data sheets and supporting documentation for the proprietary phosphoric acid system to be used shall be provided. The documentation shall verify that the chemical is suitable for the treatment of pipe before the application of the specific fusion bonded epoxy powder being applied and the final coating will meet the requirements of this specification.

Phosphoric acid pre-treatment may be omitted provided that this pipe has been subjected to high pressure de-mineralised water wash, as part of the pre-cleaning operation prior to abrasive blast-cleaning.

19.5. COATING APPLICATION

19.5.1. GENERAL

The application of the coating shall be in accordance with the material Manufacturer's recommendations and the requirements of this specification in the order of precedence of Section 19.2 (STANDARDS AND CODES).

The Contractor shall perform a coating procedure qualification trial (PQT) prior to commencing production in accordance with Section 19.6.1 (COATING PROCEDURE QUALIFICATION TRIAL (PQT)) of this Specification.

Prior to application of the fusion epoxy powder, the powder application and recovery systems shall be thoroughly cleaned. During coating application no container/ hopper shall contain powder/pellets from more than one batch of material. In addition, the spray booth shall be cleaned of excess powder at the end of each shift.

19.5.2. FBE LAYER

The FBE shall be applied to a minimum thickness of 300 microns in terms of SSPC PA2 restriction level 1 see Section 8.4.3.1 (Method of Measurement). The pipe shall be uniformly preheated in accordance with the FBE Manufacturer's instructions. This temperature shall have been confirmed during PQT. The surface temperature shall be below the melt flow temperature of the adhesive and the polyethylene polypropylene.

The minimum thickness of FBE is one of the required enhancements.

The coating shall be applied by electrostatic spray with the pipe at earth potential and the epoxy powder charged to high potentials.

Pipe temperature shall be checked periodically using a recording pyrometer. The pyrometer shall be checked for error not less than every four hours against a calibrated temperature-measuring instrument according to the procedural requirements of ISO 9002.

Oxidation of the steel prior to coating in the form of 'blueing' or other apparent oxide formation is not acceptable. If such oxidation occurs, the pipe shall be set aside as rejected and unsuitable for use for this project.

The use of recycled powder is permitted only when that powder has been recovered from the powder booth and passed immediately through the adjacent closed system for screening. A maximum 20% closed system recycled powder is permitted in any single gun.

During application, the bevelled ends and pipe bore shall be protected against mechanical damage and from contamination with coating material.

19.5.3. ADHESIVE LAYER

The adhesive shall be applied to a minimum thickness of 200 microns in terms of SSPC PA2 restricted level 1 (see Section 8.4.3.1 (Method of Measurement).

The adhesive layer shall be applied before gel time of the FBE has expired by using either the cross-head or lateral extrusion technique. Application of the adhesive shall not be permitted after the FBE has fully cured. The Contractor shall establish to the satisfaction of the Corrosion Engineer that the adhesive is applied within the gel time window of the FBE and at the temperature recommended by the adhesive Manufacturer. The Supplier shall state the proposed minimum and maximum time interval between FBE and adhesive applications at the proposed pre-heat temperature.

19.5.4. POLYETHYLENE LAYER / CUTBACK

The polyethylene may be applied by either the cross-head or lateral extrusion technique. The polyethylene shall be applied over the adhesive within the time limits established during procedure qualification testing, and within the temperature range recommended by the Manufacturer.

The polyethylene layer is to be applied to obtain a minimum total coating thickness of 3.5mm in terms of SSPC PA2 restriction level 1 (see Section 8.4.3.1 (Method of Measurement).

The coating shall be cooled sufficiently to prevent mechanical damage (typically below 85°C) before handling.

A polyethylene layer cut back of approximately 120mm shall be provided at pipe ends as follows:

Pipe ends shall be supplied as bare steel, free of all coating, for a distance of 100 mm (+25/-0mm) from the pipe end. In addition, each pipe end shall be left without polyethylene / adhesive coating so that a 20mm (+10/-0mm) FBE toe protrudes on the steel beyond the cutback polyethylene coating layer. Complete removal of the adhesive is not imperative and minor residual adhesive on the FBE toe is acceptable.

The ends of the coating shall be bevelled at 30° to 45°.

Immediately after the coating is fully cured, pipe identification marks shall be reapplied to the coated pipe using a method approved by the Corrosion Engineer.

19.6. TESTING

19.6.1. COATING PROCEDURE QUALIFICATION TRIAL (PQT)

Prior to commencing full production of each pipe diameter/wall thickness combination, three pipe joints shall be selected for PQT. One pipe joint shall be coated with a single layer FBE and two joints shall be coated with the full coating system. All coating shall be in accordance with the coating procedure specifications and shall be witnessed by the Corrosion Engineer.

The FBE coated pipe shall be subjected to the complete set of tests as specified in Section 14.3 (TESTING), given the understanding that certain tests may not be representative as a result of the lack of PE coating.

The test methods for all tests required for PQT on the complete coating system shall be performed in the same manner as the production tests described in this section. There are two tests which are performed uniquely on the FBE coating during PQT, namely: flexibility testing and hot water resistance testing.

Pipes selected for PQT testing shall pass all the criteria contained in Section 14.3 (TESTING).

Any change in the coating material or coating procedure shall require re-qualification.

If any of the tests fail to meet the Acceptance criteria defined in this specification, then the procedure qualification pipes shall be rejected. Further pipes shall be prepared and coated using revised procedures and all PQT tests shall be performed. Once acceptable results are obtained and approved by the Corrosion Engineer, the Contractor's quality plan and procedures shall be

revised, and submitted to the Corrosion Engineer for Approval. All items coated using the rejected procedures shall be stripped and recoated to the revised procedures.

Before commencement of coating PQT, the Supplier shall have obtained Approval of their coating procedures including the test methods and Acceptance criteria, as described in this Specification.

The Corrosion Engineer shall be given a minimum of seven (7) working days' notice to witness the PQT.

Within four (4) days of completion of the PQT, a written test report shall be submitted to the Corrosion Engineer. The written test report shall include a full set of records covering the properties of the raw materials and the final coating.

The Contractor shall prepare and submit a schedule, in matrix form, of all the tests to be conducted during the PQT. For each test, the schedule shall state at least the following information:

- Test name / type
- Duration
- Conditioning parameters
- Contractor's in-house procedure reference
- Reference standard
- Start date and time, planned and actual
- Test result
- Compliance / non-compliance
- Space for sign off by the Contractor when test is complete
- Space for sign off by the Corrosion Engineer when test is complete. (Note: this will not signify Acceptance by the Corrosion Engineer of the test result).
- Remarks

The schedule (PQT Testing Schedule) shall serve as an instrument for the Contractor to coordinate testing and the Corrosion Engineer to track testing progress and witness accordingly.

Inspection and testing requirements for the procedure qualification trial (PQT) are detailed in Section 19.7 (PRODUCTION TESTING).

The pipes used for (PQT) shall be reworked as production pipes. If the pipes pass all tests, then they may be released as short pipes as part of the production pipes. If they fail the tests the coatings shall be removed, and the pipes reprocessed.

19.7. PRODUCTION TESTING

Production testing shall be performed at the frequency as required by Section 4.6 (FREQUENCY OF TESTING AND INSPECTION ON AUTOMATED SYSTEMS) and recorded in the QCP. This frequency of tests is subject to change at the discretion of the Corrosion Engineer as a result of change of materials or consistent poor production performance. The frequency of tests shall be doubled when poor production performance occurs.

A single sample of coated pipe shall be sent to Corrosion Engineer for storage. The sample pipe pieces shall be taken from the same piece of pipe as used for the first set of cathodic disbondment tests and should be one-metre-long and half the circumference of the pipe.

The Contractor's quality control system shall include the following, as a minimum:

- Monitoring of blasting grit and shot size
- Visual checks, in good light, of the surface of the blasted pipe
- Profile, dust & debris
- Temperature control of the pipe surface
- Coating testing, as detailed in this Specification
- Supervision of the adequate and proper repair of all defects.

The following shall be recorded and logged at least once per shift, or at the frequency as indicated:

- Air temperature (every 4 hours)
- Relative humidity (every 4 hours)
- Surface temperature of steel
- Dew point

19.7.1. VISUAL INSPECTION

The following external surfaces of the coated pipe shall be carefully inspected in adequate lighting:

- Adjacent to the longitudinal welds,
- Adjacent to the cutback at each end of pipe,
- Within the body of the pipe

The coating shall be black (unless otherwise agreed by the Corrosion Engineer). The finished coating shall be blemish-free, with dust or other particulate inclusions. The coating shall not have any defects such as blisters, scratches, wrinkles, engravings, cuts, swellings, excess material, thickened zones, air inclusions, tears, voids, entrained foreign matter etc.

19.7.2. COATING THICKNESS

The total 3LPE coating system shall be applied to a minimum average thickness of 3.5mm.

The coating thickness shall be determined using the SSPC PA2 procedure restriction level 1 (see Section 8.4.3.1 (Method of Measurement). In the case of pipes with raised seams, three (3) readings shall be made at the apex of the weld seam, uniformly distributed over the length of the pipe.

Any individual spot measurement less than the minimum value above shall be cause for the coated pipe length concerned to be quarantined. The pipe shall be held for further review by the Corrosion Engineer.

19.7.3. HOLIDAY DETECTION

Section 8.4.2 (HOLIDAY INSPECTION) shall apply and in addition each fully coated 3LPE pipe shall be inspected for holidays over 100 percent of its coated surface using a high voltage DC Holiday detector.

The Holiday Detector shall be set to 10kV/mm based on minimum specified coating thickness, to a maximum of 25kV. This setting shall be checked once every two hours. The travel speed of the brush shall not exceed 300mm/s.

All Holidays and other defects shall be marked for subsequent repair and re-testing. On re-testing, no holidays shall be permitted in the final coating.

The number of Holidays for each pipe length shall be recorded. Coated pipe having Holidays in excess of 3 per individual pipe length shall be stripped and re-coated at no additional cost to the Client.

19.7.4. ADHESION (PEEL) TEST

The coating adhesion of the FBE layer shall be rating 1 when tested in accordance with Annex A16 of ISO 21809- 2.

For the complete coating, the adhesion shall be determined in accordance with the requirements for bond strength in DIN 30670. The relevant test temperature and Acceptance criteria for these tests shall be as detailed in Annex D of DIN 30670 for procedure qualification and for production testing. Automatic chart recording equipment shall be used and the average peeling force shall be recorded.

The failure mode shall be recorded. The failure should occur at the adhesive/polyethylene interface or adhesive/FBE interface or cohesively in the polyethylene layer. If a failure should occur at the FBE/steel interface, this will be considered a total failure of the system.

During adhesion testing, samples of coating shall be examined, using 30X magnification for air entrapment.

19.7.5. IMPACT TEST

A sample of coated pipe shall be impact tested in accordance with the procedures and Acceptance criteria of DIN 30670. For PE coated pipe this requires 5 J/mm. Holiday detection after Impact Testing shall be conducted as per Section 19.7.3 (HOLIDAY DETECTION) above.

19.7.6. RESISTANCE TO INDENTATION TEST (INDENTATION HARDNESS)

Once per shift (and when the FBE or polyethylene batch is changed), the indentation hardness of two coated samples shall be measured (at 20°C ±5°C and 70°C ±2°C) in accordance with DIN 30670.

For Polyethylene the indentation depth shall not exceed 0.2mm at 23°C ±3°C and 0.3mm at 70°C ± 3°.

19.7.7. PERCENTAGE ELONGATION AT FAILURE

This test shall be conducted on two (2) samples from each of the full system procedure qualification pipes to the requirements of DIN 30670. Elongation at failure shall be no less than 200%, when tested at 23°C, in accordance with DIN 30678.

19.7.8. OTHER DIN 30670 TESTS

The Supplier shall demonstrate, attainment of DIN 30670 requirements for Coating Resistivity. The Supplier shall demonstrate attainment of resistance to Thermal Ageing and Light Ageing as required by DIN 30670.

19.7.9. CATHODIC DISBONDMENT TEST

Cathodic Disbondment testing shall be conducted in accordance with the requirements in the following table:

CATHODIC DISBONDMENT TEST REQUIREMENTS

Conditioning	Duration / When	Acceptance Criteria	Frequency
3.5V, 65 ± 3°C	24h / PQT	7mm maximum average radius	2 pipes as per Section 19.6 (TESTING)
1.5V, 23 ± 3°C	28d / PQT	7mm maximum average radius	2 pipes as per Section 19.6 (TESTING)
3.5V, 65 ± 3°C	24h / production	7mm maximum average radius	1 pipe per shift
1.5V, 23 ± 3°C	28d / production	7mm maximum average radius	See notes below

NOTES: For production line 24 hour testing one pipe per shift and/or at the start of a new coating batch.

Any change in raw material batch number shall constitute a new coating batch.

If a 24 hour production test fails, there will be a mandatory 28 day test on the failed pipe as well as repeat tests in accordance with Section 19.7.13 (TEST FAILURE).

The test requirements shall be in accordance with ISO 21809-1 Annex H.

19.7.10. AIR ENTRAPMENT ASSESSMENT

A sample of the applied coating shall be microscopically examined for the presence of foaming, voids and contamination. All layers (FBE, adhesive and polyethylene) shall be examined in accordance with CAN/CSA-Z245.20-21.

Examination may be carried out on strips of coating from the adhesion test or by cutting the coating at a 45°angle along the edge of the remaining coating on the pipe at the test area.

No more than 10 percent of the observed area of the polyethylene shall be air entrapment (porosity or bubbles), equivalent to Rating 2 of Figure 6 in CAN/CSA-Z245.20. Individual bubble size in the polyethylene layer shall be limited to less than half the thickness of the polyethylene layer in height or circumference. Bubbles shall not link together to provide a moisture path to the adhesive/FBE layers.

Cross section and interface porosity of the FBE and adhesive layer coating shall be in Rating 2 to 3 of Figures 6 and 7 respectively of CAN/CSA-Z245.20.

Strips shall also be cut from longitudinal welds and examined for voids (‘tenting’).

19.7.11. DEGREE OF CURE

Thermal analysis shall be carried out using differential scanning calorimetry (DSC) techniques.

Epoxy film samples shall be carefully removed from the coated surface using a hammer and cold chisel. This produces furled coating flakes. Care shall be taken to remove samples of full film thickness but at the same time avoid the inclusion of steel debris and con1mination with adhesive or polyethylene.

Differential scanning calorimetry shall be carried out utilising an instrument which has been calibrated within the three months immediately preceding the start of production for this order. The test shall be conducted using a nitrogen atmosphere. Sample preconditioning shall be carried out in accordance with the parameters (maximum temperature, heating rate, holding time) defined by the Powder Manufacturer.

The procedure shall be in accordance with CAN/CSA-Z245.20-02 Clause 12.7.3.

The coating shall be demonstrated to be fully cured by recording a delta Tg (i.e. Tg4 - Tg3) of between +3°C and -2°C. If delta Tg is outside this range, the test is deemed as a failure.

The cure shall be assessed in accordance with CAN/CSA-Z245.20-02 Clause 12.7.3.3.1. Reporting shall be in accordance with CAN/CSA-Z245.20-02 Clause 12.7.4.

19.7.12. DESTRUCTIVE TESTS

A sufficient length of production pipe shall be cold cut to provide the required number of samples for conducting the coating destructive tests.

19.7.13. TEST FAILURE

Items that fail individual tests and that cannot be repaired in accordance with Section 19.8 (COATING REPAIRS) shall be rejected. Subject to the Approval of the Corrosion Engineer, the rejected coating shall be stripped, and the pipe length shall be re-blasted and coated in the manner specified for new pipe in this Specification.

Where a test relates to a quantity of coated items, e.g. 1 per 50 items or 1 per 150 items etc., the quantity of items represented by the item tested shall be considered to be a batch.

If a test on an item in a batch fails, then this item shall be rejected, and two further items before and two further items after the failed pipe shall be selected from the batch in the coating sequence for testing. If there is a failure in either of these tests, then the whole batch shall be quarantined for review by the Corrosion Engineer.

The cause of failure shall be established and reported to the Corrosion Engineer and if deemed necessary by the Corrosion Engineer the coating procedure shall be amended and re-qualified. The Corrosion Engineer will decide whether the whole batch is rejected and sent for re-blasting and re-coating or whether Acceptance may be on the basis of acceptable tests carried out on individual items.

19.8. COATING REPAIRS

The repair methods depend on the extent of the damage. These repair methods are for factory repairs.

Minor site repairs where the extent of damage exceeds 30% of the polyethylene thickness shall be repaired in accordance with section 19.8.1

Major site repairs are to be dealt with in the same way as field joint coatings.

The maximum number of coating defects allowable, before a length of pipe shall be classed as reject and recoated, shall not exceed three per pipe (inclusive of damage caused by testing).

19.8.1. REPAIR METHODS FOR MINOR DEFECTS

This method shall be applicable to damaged areas smaller than 10cm^2 and where the damage does not extend into the FBE layer of the 3LPE system. The repair shall be carried out with a melt stick (thermo-sensitive co-polymer) as follows:

- Trim off the damaged PE layer of the 3LPE system to remove the damaged area.
- Abrade the exposed area using an 80 grit emery cloth or sand paper.
- Vacuum clean the surface to remove dust, debris and dirt. Wipe the repair area with an appropriate cleaning solvent (Xylene or similar) and thoroughly wash with potable water and non-ionic detergent using brushes and lint free rags. Provide a final rinse with de-mineralized water.

- Heat the area to be repaired with a gas torch to approximately 50°C. Heat the melt stick until it softens (max of 150°C) and apply to the prepared area of damage. Smooth the repaired area with a heated spatula.

19.8.2. REPAIR METHODS FOR MAJOR DEFECTS

This method shall be applicable to damaged areas larger than 10cm^2 or where the damage extends into the FBE layer of the 3LPE system. The repair shall be carried out as follows:

Trim back the damaged PE layer of the 3LPE system to expose the damaged area to a distance of at least 50 mm beyond the damage area. The coating edges shall be bevelled/chamfered to make a 10 mm minimum tapered transition between the full thickness coating and the exposed steel.

All corrosion products and/or contaminants (oil, grease, tar, chlorides, soluble salts, pipe end primer, etc.) on the exposed FBE layer or steel substrate shall be removed.
Following the removal of all corrosion products and/or contaminants, the surface shall receive a final high pressure (20-35MPa) de-mineralized water wash. Surface condition after pre-cleaning shall comply with SSPC-SP1.

The steel substrate shall be blast-cleaned to remove all mill scale, rust, oxides, corrosion products and other impurities to Sa 3 (ISO 8501-1). The mainline pipe coating shall be protected from damage or contamination from the blasting operations.

The 3LPE coating shall be sweep blasted to a distance of 150 mm from the damaged area to provide a key for the application of the repair. Under no circumstances shall the FBE coating be completely removed during blast cleaning, the intention is that the surface be feathered/roughened only.

The mainline pipe coating shall be protected from damage or contamination from the blasting operations. Where damage or contamination does occur, the affected area shall be cleaned and the coating reinstated.

The joint area shall be vacuum cleaned to remove all dust and debris in accordance with SANS 8502-3. With prior Approval of the Engineer, dust and debris may be removed by blowing with clean uncontaminated compressed air.

The steel surface temperature shall always be 3°C above the dew point to remove any moisture prior to application of a primer.

The Contractor shall provide dust protective shields where Site conditions require such measures. The Contractor shall not execute surface preparation in an unprotected dusty environment.

To complete the repair, apply the System (paint plus tape wrapping) as detailed in Section 19.9 below.

19.9. FIELD JOINT COATINGS (EXTERNAL)

19.9.1. GENERAL REQUIREMENTS

Field joint repairs shall be suitable to be applied to steel pipes with welded joints. The field joint repair system shall be able to provide effective corrosion protection of the welded field joint over the full design lifespan of the pipeline and shall be fully compatible with the coating of the pipeline. The field joint repair system shall be suitable for use with a cathodic protection system.

The following field joint repair system shall be used:

A layer of applied liquid epoxy, polyurethane or urethane modified epoxy followed by the application of an additional cold applied tape wrapping system. The circumferential cold tape wrapping system

shall consist of a primer, an inner wrapping tape and an outer wrapping tape.

19.9.2. QUALITY CONTROL REQUIREMENTS AND ENVIRONMENTAL CONDITIONS

Shall be in accordance with Chapters 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES) and 8 (APPLICATION AND QUALITY CONTROL).

During all surface preparation and field joint application operations, relative humidity, dew point temperature, other relevant environmental conditions in the immediate vicinity of item being worked on and the steel surface temperature shall be determined and recorded at two hour intervals.

Surface preparation and field joint application operations shall only be permitted when:

- The relative humidity is less than 85%.
- The ambient temperature is above 10°C.
- The substrate temperature is ≥ 3°C above the dew point.

19.9.3. SURFACE PREPARATION FOR EPOXY PAINT PLUS TAPE WRAPPING

The surface preparation of the field joint area for the epoxy paint application shall be as follows:

All corrosion products and/or contaminants (oil, grease, tar, chlorides, soluble salts, pipe end primer, etc.) on the exposed steel substrate shall be removed.

The edges of the HDPE coating shall be cut back to a distance of 150 mm from the weld joint. The HDPE coating edges shall be bevelled/chamfered to make a 15º minimum tapered transition between the full thickness coating and the exposed epoxy.

The steel substrate shall be blast-cleaned to remove all mill scale, rust, oxides, corrosion products and other impurities to Sa 3 (SANS 8501-1) for a distance of 100mm from the weld joint. The pipe coating shall be protected from damage or contamination from the blasting operations.

The FBE coating shall be sweep blasted to a distance of 150 mm from the weld joint to provide a key for the field joint. Under no circumstances shall the FBE coating be completely removed during blast cleaning, the intention is that the surface be feathered / roughened only.

The pipe coating shall be protected from damage or contamination from the blasting operations. Where damage or contamination does occur, the affected area shall be cleaned and the coating reinstated.

The joint area shall be vacuum cleaned to remove all dust and debris in accordance with SANS 8502-3. Shall be in accordance with Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL) With prior Approval of the Engineer, dust and debris may be removed by blowing with clean uncontaminated compressed air.

The Contractor shall provide dust protective shields where Site conditions require such measures. The Contractor shall not execute surface preparation in an unprotected dusty environment.

19.9.4. COATING REPAIR MATERIAL FOR EPOXY PAINT PLUS TAPE WRAPPING

The liquid coating component of the field joint repair system shall comprise of liquid epoxy, polyurethane or urethane modified epoxy. The liquid coating component shall be fully compatible with the FBE and polyethylene of the 3LPE coating of the line pipe and shall be subject to the Approval of the Engineer. The Contractor shall provide full details of the liquid coating to be used (manufacturer and product number) as well as data and detail sheets.

The Contractor shall provide full details of the primer to be used (manufacturer and product number) as well as data and detail sheets for the application of the cold tape wrapping of the field joint repair system. The inner wrap shall consist of a 100 mm wide conformable polyethylene backed modified bitumen mastic tape, compliant with the requirements of SANS 1117 type C. The outer wrap shall consist of a 100 mm wide medium density adhesive polyethylene compliant with

the requirements of SANS 1117 Type B & D.

19.9.5. COATING REPAIR APPLICATION OF EPOXY PAINT PLUS TAPE WRAPPING

19.9.5.1. HEATING

The surface may be heated using an induction heating coil to a temperature as recommended by the coating material manufacturer and in accordance with this Section. In any event the temperature shall not exceed 50°C and qualification of this heating temperature shall be carried out by porosity checks as required by the Engineer.
The use of propane torches or naked flames for pre-heating and post-heating is expressly prohibited. Infrared heaters may be used for post-heating.

The temperature of the bare steel shall be monitored using infra-red non-contact thermometer. The use of crayon or wax melt sticks is expressly prohibited because it can reduce the adhesion. Care shall be taken to ensure a uniform heating pattern.

19.9.5.2. LIQUID COATING APPLICATION

A layer of liquid coating shall be applied to the blast cleaned field joints and adjacent prepared factory FBE coating using pre-packed joint repair kits. Pre-heating of the resin and/or the curing agent may be required prior to mixing and application in accordance with the manufacturer's recommendations. The minimum required dry film thickness for the external coating is 400 µm over any part of the surface/item to be coated.

For each coat, the overlap onto the factory applied coating shall not be less than 20 mm external.

If post-heating of the coating after application is required, this shall also be carried out in accordance with the product manufacturer's procedure.

The coating shall be uniform, free of defects and shall not show a tendency to delaminate, to sag or to curtain.

The wet film thickness shall be measured in accordance with SANS 2808.

No thinner shall be used unless recommended by the product manufacturer. Tools and equipment shall be cleaned using only such solvents as are recommended by the product manufacturer.

Particular care shall be taken in the handling of the field joints before the coating has reached the minimum value of hardness recommended by the manufacturer and qualified during the impact test.

19.9.5.3. FINISHED FIELD JOINT COATING

The finished coating shall be smooth and uniform and free of any defects.
When the coating has cured sufficiently, dry film thickness which shall be measured in accordance with SSPC PA 2 restriction level 1 as described in Section 8.4.3 (DRY FILM THICKNESS (DFT))

Holiday detection shall be carried out in accordance with Section 8.4.2 (HOLIDAY INSPECTION).

19.9.5.4. APPLICATION OF CIRCUMFERENTIAL COLD TAPE WRAPPING

Primer Application
Once the Liquid Applied Field Joint Coating has cured to the extent required by the product data sheet and has been inspected, the cold tape wrapping procedure shall be as follows:

The factory applied polyethylene line pipe surface to which the cold tape wrapping is to be applied shall be abraded.

The entire joint surface to be wrapped shall be primed with a suitable primer.

Priming shall not be carried out further ahead of physical tape wrapping than a maximum of 8 hours.

Ensure the tape primer is dust free prior to application of a tape wrap system. If the primer has become contaminated with dust, sand or dirt, the primer shall be removed with a manufacturer recommended cleaning solvent and re-applied.

Allow approximately 30 minutes drying time or until the primer is tacky to the touch.

- Inner Wrap

  The inner wrap shall consist of a 100 mm wide conformable polyethylene backed modified bitumen mastic tape compliant with SANS 1117 type C.

  Peel back approximately 0.5 m of interleaving. Align the edge of the 100 mm wide tape 50 mm beyond the exposed FBE toe onto the primed, factory applied, polyethylene line pipe coating. Press down firmly.

  Before spiral wrapping commences, a full circumferential wrap of tape is applied by hand with sufficient tension to narrow the width of tape between 1 and 2 mm.

  Whilst maintaining tape tension described above, the tape shall be applied spirally. Remove interleaving as wrapping proceeds.

  The tape shall be applied to ensure that a minimum 25 mm overlap shall be achieved.

- Outer Wrap

  The outer wrap shall consist of a 100 mm wide medium density adhesive polyethylene tape compliant with SANS 1117 type B and D.

  Centre 100 mm wide outer-wrap tape on the edge of the applied inner wrap tape on the factory applied coating. Press down firmly.

  Before spiral wrapping commences, a full circumferential wrap of tape is applied by hand with sufficient tension to narrow the width of tape between 1 and 2 mm.

  Whilst maintaining tape tension described above, the tape shall be applied spirally.

  The tape shall be applied to ensure that a minimum 55% overlap shall be achieved.

  The tape shall be applied to a minimum width of 50 mm beyond the applied inner tape-wrapped area onto the primed shop applied coating.

- Finished Cold Tape Wrapping

  Ensure that the tape is in full contact with the underlying surface with no wrinkles, fish-mouths or bubbles.

  Holiday detection shall be carried out in accordance with Section 19.7.3 (HOLIDAY DETECTION) to ensure that field joint has the same electrical characteristics as the factory applied coating.

20. SINTERED POLYETHYLENE EXTERNAL COATING SYSTEM

STANDARDS

Reference is made to the latest issues of the following Standard Specifications:

DIN	30670	Polyethylene coatings on steel pipes and fittings – and testing.
SANS	2808	Paints and varnishes – Determination of film thickness.

20.1. GENERAL

Sintered Polyethylene shall not:

- be used as internal lining.
- be used on flexible pipes (D/t ratio > 120). (Refer Section 6.2.4 (SHAPE IMPERFECTIONS), steel pipe shall not deform under its own weight to limit shear and annular disbondment)
- be subjected to point loading under handling (picking up from the cut back ends or using broad nylon slings on site)
- be subjected to storage point loading; as for example: resting on steel rails.
- be used on pipe specials and pipe fittings.

20.2. MATERIAL

Shall conform to DIN 30 670.

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warranted by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

20.3. APPLICATION

20.3.1. SURFACE PREPARATION

All surfaces to be coated shall be abrasive blast-cleaned in accordance with Section 7 (SURFACE PREPARATION).

For detailed weld finish refer to 6.2.5.4 (Weld Finish for sintered polyethylene coating)

20.3.2. APPLICATION

The pipes shall be heated in such a way as not to produce any deleterious contaminants on the surface to be coated. The use of a naked flame to heat the steel pipe surfaces is prohibited.

The polyethylene compound shall be applied to obtain a smooth finished surface.

The sintered polyethylene coating shall not be post-heated by use of a torch or other flame treatment being applied directly to the coating as a method of surface treatment to improve the adhesion of the field joint repair system.

20.3.3. END TREATMENT

(a) Where the coating is terminated externally it shall be set back a nominal distance of 100 mm from the closest assembly weld point and sealed with a primer for tape systems**.**

(b) The end coating shall be tapered over a distance not less than the coating thickness.

20.3.4. COATING THICKNESS

When determined with a magnetic thickness gauge in accordance with method 5 of SANS 2808, the minimum coating thickness of the sintered polyethylene applied to pipes and specials shall be as tabled below.

Pipe OD in mm	Minimum coating thickness in mm
	Sintered Polyethylene Coating
OD ≤ 273	2.7
273 < OD ≤ 508	2.9
508 < OD ≤ 813	3.2
813 < OD	3.7

20.4. TESTING

Shall be in accordance with Chapters 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES), 6 (MANUFACTURE AND PRE-PREPARATION) and 8 (APPLICATION AND QUALITY CONTROL).

20.4.1. RAW MATERIAL TESTING

One-kilogram test batches shall be retained for every ton of material used and these batches shall be subject to Fourier-Transform Infra-Red spectroscopy (FTIR) fingerprint testing to ensure consistent material quality**.**

Additional testing to be done in accordance with Section 4.3.2 (TEST AND CONTROL SPECIMENS FOR DESTRUCTIVE TESTING).

20.4.2. VISUAL INSPECTION

The coating shall be smooth, glossy free from pinholes, excessive orange peel, bubbling or excessive runs or sags as determined by the Corrosion Engineer.

20.4.3. THICKNESS

When testing the coating thickness, the minimum thickness shall be as shown in the table in Section 20.3.4 (COATING THICKNESS).

Thickness testing must be done with a calibrated magnetic gauge in accordance with SANS 2808 Method 7 A to D. The default method of measuring and evaluating coating thickness shall be a minimum thickness which shall mean that no readings below the minimum thickness will be accepted. This shall be in accordance with SSPC PA - 2 restriction level 1 as detailed in Section 8.4.3 (DRY FILM THICKNESS (DFT)).

20.4.4. ELECTRICAL INSULATION DEFECTS

The total coated surfaces of every pipe shall be tested in accordance with Annex E of DIN 30 670. All holidays detected shall be repaired in accordance with clause 10 of DIN 30 670.

EID testing must be conducted at 25kV for all thicknesses above 2.7mm with a calibrated high voltage spark tester as per Section 8.4.2. (HOLIDAY INSPECTION).

20.5. TEST REQUIREMENTS

20.5.1. TYPE TEST

Type tests shall be carried out at commencement of each project in terms of Section 4.4.3 (PROCEDURE QUALIFICATION TRIAL (PQT)) and at any change in formulation or source of polyethylene compounds and at any change in application process.

20.5.1.1. POLYETHYLENE COMPOUND

The polyethylene compound to be used for coating, and repairs shall be type tested for thermal stability, water absorption, penetration resistance, tensile stress at yield, environmental stress-cracking resistance, density and impact resistance as specified in Table 2 of DIN 30 670.

Test samples may be prepared in the laboratory or in the coating plant.

20.5.1.2. PRODUCTION TESTS

The coating shall comply with the production test requirements specified in Table 4 of DIN 30 670.

20.6. REPAIR METHODS

Where a holiday is located it shall be repaired to produce a continuous coating. Damaged areas that pass the continuity test need not be repaired provided the coating thickness remains greater than or equal to the minimum thickness specified in the table in Section 20.3.4 (COATING THICKNESS).

Any delamination of coating shall be a cause for rejection of the pipe.

The bare steel surface shall be prepared in such a way to produce a rust-free, clean, abraded surface. The adjacent FBPE coating or lining shall be tapered to 30°.

The repair method shall be agreed between the purchaser and the applicator.

NOTES: 1. The repair methods outlined apply to repairs at the application plant only.
2. The Corrosion Engineer may specify a particular repair method.

20.6.1. REPAIR LIMITS

The number of coating repairs shall not exceed three (3) per pipe length. Should the amount, of repairs of the pipe exceed three (3) the pipe shall be rejected, stripped, and recoated.

The defect area of any single coating repair shall not exceed 10cm².

If the repair is due to a gouge or cut which exposes the steel, the coated pipe shall be rejected, stripped, and recoated.

If the gouge or cut is not through to bare steel, then the length of such repair shall not exceed 0.5 m in any direction, regardless of the surface area.

20.6.2. REPAIR TEST METHODS

All repairs shall comply with the same EID test requirements of 25kV as specified in Section 20.4.4 (ELECTRICAL INSULATION DEFECTS).

21. CEMENT MORTAR LINING SYSTEM

STANDARDS

SANS ENV	197-1	Cement composition, specification, and conformity criteria.
SANS	0100	Structural use of concrete.
SANS	1024	Welded steel fabric for concrete reinforcement.
SANS	1083	Aggregates from natural sources.
SANS	1200	Standardised specifications for civil engineering construction.
SANS	9000	Model for quality assurance in production and installation.
SANS Method	551	Sodium and potassium contents of Portland cement.
SANS Method	769	Cleanliness of blast-cleaned steel surfaces for painting (dust and debris).
SANS Method	830	Chloride content of aggregates.
SANS Method	863	Compressive strength of concrete (including making and curing of the test cubes).
SANS Method	1245	Potential reactivity of aggregates with alkalis (accelerated mortar prism method).
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
AWWA	C602	Cement-motor lining of water pipelines – 4 inches (100 mm) and larger – in place.
BS	3148	Methods of test for water for making concrete (including notes on the suitability of the water).
SSPC	SP 15	Commercial grade power tool cleaning

21.1. CEMENT

Cement shall be of Type I with class strength of 42.5 and shall be identified by CEM I : 42.5.

The cement shall conform to SANS ENV 197-1.

The alkali content of the cement, when expressed as sodium oxide (Na2O) equivalent, shall not be greater than 0.6 percent by mass of cement determined in accordance with SANS Method 551 or any other reduced value as determined by the Engineer, where:

- % Na_2O equivalent = % Na2O + (0.658 x % K2O).

Cement shall be from the same source and shall be fresh. Cement shall be used strictly in the order of delivery. All cement in storage for longer than eight weeks and all cement in unsealed pockets shall be removed from storage and discarded.

Cement shall be stored in weather-proof bulk silos, or if in pockets, shall be stored in weather-proof sheds provided with damp proof floors at least 300 mm above ground level, stacked on pallets and covered with a waterproof membrane.

21.2. AGGREGATES

Both, the coarse aggregate (stone) and fine aggregate (sand) used in the manufacture of concrete or mortar shall conform to SANS 1083.

The aggregates shall be evaluated for potential alkali reactivity using SANS Method 1245.

The chloride content of the sand determined by SANS Method 830 shall not exceed 0,01percent per mass.

Coarse aggregate shall be suitable for concrete subject to surface abrasion, and of the largest possible size that would allow placement of concrete without difficulty.

Within eight (8) weeks of award of Contract, the Contractor shall submit to the Engineer the results of tests carried out on aggregates from the Contractor's proposed source by an independent and competent body. The Engineer reserves the right to take further samples of aggregates at any time from the Contractor's source or from his stockpiles and have same tested for compliance with the Specification.

21.3. WATER

Water used for concrete, mortar or cement slurry shall be clean i.e. free from oil, acid, alkalis, vegetable and mineral matter.

The water shall generally conform to the recommendations in the Annexure to BS 3148.

21.4. Concrete and Mortar

Concrete and mortar ingredients shall be batched by mass and shall be well mixed in mechanical mixers of good condition for a duration of not less than two (2) minutes.

There shall be no re-tempering of the mix after discharge from the mixer. Only fresh concrete and mortar shall be used and all concrete, mortar or cement slurries in a mixed state for longer than thirty (30) minutes shall be discarded.

No additives shall be used, except where approved by the Corrosion Engineer in writing.
The minimum cement content per cubic metre of concrete shall be 400 kg.

Mortar shall be a mixture of one (1) part cement to two (2) parts fine aggregate, for linings of up to 15 mm thickness and one (1) part cement to three (3) parts fine aggregate for thicker linings.

Total water content shall be the minimum required to produce suitable consistency and shall not exceed fifty (50) percent by mass of cement content, allowance being made for the moisture content of aggregates.

150 mm cubes of concrete or mortar made and cured in accordance with SANS Method 863 shall have a minimum compressive strength of 30 MPa after twenty-eight (28) days.

21.5. WELDED STEEL FABRIC

Welded steel fabric shall conform to SANS 1024, except that wire diameter and mesh sizes shall conform to this Section.

21.6. INTERNAL CEMENT MORTAR LINING

21.6.1. THICKNESS

The thickness of linings on pipes shall generally be as tabled below, except where specified to the contrary in the Schedule of Quantities or on the Drawings.

INTERNAL CEMENT MORTAR LINING THICKNESS

PIPE OD IN MM	THICKNESS OF LINING IN MM		
	NOMINAL	MAXIMUM	MINIMUM
273.0 to 609.6	10	13	8
Above 609.6 to 1 016	14	16	12
Above1 016.0 to 1 220	16	20	14
Above 1 22.0 to 1 620	20	24	16

The thickness of lining on specials shall generally comply with the above, provided the minimum cover of mortar over reinforcement mesh shall not be less than 10 mm.

21.6.2. SURFACE PREPARATION

After bare pipes and specials have been tested and inspected for compliance with the applicable Specification and after application of coating, if applicable, surface shall be prepared as follows:

21.6.2.1. SHOP APPLIED

- Weld spatter shall be removed by chipping and/or scraping.
- Deposits of grease, oil, or other contaminants shall be removed by water soluble degreaser.
- Other contaminants shall be removed by manual-, mechanical- or abrasive blast cleaning. The standard of cleaning shall not be less than grade Sa 2 of ISO 8501-1, with all mill scale removed.
- Should the abrasive blasted surface deteriorate to show visible rust then the abrasive blasted surface may be cleaned using wire brush to grade St 2.
- Residual dust and debris on the pipe surface shall be 0.5percent maximum when tested in accordance with SANS Method 769.

21.6.2.2. IN-SITU REHABILITATION

- The removal of bitumen for maintenance for cement mortar lining shall be by scraping, mechanical cleaning or water jetting. The entire surface must be cleaned.
- The resultant surface shall compile with SSPC SP 15, Commercial grade power tool cleaning, with a maximum of 33 % residual material in the base of pits.

21.6.3. SHOP APPLIED LININGS - CENTRIFUGAL SPUN

Within twenty-four hours of having been grit blasted and provided the pipe surfaces are kept dry, free of dust, oil and other deleterious contaminants and provided ambient temperatures are above 20°C the pipe shall be transported to a suitable spinning machine. The coating, if applicable, shall be suitably protected against mechanical damage during the handling and spinning operation. Before being placed in the spinning machine, the pipe shall be suitably braced with external stiffening rings, which shall not be removed until the appropriate one of the following periods has elapsed from the time of placing of the lining:

- Seventy-two (72) hours when water curing is used; and
- Thirty-six (36) hours when steam curing is used.

End gauge rings shall be securely attached to the pipe ends to control the lining thickness, to act as stop end to prevent mortar leakage and to stiffen and hold the pipe ends round.
Each pipe shall be rotated in a spinning machine with its axis horizontal during and for a suitable period after the placing of the lining. The speed of rotation shall be such as to produce a uniform distribution of the cement mortar over the interior surfaces of the pipe.

Sufficient mortar to line completely one pipe to the appropriate nominal thickness as specified shall be mixed in one batch, and it shall be of such consistency as to minimise segregation during spinning. The mortar shall be placed in the pipe immediately after mixing and before initial set has taken place, and in a manner providing uniform longitudinal distribution of the batch from end to end of the pipe.

As soon as the mortar lining has achieved a uniform thickness over the whole interior surface of the pipe, the speed of rotation shall be increased to a speed that will compact the mortar and is not less than 1 peripheral speed of 17 metres per second. The required speed shall be maintained for such a period as will give the maximum density of mortar and smoothness of surface, and sufficient bonding to permit removal of the pipe from the machine without injury to the lining.

The ends of the lining shall be finished uniform and square or slightly bevelled as required in Section 21.6.8 below (PIPE ENDS).

All water and laitance expelled during spinning shall be removed in such a manner that the surface of the lining is smooth, level and true.

After the lapse of a suitable period after spinning (as determined by experiment), the spun lining shall be given a steel trowelled or smoothing bar finish. A second trowelling may be necessary to remove all laitance and produce a smooth and hard finished surface. The Colebrook-White (k) friction value shall be not more than 0.13 mm.

21.6.4. IN-SITU APPLIED LININGS

(a) Standard

Shall be carried out generally in accordance with the provisions of the latest issue of AWWA C602 for “Cement-Mortar Lining of Water Pipeline - 4 in (100 mm) and larger - In Place”, subject to the modifications, amendments, and amplifications in this Section.

(b) Curing

The contents of Clauses 4.7.2, 4.7.3, 8.7.2 and 8.7.3 of AWWA C602 shall be deleted and shall be replaced by: “Curing by Contractor”. The Contractor shall be responsible for careful curing of the mortar lining until the pipeline has been handed over to the Purchaser.

(c) Length of Uninterrupted Lining

Tenderers shall state in Tenders the maximum length of lining which they are prepared to undertake between any two consecutive points of access and under what circumstances they would require this length modified.

This factor will be taken into account when assessing the comparative economic merits of Tenders.

(d) Methods of Lining

For pipe sizes up to 500 mm nominal bore, the “Tate System” of lining is permissible. The “Perkins System” of lining by means of a suitable machine that travels through the pipe and distributes mortar by high velocity centrifugal spraying, followed by a trowelling device, shall be permissible for all pipe sizes.

Tenderers shall submit full details of the system to be employed with special reference to methods of pre-cleaning of surfaces and delivery of mortar to the spraying head.

21.6.5. LINING OF SPECIALS

Bends, tees, and other specials that cannot be lined by machine shall be manually lined. In case where the nominal diameter exceeds 600 mm the lining shall be reinforced by steel mesh tack-welded to the inside of the pipe in such a way that it is not in contact with the pipe except where welded. The steel mesh shall be of 2.5 mm diameter steel wire at 100 mm by 50 mm, or equivalent spacing. The minimum cover over the mesh shall be 10 mm.

21.6.6. FINISH

The lining shall be well finished with a smooth surface free from excessive laitance and surface irregularities. Projections exceeding a height of 1.5 mm shall be removed by trowelling before the concrete has set, or by grinding after the lining has cured.

The thickness of the laitance, if any, shall not exceed ten (10) percent of the thickness of the lining, or 1.25 mm, whichever is less.

The effective surface roughness of the lining when measured in terms of the Colebrook-White "K" friction coefficient for lining surface effective roughness shall be guaranteed by the Contractor and shall not be more than 0.13 mm when actually measured in the field after completion of the pipeline. No rougher surface will be acceptable.

21.6.7. CURING

(a) Water curing

Immediately after the placing of the concrete, the pipe shall be so sealed as to prevent loss of contained water, and the concrete shall be kept continuously moist for a period of at least seven (7) days or, in the case of an in-situ applied lining, until the pipe has been handed over to the Purchaser. During this period steps shall be taken, when necessary, to prevent the temperature of the steel shell falling below 2°C.

(b) Steam curing

Pipes that have shop applied linings, and that have not been coated with bitumen or coal tar may be steam cured.

Immediately after application of the concrete lining, the ends of the pipe shall be completely sealed. After the lined pipe has been standing for not less than two (2) hours, steam shall be injected into it so as to raise the temperature at a rate not exceeding 28°C per hour until the temperature of the lining is within the range 55-70°C.

Steaming shall continue for a further six (6) hours, the temperature of the lining being maintained within the range specified. Steaming shall be discontinued and the pipes shall remain sealed for a further two (2) days from the time that the temperature of the pipe has fallen to ambient. During this period precautions shall be taken to prevent the temperature of the steel falling below 2°C.

During the curing cycle, excluding the two (2) day holding period, the temperature of at least one pipe out of that day's production, shall be recorded by a suitable automatic recording instrument. If the temperature record reveals that the requirements set out above have not been achieved, then the pipes shall be subjected to the full period of water curing as specified in Section 21.6.7 (a) (Water curing) above.

(c) General

Concrete lined pipes shall not be moved or transported for a period of twenty-one (21) days after the date of lining.

21.6.8. PIPE ENDS

Where lining takes place before welding, i.e. not in-situ but on Site or in the shop, the following shall apply:

- For flanged pipes and specials and pipes intended for jointing by couplings, concrete lining shall be ended flush with pipe ends with a 6 mm bull-nosing of edges by means of a nosing tool.
- For pipes to be butt welded the lining shall terminate 100 mm from the internal end of each pipe and the end of the lining shall be bevelled to form an angle of approximately 85 degrees between the clear end of the pipe barrel and the lining end.
- The unlined circumferential strip of grit blasted surface shall be temporarily protected between the Works and the Site with a coat of (red or a different colour to the lining/coating) weldable primer.

21.7. EXTERNAL CEMENT MORTAR COATING

21.7.1. THICKNESS

The thickness of cement mortar coatings on pipes and specials shall generally be as in table below, except where specified to the contrary elsewhere in these documents.

EXTERNAL CEMENT MORTAR COATING THICKNESS

PIPE OD IN MM	THICKNESS OF COATING IN MM		
	NOMINAL	MAXIMUM	MINIMUM
273.0 to 609.6	16	18	14
Above 609.6 to 1 016	20	22	18
Above1 016.0 to 1 220	25	25	22
Above 1 220.0 to 1 620	30	30	25

21.7.2. COVER TO REINFORCEMENT

The cover to reinforcement of cement mortar coatings on pipes and specials shall generally be as tabled below, except where specified to the contrary elsewhere in these documents.

COVER TO REINFORCEMENT

NOMINAL COATING THICKNESS IN MM	MINIMUM COVER TO REINFORCEMENT IN MM
16	10
20	14
25	18
30	20

21.7.3. APPLICATION

(a) Stiffening Rings

End gauge rings shall be securely attached to the pipe ends to control the coating thickness, to act as stop end to prevent mortar spillage at pipe ends and to stiffen and hold pipe ends round.

(b) Reinforcement

The coating shall be bonded to the pipe surface and shall be reinforced by 2.5 mm diameter round steel wire wound spirally around the total length of the pipe and tack-welded to the pipe surface. The pitch between windings shall not exceed 40 mm. Alternatively, the reinforcement shall consist of 2.5 mm thick, 100 mm by 100 mm steel mesh wrapped around the pipe and tack-welded to the surface.

Except where welded, the reinforcement shall not be in contact with the pipe surface.

(c) Cement Slurry

Within twenty-four (24) hours of having been grit blasted and provided the pipe surfaces are kept dry, free from dust, oil and other deleterious contaminants and provided ambient temperatures are above 2°C on a rising thermometer, the pipe surfaces and reinforcement shall be coated with a slurry consisting of approximately ten (10) litres of water to twenty (20) kilograms of cement. No more of the pipe surface shall be coated at any time than what can be covered with cement mortar immediately without the cement slurry drying out.

(d) Concrete Application

Immediately after application of the cement slurry and while the cement slurry is still wet, concrete shall be applied by impact, or under vibration, or by hand plastering where mechanical means of application are not possible.

(e) Finish

The finished coating shall be firm and dense, shall adhere rigidly to the outside of the pipe and the thickness of laitance shall not exceed 1.25 mm. The coating shall furthermore be free from pinholes, craters, cracks, laminations, and other imperfections.

(f) Curing

Upon completion of the coating operation and until the coating has set sufficiently to allow the pipe to be handled and transported to the curing Site without damage to the coating, the coated pipe shall be fully protected from wind, rain, direct sunlight and against loss of moisture from the coating.

(i) Water curing: As soon as the coating has set sufficiently for the pipe to be handled, the coating shall be kept continuously moist by continuous water spraying for a period of at least 7 days. During this period steps shall be taken to prevent the temperature of the steel shell from dropping below 2°C.

(ii) Steam curing: Sections 21.6.4 (b) (Curing) and 21.6.7 (b) (Steam curing) shall apply, except that steam curing shall continue for 6 hours before end stiffeners and gauging rings are removed. Steam curing shall thereafter continue for a further twelve (12) hours or alternatively, after six (6) hours of steam curing, the coatings may be water cured by continuous water spraying for at last five (5) days.

21.7.4. PIPE ENDS

For pipes and specials intended for jointing by flexible couplings, the coating shall be terminated 250 mm from pipe ends with a 6 mm radius bull-nosed outer edge.

For pipes to be butt welded, the coating shall terminate 100 mm from pipe ends and the ends of coatings shall be bevelled to form an angle of approximately 85 degrees between the clear end of the pipe barrel and the end face of the coating.

The unlined circumferential strip of grit blasted surface shall be temporarily protected between the Works and the Site with a coat of (red or a different colour to the lining/coating) weldable primer.

21.8. REPAIR OF DEFECTS

Section 21.10 (CEMENT MORTAR - REPAIR OF DEFECTS) shall apply.

The thickness of linings and coatings shall be as given by Section 21.6.1 (INTERNAL CEMENT MORTAR LINING THICKNESS) and 21.7.1 (EXTERNAL CEMENT MORTAR COATING THICKNESS) respectively.

21.9. CONTRACTOR'S AND ENGINEER'S INSPECTIONS

The relevant sections in Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES) shall apply.

21.9.1. LINING

21.9.1.1. VISUAL INSPECTION

(a) Shop Applied Lining

The cured lining in every pipe and special shall be inspected visually for defects before the pipe leaves the factory, but not sooner than twenty-one (21) days after application of the lining.

The lining shall have a smooth, steel floated appearance and shall have no projections exceeding a height of 1.5 mm above immediate lining surface.

Slight surface crazing and hair cracks shall be permissible. All cracks into which a suitable metal depth gauge with a probe of 1.5 mm diameter can be inserted to a depth of half the minimum specified thickness of the lining shall be considered a defect and shall be repaired as described in Section 21.10 (CEMENT MORTAR - REPAIR OF DEFECTS).

(b) In-situ Lining

Visual inspection of the finished lining shall include the provision of a camera mounted on a suitable trolley which shall be so arranged as to make exposures at intervals of approximately twenty (20) metres throughout the lined pipe.

Accurate records including exposure serial numbers and the relative pipe chainages shall be kept by the Contractor. All records and exposures shall become the property of the Employer.

The Contractor shall supply all equipment, facilities and chemicals required for the processing of films. A full description of the equipment and method proposed shall be submitted with Tenders.

Exposures of any completed section of lining shall be processed and be made available immediately after processing. The Engineer may order repeat exposures at any point in the line due to the lack of good definition, lighting, focus or because a defect in the lining is suspected. Repeat exposures shall be to the account of the Contractor. Repeat exposures to clarify suspected defects however, shall, if the suspected defects prove acceptable or non-existent, be to the account of the Department.

21.9.1.2. DESTRUCTIVE TESTING

(a) Thickness of Lining and Cover to Reinforcement

On the first pipelined and thereafter on one pipe selected at random out of every day's production and after completion of curing, chisel down to bare steel base a representative section of area at least 0.25 square metres of the lining. The area shall contain the weld

bead.

Measure distance between:

- the steel base and surface of concrete and
- the top of the weld bead and the steel surface and
- the reinforcement mesh to surface of concrete,

with a suitable dial gauge or micrometre to an accuracy of 0.1 mm. Take not less than five (5) readings for each pipe and record all readings, the mean of readings, the maximum and the minimum readings.

Repair lining as described in Section 21.10 (CEMENT MORTAR - REPAIR OF DEFECTS). Should thickness not fall within the specified ranges, a further two pipes out of the day's production shall be tested. If thickness of any of the two pipes or specials tested shall fail the requirements, the lining of all pipes and specials in that day's production may be rejected.

(b) Water Absorption

On first pipe and thereafter on one pipe selected at random out of every day's production, chisel out approximately 0.2 cubic metres of cured lining in as large chunks as possible. Dry the sample in an oven at 100°C to constant mass. Allow to cool to room temperature and determine dry mass to the nearest gram. Immerse sample in clean water for twenty-four (24) hours. Withdraw sample, remove excess surface water and determine saturated mass to the nearest gram.

$$\text{Water absorption \%} = \frac{\text{Saturated mass - Oven dry mass} \times 100}{\text{Oven dry mass}}$$

Water absorption shall not exceed 6 percent.

(c) Concrete Strength

Prepare, cure and test in accordance with SANS Method 863, three 150 mm cubes daily of mortar sampled out of a single batch of mortar selected at random from batches mixed for every day's production. Standard of Acceptance shall be in accordance with Clause 5.8 of SANS 0100, Part II.

21.9.2. CEMENT MORTAR COATING

21.9.2.1. VISUAL INSPECTION

The cured coating in every pipe and special shall be inspected visually for defects before leaving the factory, but not sooner than twenty-one (21) days after application.

The finished coating shall be firm and dense, shall adhere rigidly to the outside of the pipe and the thickness of laitance shall not exceed 1.25 mm.

The coating shall be free from pinholes, craters, cracks, and laminations, although slight surface crazing and hair cracks shall be permissible.

All cracks into which a suitable depth gauge with a probe of 1.5 mm diameter can be inserted to a depth of half the minimum specified thickness, shall be considered a defect and repaired as described in Section 21.10 (CEMENT MORTAR - REPAIR OF DEFECTS)

21.9.2.2. DESTRUCTIVE TESTING

Section 21.9.1.2 shall apply, except that lining shall be read as coating.

21.10. CEMENT MORTAR - REPAIR OF DEFECTS

The relevant sections in Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES) and Section 8.5 (REPAIR OF COATINGS AND LININGS) shall apply.

(a) Repair of Defects

All defective concrete shall be removed and the surrounding area of concrete chipped back to a position where the concrete is firmly bonded to the steel.

The edges of the firm surrounding concrete shall be bevelled to form an angle of 85 degrees with the portion of pipe barrel under repair.

The pipe surface shall be cleared from all signs of concrete and dust.

The pipe surface and surrounding concrete shall then be given one coat of cement/water grout and the fresh mortar applied by hand while the grout coat is still wet. The mortar shall be of the same mix and consistency as the lining.

The repair area shall be built up to the full thickness of the lining, care being taken to ensure complete filling of the bevelled edges with the mortar.

The repaired areas shall be covered by damp hessian, which shall be kept continuously wet for seven (7) days after completion of repair.

22. RIGID POLYURETHANE PIPE COATING SYSTEM

22.1. INTRODUCTION

This part of the Specification defines the minimum technical requirements for liquid applied coating for factory coated pipe and specials. The coating system shall comprise a homogenic layer of 100% solids rigid polyurethane mechanically bonded to the metal substrate.

Where specified it shall be used for the external coating of pipes. The pipeline will be buried and will be protected against external corrosion by the external coating and cathodic protection systems. The external coating (primary corrosion protection system) shall be suitable for the operating conditions applying to the specific pipeline.

The use of rigid polyurethane as a lining is not recommended.

22.2. STANDARDS

Unless otherwise specified herein, the latest edition of the following Standards should be read in conjunction with this Specification:

ASTM	D 16	Standard Test Method for Paint, related coatings, materials, and applications.
ASTM	D 543	Standard Test Method for Evaluating the resistance of plastics to chemical reagents.
ASTM	D 570	Standard Test Method for Water absorption of plastics.
ASTM	D 2240	Standard Test Method for Rubber Property (Durometer Hardness)
ASTM	D 4060	Standard Test Method for Abrasion resistance of organic coatings by the Taber abrader.
ASTM	D 4541	Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
ASTM	G14	Standard test method for impact resistance of pipeline coatings (Falling Weight Test)
ASTM	D 4285	Method for indicating Oil or Water in Compressed Air
EN	10290	Steel tubes and fittings for onshore and offshore pipelines - External liquid applied polyurethane and polyurethane-modified coatings.
ISO	1514	Paints and varnishes - Standard panels for testing.
ISO	2808	Paints and varnishes – Determination of film thickness.
ISO	4624	Paints and varnishes – Pull off test for adhesion.
SANS	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after overall removal of previous coatings.
SANS	8502	Preparation of steel substrates before application of paints and related products - Tests for the assessment of surface cleanliness.
SANS	8503	Preparation of Steel Substrates Before Application of Paints and Related Products - Surface Roughness Characteristics of Blast-Cleaned Steel Substrates. Part 1: Specifications and definitions for ISO surface profile comparators for the assessment of abrasive blast-cleaned surfaces. Part 2: Method of grading of surface profile of abrasive blast-cleaned steel comparator procedure. Part 4: Method for the calibration of ISO

		surface profile comparators and for the determination of surface profile - Stylus instrument procedure. Part 5: Replica tape method for the determination of surface profile.
SANS	8504-2	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast cleaning.
ISO	11124-1	Preparation of Steel Substrates Before Application of Paints and Related Products - Specifications for Metallic Blast Cleaning Abrasives - Part 1: General introduction and classification. Part 2: Chilled iron grit. Part 3: High-carbon cast-steel shot and grit. Part 4: Low-carbon cast-steel shot.
NACE	RP0274	High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation.
NACE	RP0287	Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using a Replica Tape.
NACE	RP0394	Application, Performance, and Quality Control of Plant-applied, Fusion- Bonded Epoxy External Pipe Coating.
SSPC	SP11	Power Tool Cleaning to Bare Metal.
SSPC	PA 2	Measurement of Dry Coating Thickness with Magnetic Gauges (Steel Structures Painting Manual, Ch 5 - Paint Application Specs.).
SSPC	SP 10	Near-White Metal Blast Cleaning NACE No.2-2000 (Steel Structures Painting Manual, Ch 2 - Surface Preparation Specs.).

22.3. MATERIALS

The required coating shall be a two-component liquid applied rigid polyurethane subject to the Approval of the Corrosion Engineer.

The two components shall have different colours allowing the verification of the correct mixing and checking of the uniformity of the colour of the mixed product.

The coating is considered cured when it has attained the hardness recommended by the product manufacturer.

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warrantied by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application

- The SANS mark or SANS 9001 certificate where applicable

22.3.1. HANDLING OF MATERIALS

Materials shall be handled and stored in accordance with the material manufacturer's recommendations, which shall be available for review by the Corrosion Engineer at the Contractor's premises. Materials shall be stored in an air-conditioned, temperature-controlled environment until required for use.

Coating materials shall be segregated by type and batch during storage and handling. Materials from damaged containers shall be rejected, unless otherwise agreed with the Corrosion Engineers representative in the factory or on Site.

Materials shall be used in the order in which they are delivered and before their expiry date for use.

22.3.2. DOCUMENTATION FROM THE MATERIALS MANUFACTURER

The commercial rigid polyurethane coating system offered shall be qualified by the Contractor and will be subject to the Corrosion Engineer's Approval prior to application. Testing should be conducted on each applicable coating and shall meet the Acceptance criteria of the in clause 22.3.3. The qualification shall be based on tests carried out by an independent recognized certifying body and the relevant documents shall be submitted to the Corrosion Engineer.

Full traceability of each batch of coating material shall be maintained. As a minimum, the following data shall be compiled and shall be available for immediate review by all parties:

- Name of manufacturer
- Complete material identification: Trade name, chemical name and type of product details
- Batch number
- Date of manufacture
- Place of manufacture
- Shelf life / expiry date (if appropriate)
- Health and safety, and environmental instructions
- Hazard warnings
- Storage instructions
- Quantity and
- Manufacturing standard.

Any material not labelled with the above information shall not be used.

22.3.3. RIGID POLYURETHANE PROPERTIES

The coating material properties and characteristics with respect to the 100% solids rigid polyurethane coating shall comply with the requirements of a Type V coating type in terms of the ASTM D16 Standard. The coating material shall be a homogenic solvent free layer with a chemical three-dimensional covalent cross-linked structure. The layer shall be made up from a liquid two pack coating system with Part A being poly-isocyanate rich and Part B consisting of polyols or amines that ensures relatively short curing times. Aliphatic polyurethanes shall be used above ground and aromatic polyurethanes shall be used below ground.

The performance properties of the coating shall comply with the requirements stated in the table below. The Contractor shall submit a full and comprehensive product datasheet to confirm material compliance with the Specification.
The cured coating shall comply with the below requirements for pre-qualification:

POLYURETHANE COATING PERFORMANCE REQUIREMENTS

PROPERTIES	TEST REFERENCE	ACCEPTANCE CRITERIA
Minimum application thickness	SSPC PA2 restriction level 1	> 1.5mm
Adhesion to steel	ASTM D 4541 Method E	> 15 MPa
Field Joint Adhesion to factory coating	ASTM D 4541 Method E	> 10 MPa
Adhesion to primed steel after 28-day hot water soak at 70°C	ASTM D 4541 Method E	> 7 MPa.
Adhesion to factory coating after 28-day hot water soak at 70°C	EN 10290 Annex D	rating 4.
Hardness	ASTM D 2240 (Shore D)	As specified by coating manufacturer
Flexibility	EN 10290 (Annex K)	Pass
Tensile strength	ASTM D 638	>15 MPa at 3mm thickness
Resistance to cathodic disbondment	EN 10290 (Annex E)	radius < 8mm (28 days)
Dielectric strength	ASTM D 149	Minimum 15 V/µm
Specific Electrical Insulation Resistance (100 days)	EN 10290 (Annex F)	10^6 ohm.m^2
Impact resistance	EN 10290 (Annex C)	> 5J/mm at 23°C >3J/mm at 5°C
Indentation resistance	EN 10290 (Annex H)	<0.2mm at 23ºC
Water Vapour Permeability	ASTM D 1653	<0,5 g/24 h/m²/mm².
Water absorption	ASTM D 570	< 3% max

22.4. Application

22.4.1. GENERAL

Refer to Section 8 for the quality assurance required on the application of this coating.

22.4.2. SURFACE PREPARATION

Refer to Chapters 6 (MANUFACTURE AND PRE-PREPARATION) & 7 (SURFACE PREPARATION) for the general steel surface preparation requirements. The steel surface shall be grit blasted to Sa 3 in accordance with SANS 8504-1 for surface cleanliness with an anchor profile of minimum 75 µm.

The Quality Control Plan (QCP) hold point at the completion of the surface preparation shall be subject to the signing off by the Approved Inspection Authority (AIA) prior to the application of the coating material for all pipes, specials, and joint repairs Coating Application.

The application of the coating shall only proceed once the cleanliness of the steel substrate has been approved and the substrate temperature is more than 3ºC above the dew point temperature. The work area shall be kept dry as the polyurethane materials react with humidity and moisture.

When required the surface shall be heated using an induction heating coil, radiant heaters or hot air to a temperature as recommended by the coating material manufacturer and in accordance with this Specification. The temperature shall not exceed 85°C and the use of propane torches or gas burners for pre-heating and post-heating is expressly prohibited. Infrared heaters may be used for post-heating. The temperature of the bare steel shall be monitored using contact thermometers or infrared thermometers.

22.4.3. COATING APPLICATION

The individual liquid components of the rigid polyurethane coating shall be agitated thoroughly before use to disperse pigments and assure homogeneity. No thinning shall be done, and the components shall not be mixed together.

The material shall be applied using a plural component, adjusted to the specified mix ratio on a heated airless spray unit with metering pumps. The width of the spray jet, the set-up distance from the substrate surface and the overlap, the pipe rotation speed and the rate of application shall be predetermined for the final required dry film thickness applied in the workshop.

The wet film thickness shall be measured in accordance with SANS 2808. Particular attention shall be paid to the recommended dry film thickness which shall be measured in accordance with SSPC PA 2 with specific reference to Section 9 of SSPC PA 2 and restriction level 1. Tools and equipment shall be cleaned using only such solvents as are recommended by the product manufacturer. Particular care shall be taken in the handling of the coated items before the coating has reached the minimum value of hardness recommended by the manufacturer. All pipes and other components shall be high voltage spark holiday tested in accordance Section 8.4.2.2 (Test Method B (High Voltage)) (minimum 15 kV for 1.5 mm DFT).

For factory-coated pipe, bends and specials the cut-back shall be 150 ± 20 mm. The edge of the cut-back shall be feathered at 30 – 45°.

Site or hand application shall be undertaken using 1:1 material to minimise the risk of off ratio product.

It is mandatory that for all plural spray application of polyurethane that the application shall start and end, off the target work piece. No triggering of the spray equipment is permitted on the workpiece during spraying in order to prevent polyol-rich splodges.

Refer to Section 8.3.3.3 (Plural Spray Mixing) for mitigation of mix ratio risk.

22.4.4. INSPECTION AND TESTING

The Contractor shall demonstrate that the proposed coating material and procedures will meet the requirements of this Specification when applied to pipes and pipe specials. The Contractor shall provide the documentation proof that the final selected coating material complies with the requirements listed in the table under clause 22.3.3.

The Contractor shall test the finished coating during production to demonstrate continued compliance with this Specification. Details of all inspections and testing shall be fully documented in accordance with the approved quality control plan mentioned in Section 4.4 (QUALITY PLAN AND DOCUMENTATION).

All stages of the surface preparation, coating and testing shall be subject to 100% inspection by the Contractor. The Corrosion Engineer shall be informed at least two weeks prior to the start of surface preparation to allow scheduling of inspection personnel in the factory as well as on Site.

22.4.5. TESTING OF PRODUCTION PIPES

The Contractor shall execute the following tests and provide written documentation proof of the test results within the agreed time frames:

22.4.5.1. VISUAL INSPECTION (EVERY PIPE)

The coating shall be smooth, glossy, free from pin holes, excessive orange peel effect, bubbling or excessive runs or sags.

(a) Dry Film Thickness (every pipe)

DFT shall be inspected in accordance with SANS 2808. The minimum thickness shall be 1.5mm in order to comply with table in 22.3.3.

(b) Electrical Insulation Defects (Holiday) Inspection (every pipe)

The coating shall be free from electrical insulation defects when tested with a high voltage holiday detector set at 15 kV.

(c) Hardness Shore ‘D’ (every pipe)

The Shore ‘D’ hardness shall comply with the minimum set by the manufacturer in pre-qualification.

(d) Adhesion (1 test per shift).

The pull-off adhesion at 23ºC shall be greater than 15 MPa.

(e) Cathodic Disbondment (1 test per shift and commencement of new batch or new production run)).

The disbondment shall be less than 8mm radius. EN 10290 Annex E 48hr.

(f) Composition (1 test per shift or new batch or new production run)

The TGA (Thermo Gravimetric Analysis) scan shall be checked against the manufacturer’s qualification scan.

22.4.6. HANDLING

Pipes shall be handled in accordance with the requirements of Section 5.4 (HANDLING AND TRANSPORT). The coating materials shall be handled, stored, applied, and cured in accordance with the recommendation of the specific material manufacturers.

As the coating requires a certain time to cure the pipes should not be handled prior to the coating achieving sufficient cure. The coating is considered sufficiently cured and ready for handling when it has attained the hardness recommended by the product manufacturer.

22.4.7. COATING REPAIRS

Since polyurethane systems are chemically cured, very thorough abrasion of damaged or defective coating is required to ensure an adequate mechanical bond.

22.4.7.1. REPAIRS BEFORE FULL CURE

[Within Sixteen (16) Hours at 23°C of Application of Last Coat]

The area to be over-coated shall be abraded with abrasive paper grade 220 to a uniform matt finish.

The abraded surface shall be vacuum-cleaned or be blown clean with uncontaminated dry compressed air to remove dust and debris.

Brush grade polyurethane shall be applied in as many coats as are required to achieve the specified thickness free of electrical insulation defects.

22.4.7.2. REPAIRS AFTER FULL CURE

[After Sixteen (16) Hours at 23°C of Application of Last Coat]

The area to be over-coated shall be abraded with abrasive paper grade 220 to a uniform matt finish.

The abraded surface shall be vacuum-cleaned or be blown clean with uncontaminated dry compressed air to remove dust and debris.

The coating manufacturer's adhesive primer or activating solvent shall be applied only to the abraded surface.

After the designated curing time, brush grade polyurethane shall be applied in as many coats as are required to achieve the specified thickness free of electrical insulation defects.

Repairs shall be carried out with repair grade materials of the same grade as the spray-applied coating. The repairs shall be tested in accordance with approved procedures recommended by the material manufacturers. The Contractor shall confirm material compatibility and surface preparation requirements.

Based on the above the Contractor shall prepare a detailed method statement on the repair of the coating for the Approval of the Corrosion Engineer.

22.4.8. FIELD JOINTS

22.4.8.1. GENERAL

The surface to be coated on Site shall at the time of application be dry and free of dust and any contamination detrimental to the adhesion of the coating to the steel substrate. The Contractor shall prepare a detailed method statement on how the field joint area will be kept dry and clean during the application operation. It shall also include the trench space requirements for the application equipment.

22.4.8.2. BLAST CLEANING ABRASIVES

All types of abrasive that are used in the preparation of the field joints and small repairs shall comply with ISO 11124-2 to 4.

22.4.8.3. SURFACE PREPARATION

Abrasive blast cleaning in accordance with Chapter 7 (SURFACE PREPARATION) shall be used for field joint surface preparation as well as larger areas requiring repair. The minimum standard of cleanliness of the surface after abrasive cleaning shall be Sa 3 in terms of SANS 8501-1.

The edges of the mainline coating shall be chamfered and a minimum overlap of 50 mm onto the mainline coating shall be abraded to obtain a surface profile between 40 and 70 µm.

Hand or power cleaning can be used for small repair areas such as pinholes and areas inaccessible for blast cleaning. 80 Grit or coarser sandpaper can be used to suitably roughen and abrade the area to be prepared. The area shall be sanded to the substrate taking care not to polish the substrate.

22.4.8.4. SUBSTRATE TEMPERATURE CONTROL

The application of the coating shall only proceed once the cleanliness of the steel substrate has been approved and the substrate temperature is more than 3ºC above the dew point temperature.

The temperature of the substrate shall be within the application temperature range specified by the coating manufacturer. When required the surface shall be heated using an induction heating coil, radiant heaters or hot air to a temperature as recommended by the coating material manufacturer and in accordance with this Specification.

23. VISCO-ELASTIC COATING SYSTEMS

This part of the Specification is applicable to field joint coatings and factory coating of pipes.

23.1. MATERIALS

(a) The Contractor shall have available the latest editions of all the relevant National specifications and Codes of Practice and the manufacturer's data sheets of materials to be used.

(b) Materials offered and subsequently approved shall not be changed without written Approval of the Corrosion Engineer.

(c) The coating and lining material selected shall be warrantied by the material manufacturer as fit for purpose to provide the anticipated life expectancy requirements described in the project specifications. The Corrosion Engineer shall receive written verification from the material manufacturer that the materials comply with the specified requirements.

(d) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SANS mark or SANS 9001 certificate where applicable

23.1.1. VISCO-ELASTIC INNER WRAP

For factory coating together with the glass reinforced epoxy outer wrap, the inner wrap shall be a fabric backed polyisobutylene tape 1 – 1.2mm thick.

For hand application, the inner wrap shall be a high temperature pipeline grade 1.5mm thick polyisobutylene tape of appropriate width for field joints, bend, and specials.

23.1.2. FACTORY APPLIED GLASS REINFORCED EPOXY OUTER WRAP

The glass woven roving for factory applied outer wrap shall be 600gsm.

The epoxy for saturating the glass shall be a bespoke solvent free 2–component resin designed for pipeline encapsulation. An additional accelerant or retardant may be required based on seasonal application temperatures.

The outer veil for factory application shall be a non-woven 30gsm glass tissue which prevents the glass strands of the outer wrap from protruding outside the epoxy coating thus creating a smooth and uniform finish.

23.1.3. ADHESIVE PE/PVC OUTER WRAP FOR FIELD JOINTS

Either polyethylene (PE) or PVC outer wrap shall be 300µm tape with synthetic butyl rubber adhesive.

23.2. Application

23.2.1. SURFACE PREPARATION

Surfaces shall be prepared in accordance with Chapter 7 (SURFACE PREPARATION) and shall conform to the requirements for the rough blast to ensure that all millscale is removed.

This specification does not permit the application of visco-elastic to steel surfaces that have not been grit blasted.

All requirements for contamination, residual dust and debris, surface temperature and environmental parameters shall be complied with.

23.2.2. FACTORY COATING

23.2.2.1. MACHINE WRAPPING PROCEDURE

Apply a single circumferential wrap at each end of the pipe to define the 100mm cut-back for welding.

Apply the inner wrap in a spiral with a minimum 10mm overlap, starting and finishing on the circumferential wrap each end of the pipe.

Ensure that the inner wrap is free of folds, bubbles, and fish-mouths.

Holiday test the inner wrap at 10kV and repair any insulation defects.

Prepare the epoxy for the outer wrap by mixing the components in accordance with the required pump mix ratios, as per the manufacturer's data sheets.

Saturate the start of the glass fibre outer wrap and draw it through the epoxy, ensuring that the glass fibre fabric is fully coated.

Apply the saturated outer wrap in a spiral at 50% overlap ensuring that there are no wrinkles or entrapped air bubbles.

Whilst the epoxy is still wet, apply the synthetic veil tissue in a spiral to cover the woven roving edges, side by side with no overlap onto itself.

Allow the outer wrap to cure prior to handling and stock piling. Pipes must be stored on custom racks which contact the pipe only on the cut-back ends. Until the coating is cured, the use of slings is prohibited.

23.2.2.2. ARMOURED COATING

Where armoured coating is specified in a pipe laying specification, apply an additional layer of glass reinforced epoxy outer wrap in the factory, or apply a layer of moisture cured urethane impregnated glass tape at 55% overlap in the field.

23.2.2.3. PIPE ENDS

No coating is to be applied to the pipe ends as they are required to be left bare for welding.

23.2.3. HAND APPLIED COATING OF SPECIALS

(Visco elastic Polyisobutene systems can be used in conjunction with any pipeline coating)

The inner wrap may be applied spirally, or cigarette wrap as appropriate with 10mm adjacent and 100mm circumferential overlap.

As the hand applied inner wrap tape is thicker than the factory applied tape, the inner wrap shall be holiday tested at 15kV prior to application of the outer wrap.

Adhesive PVC/PE outer wrap shall be applied spirally with 55% overlap.

23.2.4. FIELD JOINTS

(Visco elastic Polyisobutene systems can be used in conjunction with any pipeline coating)

Field joints shall be free of all contamination, weld spatter and flux.

The (previously grit-blasted) surface shall be prepared to grade St2 of SANS 8501-1

Prior to application of the field joint coating, the surfaces of the field joint and the adjacent factory coating shall be wiped down with isopropanol.

Apply the polyisobutylene inner wrap to the field joint with 50mm overlap onto the factory applied coating and 100mm overlap onto itself.

Ensure the circumferential overlap is correctly weatherboarded.

Apply the adhesive PVC/PE outer wrap with 55% overlap and 100mm overlap onto the factory applied coating.

23.2.5. VISUAL INSPECTION

The completed pipe or pipeline shall be visually inspected for mechanical damage prior to transport, on receipt at site and prior to backfilling. Any visual damage shall be assessed and repaired as appropriate (see sections 23.2.6 (HOLIDAY TESTING) and 23.2.7 (REPAIR METHODS)).

23.2.6. HOLIDAY TESTING

Holiday testing shall be conducted on completion of application of the inner wrap, whether applied to pipes, specials, or field joints.

In addition, the completed pipeline shall be tested at 25kV after laying and prior to backfilling.

23.2.7. REPAIR METHODS

23.2.7.1. DAMAGE TO SUBSTRATE

Areas dis-bonded or damaged through to the substrate shall be repaired as follows:

- Remove any loose or disbonded coating and chamfer the edges of the sound coating.
- Clean the exposed steel surface and wipe the steel and surrounding coating with isopropanol.
- Apply a patch of 1.5mm pipeline grade inner wrap overlapping 50mm onto the sound coating.
- For tape wrapped surfaces, apply a full circumferential wrap of adhesive PE/PVC with 55% overlap and 100mm overlap onto the sound coating.
- For GRE coated surfaces, abrade the edges of the damaged area, apply a patch of the woven roving and saturate the fabric with a repair kit of 2 part epoxy of the same kind as is used in the factory application.

23.2.7.2. PARTIALLY DAMAGED

- Areas where the outer wrap is damaged without exposing the substrate shall be verified by means of holiday detection and repaired with a full circumferential wrap of adhesive PE/PVC with 55% overlap extending 100mm beyond the damaged area or abrade the edges of the damaged area, apply a patch of the woven roving and saturate the fabric with a repair kit of 2 part epoxy of the same kind as is used in the factory application, as appropriate.

24. RUBBER LINING

STANDARDS

EN	14879-1	Organic coating systems and linings for protection of industrial apparatus and plants against corrosion caused by aggressive media – Part 1: Terminology, design and preparation of substrate.
SANS	1198	The manufacture of rubber sheeting for rubber lining.

24.1. GENERAL REQUIREMENTS

The rubber lining standards in SA are SANS 1201 and SANS 1198 for application to new steel.

It is predominantly used in mining and in water treatment plants. In the raw water and potable water industry, rubber lining is only used for specialised applications such as valves and slurry handling material, and in sand filters.

For maintenance applications, great care must be taken as rubber lining requires a smooth surface. Pitting of steel surfaces due to corrosion and proud welds are not allowed for rubber lining. One of the limitations of rubber is when the steel surface is pitted, the rubber does not follow the contours and fill the pits, leaving micro voids behind the rubber.

Rubber lining over pitted steel always leaves voids and micro spaces under the rubber sheet, which is one of the main reasons why rubber lining over a corroded surface has reduced life expectancy.

The steel finish required for maintenance rubber lining shall meet the requirements of EN 14879 Part 1:2005 Table 4 – Substrate imperfections – Class A4 - For a nominal lining thickness (natural or synthetic rubber sheeting) over 1 mm. Refer to pictorial diagrams in Annex G: SUBSTRATE IMPERFECTIONS - EN 14879.

Selected extract from Table 4 – Substrate imperfections – Class A4:

- For autoclave vulcanised rubber, permitted where $R_z \leq 160$ µm; otherwise, permitted where $R_z \leq 100$ µm.
- Shallow pits with a width/depth ratio of 30 or higher are permitted for rubber lining.
- Permitted when the initial condition of the substrate does not correspond to a rust grade higher than C as in EN ISO 12944-4.
-

Selected extract from Table 5 – Weld imperfections – Class A4:

- Weld bead permitted where b/h ≥ 10. Where b is the bead width and h is the bead height.

For more details weld finish refer to 6.2.5.3 (Weld Finish for rubber lining) and refer to pictorial diagrams in Annex H: WELD IMPERFECTIONS - EN 14879.

The EN 14879 requirements are more comprehensive with respect to steel finish before blasting and requirements for rubber lining than SANS 1201 and SANS 1198.

Rubber lining shall not be used for mainline pipe lining.

Rubber lining is applied as sheet and is typically available in 1.2m or 1.5m widths. This as a consequence requires special attention to the joints being the weakest point in the corrosion protection system. The joints shall be scarf in scarf out with overlap or bevelled joints as per the figures in the standard. Rubber lining of valves and flange faces shall have the rubber buffed smooth at all overlap joints.

For the bulk water industry, the rubber shall be a soft natural rubber Class I type A 50 shore A IRHD material with a minimum thickness of 5mm unless otherwise specified.

Default specification for fully bonded rubber is to use uncured rubber compound and pressure steam cure in an autoclave because the bond strength to steel is approximately double that when

compared to precured rubber.

For small bore butterfly valves the use of pre-moulded and precured rubber inserts are permissible.

Quality control shall include high voltage spark testing at 3000V/mm thickness or 15kV for 5mm.

25. GALVANIZING

The standard for Hot Dip galvanizing in SA is SANS 121. This is the identical specification to ISO 1461. These two standards do not include the specification for heavy duty galvanizing. For heavy duty galvanizing increased thickness, refer to the table in Section 25.4.2.2 (Thickness).

STANDARDS

Reference is made to the latest issues of the following Standard Specifications:

EN	1179	Zinc and zinc alloys – Primary zinc
EN	10240	Internal and/ external protective coatings for steel tubes. Specification for hot dip galvanized coating applied in automatic plants
ISO	1461	Hot dip galvanized coatings on fabricated iron and steel articles – Specification and test methods
ISO	12944-5	Paint and Varnishes – Corrosion protection of steel structures by protective paint system – Part 5: Protective Paint Systems
ISO	752	Zinc Ingots
SANS	32	Internal/external protective coatings for steel tubes.
SANS	121	Hot-dip galvanized coatings on fabricated iron and steel articles - Specifications and Test Methods
SANS	14713	Zinc coatings – guidelines and recommendations for the protection against corrosion for iron and steel in structures.
SANS	2063	Thermal spraying – Metallic and other inorganic coatings – Zinc, aluminium and their alloys

25.1. GENERAL REQUIREMENTS

- Only permissible for use with pipes up to 200 mm diameter maximum and flow velocity less than 2 m/s.
- It is a requirement that buried galvanized pipe be externally overcoated (duplex system) or wrapped with one of the specified materials in this specification.
- Galvanized structures and pipes shall not be subject to stagnant water conditions due to corrosion associated with oxygen depletion cells.
- Galvanized Pipes shall not be embedded in concrete
- Water analysis shall be provided so that the Corrosion Engineer can evaluate and decide if internal polymer lining/over coating is necessary to be applied on top of the galvanized.
- Galvanized structural steel for C4 and C5 atmospheric conditions as defined by ISO 12944-5 shall be duplex coated.
- Structural steel inside valve chambers shall not be galvanized.
- Zinc electro-plating of bolts and fasteners is not permitted due to the risk of hydrogen embrittlement and low film thickness.

25.2. MATERIAL

(a) The impurities in the molten zinc, as defined in ISO 752 and EN 1179, shall not exceed a total 1,5 percent.

(b) Steel to be hot-dip galvanized shall be:
  (i) For aesthetic appearance
    - Aluminium-killed steel or
    - Silicon-killed steel with a Silicon content not exceeding 0,04 percent and a Phosphorus content not exceeding 0,02 percent.

NOTE: Material certification shall be supplied.

(i) For general corrosion protection
- Aluminium killed steel or
- Silicon killed steel with a Silicon content not exceeding 0,25 percent and a Phosphorus content not exceeding 0,02 percent.

(c) The condition of articles to be hot-dip galvanized shall comply with ISO 14713-2.
(d) The condition of tubes to be hot-dip galvanized on a continuous line shall comply with "Annex A" of EN 10240.

25.3. APPLICATION

(a) Shall only be done by members of the Hot Dip Galvanizers Association of Southern (HDGASA) in accordance with SANS 9001.
(b) Shall be in accordance with SANS 121 / ISO 1461 and EN 10240 for tubes.

25.4. TOLERANCES

25.4.1. STEEL SPECIALS

Shall be in accordance with clause 6 of SANS 121 / ISO 1461.

25.4.1.1. SURFACE FINISH

The surfaces shall be free from nodules, blisters, roughness, and sharp points. Un-coated areas, flux residues, lumps and zinc ash shall not be permitted.

Notwithstanding Clause 6.1 of SANS 121 / ISO 1461., in the case of handrails etc. a high-quality surface finish is required, and a bright smooth surface shall be achieved. Only materials specified under Section 25.2 (MATERIAL) shall be utilised. Double dipping shall not be allowed.

25.4.1.2. THICKNESS FOR STRUCTURAL STEEL

The thickness of hot-dip galvanizing shall comply with the requirements for heavy duty in the table below.

Minimum galvanizing thicknesses on items that are not centrifuged.

ARTICLES AND ITS THICKNESS		HEAVY DUTY GALVANIZING Coating thickness µm (min)	LIGHT DUTY GALVANIZING	
			Local coating thickness µm (min)	Mean coating thickness µm (min)
	Steel ≥ 6,0 mm	105	70	85
3,0 mm ≤	Steel < 6,0 mm	80	55	70
1,5 mm ≤	Steel < 3,0 mm	65	45	55
	Steel < 1,5 mm	55	35	45
	Castings ≥ 6,0 mm	105	70	80
	Castings < 6,0 mm	-	60	70

Heavy duty galvanizing is required except in the following cases:
(a) Where a highly smooth finish is required.
(b) Where otherwise specified in the Project Specification.

25.4.2. STEEL TUBES

Galvanized tubes up to a maximum of 200mm NB shall be in accordance with clause 7 of EN 10240.

25.4.2.1. SURFACE FINISH

The surface of the coating shall be continuous, smooth and free from flux residues.

25.4.2.2. THICKNESS FOR GALVANIZED TUBES

The thickness of galvanizing on tubes less than 200mm NB shall comply with the requirements of the coating quality A1, in accordance with clause 8, Table 1 of EN 10240: 2004, as specified below.

Minimum local coating thickness requirements for coating quality A1

Requirements	Coating quality A1
Minimum local coating thickness on the inside surface of a tube except at the weld bead	55 µm
Minimum local coating thickness on the inside surface at the weld bead	28 µm
Minimum local coating thickness on the outside surface	55 µm

25.4.2.3. ADHESION

The coating shall show no evidence of flaking or cracking when tested in accordance with clause 11.4 of EN 10240.

25.4.2.4. COATING QUALITIES

(a) Coating qualities shall be A1 for water installations – see sub-clause 8.2 of EN 10240.
(b) The surface of the coating on the inside shall be as smooth as can be achieved by steam blowing.

25.5. TESTING

25.5.1. STEEL ITEMS

To be read in conjunction with Section 4.3 (QUALITY ASSURANCE AND PROCEDURES).

EN 10240:2004 a Type 3.2 inspection certificate shall be issued by the manufacturer's independent third-party inspector and the purchaser's inspection representative.

25.5.1.1. VISUAL EXAMINATION

Where a superior aesthetic appearance of hot-dip galvanizing is requested, a bright mirror surface finish shall be achieved by the galvanizer.

25.5.1.2. THICKNESS

Thicknesses shall be in accordance with Section 25.4.1.2 (Thickness) and shall be tested in accordance with sub-clause 6.2 of SANS 121 / ISO 1461.

25.5.2. STEEL TUBES

To be read in conjunction with Section 4.3 (QUALITY ASSURANCE AND PROCEDURES).

25.5.2.1. VISUAL EXAMINATION

Where a superior aesthetic appearance of hot-dip galvanising is requested, a bright mirror surface finish shall be achieved by the galvanizer.

25.5.2.2. THICKNESS TEST METHOD

Shall be tested in accordance with sub-clause 11.3 of EN 10240.

25.5.2.3. ADHESION

Shall be tested in accordance with sub-clause 11.4 of EN 10240.

25.5.2.4. CHEMICAL ANALYSIS

Shall be tested in accordance with sub-clause 11.5 of EN 10240.

25.6. REPAIR METHODS

25.6.1. STEEL ITEMS

The total un-coated areas for renovation by the galvanizer shall not exceed 0,5 percent of the total surface area of a component. Each un-coated area for renovation shall not exceed 400 mm². If un-coated areas are larger, the item containing such areas shall be re-galvanized. The repair method shall be approved by the Corrosion Engineer before repairs are initiated.

The repairs shall include removal of any scale, cleaning, and any necessary pre-treatment to ensure adhesion – refer surface preparation Section 7 (SURFACE PREPARATION).

Repairs shall be by either zinc thermal spray in accordance with SANS 2063 or solvent free zinc rich epoxy with a minimum 80% zinc in the dry film.

Repairs shall be in accordance with Section 8.5 (REPAIR OF COATINGS AND LININGS).

The coating thickness on the renovated areas shall be a minimum of 30 µm more than the local coating thickness specified in Section 25.4.1.2 (Thickness) for the relevant hot-dip galvanized coating unless otherwise specified by the Corrosion Engineer. The coating on the renovated areas shall be capable of giving sacrificial protection to the steel to which it is applied.

25.6.2. STEEL TUBES

- Repairs shall not be allowed on internal surfaces of tubes. Tubes shall be re-galvanized.
- Repairs on external surfaces shall be in accordance with Section 8.5 (REPAIR OF COATINGS AND LININGS) as defined for Minor repairs in Section 8.5.1.

25.7. DUPLEX SYSTEM (HOT-DIP GALVANIZING + ORGANIC COATING)

25.7.1. SURFACE PREPARATION

25.7.1.1. SURFACE PASSIVATION

Items to be over-coated shall not be passivated.

25.7.1.2. CONTAMINANTS AND PHYSICAL FACTORS

The following contaminants shall be removed:

(a) Galvanizing residues and passivation products.
(b) Oil and grease.
(c) Perspiration and oil contamination from contact with hands.
(d) Dust and chemical contamination.

25.7.1.3. DEGREASING OF GALVANIZED SURFACES

Galvanized steel surfaces shall be degreased prior to coating, using either a water-soluble solvent degreaser in accordance with SANS 1344 and the manufacturer's instructions, or a mild acid-detergent degreasing solution to be approved by the Corrosion Engineer.

25.7.1.4. SWEEP BLAST-CLEANING OF GALVANIZED SURFACES

Large areas shall be prepared by sweep-blasting with non-metallic abrasive in accordance with Section 7.2.7.7 (Sweep-Blasting). Cracking, flaking, or any form of de-lamination of the zinc coating due to excessive blast-cleaning shall not be permitted. Removal of zinc by blast-cleaning shall not exceed 10 µm.

25.7.1.5. MECHANICAL CLEANING

Surfaces that cannot be sweep-blasted shall be abraded manually or mechanically with abrasive paper having a minimum roughness grade 220 or non-metallic abrasive pads.

25.7.2. APPLICATION

Organic coatings shall be applied to the galvanizing immediately after surface preparation in accordance with Section 8.3.3 (COATING APPLICATION). All coating materials shall be applied strictly in accordance with the manufacturer's instructions.

In the case of nuts, bolts and other fasteners, care shall be taken to ensure that all edges are over-coated to the minimum specified thickness.

Only coatings approved by the Corrosion Engineer for application on hot-dip galvanized surfaces shall be used.

COATING OVER GALVANIZING

ENVIRONMENT	SYSTEM		
For dry conditions	Epoxy primer for galvanized surfaces See note 1		One coat of re-coatable polyurethane See note 4
For wet/submerged conditions	Epoxy primer for galvanized surfaces See note 1	One coat of polyamine or polyamide cured epoxy See note 2	One coat of re-coatable polyurethane See note 4
		Fusion Bonded Epoxy or Fusion Bonded Polyester See note 3	One coat of re-coatable polyurethane See note 4

NOTES:

1. Epoxy primer 40 to 80 µm
2. Epoxy 125 to 150 µm
3. FBE or FBPE 125 µm
4. Re-coatable polyurethane 50 µm minimum

Repairs Of Duplex System

To repair coatings damaged during transportation, handling or erection, the following procedures shall be followed:

25.7.2.1. DAMAGE DOWN TO BARE STEEL

(a) Degrease in accordance with Section 7.2.3 (DEGREASING).
(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with grade 80 abrasive paper.
(c) Vacuum-clean the surface to remove dust and debris in accordance with Section 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).
(d) Where originally over-coated with two component epoxies, wipe the surface with methyl ethyl ketone and allow to dry.
(e) Apply sufficient coats of three component zinc solvent free epoxy to a dry film thickness of 30 µm more than the original thickness of the zinc.
(f) When dry, apply the same system as originally applied so as to cover the damaged area extending for 25 mm over the surrounding area.

NOTE:

1. When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.
2. Apply a final topcoat over the repaired area to achieve a pleasing, uniform finish of the item.

25.7.2.2. DAMAGE DOWN TO ZINC SURFACE

(a) Prepare the surface as described in Sections 7.5.1 (GALVANIZED SURFACES TO BE COATED) and 7.4.1 (SURFACE PREPARATION PARAMETERS FOR NEW STEEL).
(b) Apply coating as described in Section 8.3.3 (COATING APPLICATION).

NOTE: **1.** When solvent borne materials are used, curing time between coats, as specified by the material manufacturer, shall be adhered to.

2. Apply a final topcoat over the repaired area to achieve a pleasing, uniform finish of the item.

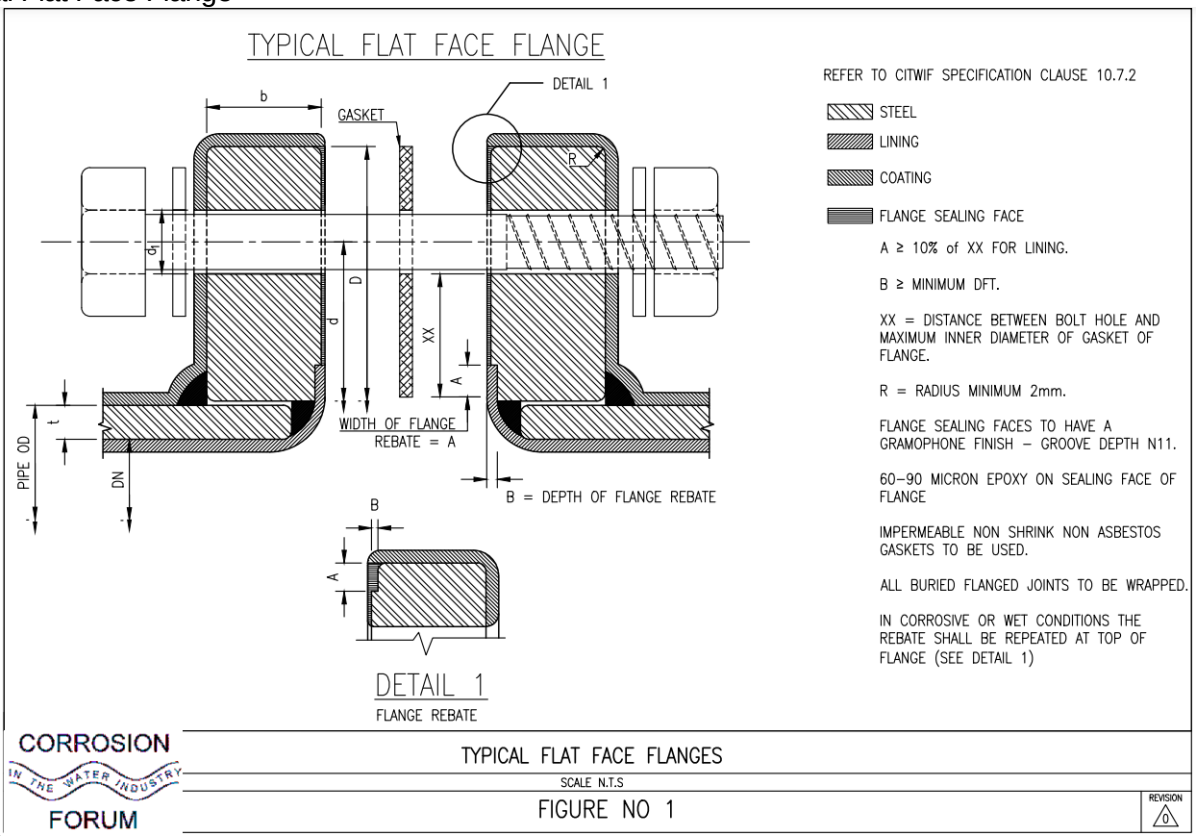
26. ANNEX

ANNEX A: ACRONYMS

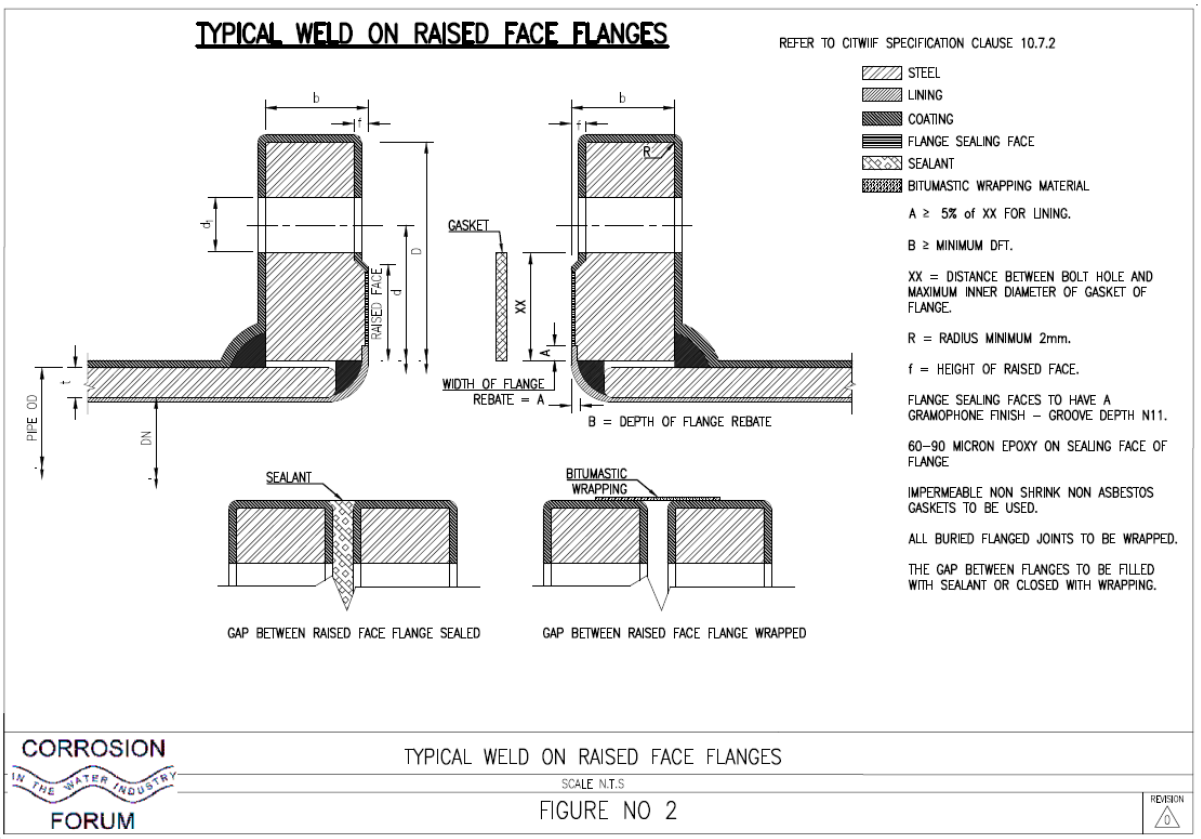
ACA	Australian Corrosion Association
AMPP	The Association for Materials Protection and Performance (previously NACE & SSPC)
API	American Petroleum Institute
APS	Application Procedure Specification
ASNT	American Society for Non-destructive Testing
CIP	Coating Inspection Programme
CoC	Certificate of Compliance
CorrISA	Corrosion Institute of Southern Africa
CD	Cathodic Disbondment
CP	Cathodic Protection
DFT	Dry Film Thickness
DWS	Department of Water & Sanitation
EIDs	Electrical Insulation Defects
EIS	Electrical Impedance Spectroscopy
FBE	Fusion-bonded Epoxy
FBPE	Fusion-bonded Polyethylene
HDG	Hot-dip galvanized
ICorr	Institute of Corrosion (United Kingdom)
IMESA	Institute of Municipal Engineers of Southern Africa
IOZ	Inorganic Zinc - Silicate paint
ISO	International Standards Organisation
ITP	Inspection and Testing Plan
MEK	Methyl Ethyl Ketone solvent
MIC	Microbial Induced Corrosion
MIO	Micaceous Iron Oxide
MVT	Moisture Vapour Transmission
NACE	see AMPP
NDT	Non-Destructive Testing
PPT	Pre-Production Trials
PQT	Procedure Qualification Trial
PVA	Poly Vinyl Acetate
QCP	Quality Control Plans
RFQ	Request for Quotation
SABS	South African Bureau of Standards
SAINT	South African Institute of Non-Destructive testing
SAIW	South African Institute of Welding
SANS	South African National Standards
SAQCC	South African Qualifications and Certification Committee (Corrosion Protection)
SAW	Submerged Arc Welded
SS	Stainless steel – grades 304L or higher
SSPC	see AMPP
UV	Ultra Violet
WSA	Water Services Authorities
WSP	Water Services Providers
µm	Micrometre (micron)
3Cr12	Corrosion resistant steel

ANNEX B: DRAWINGS

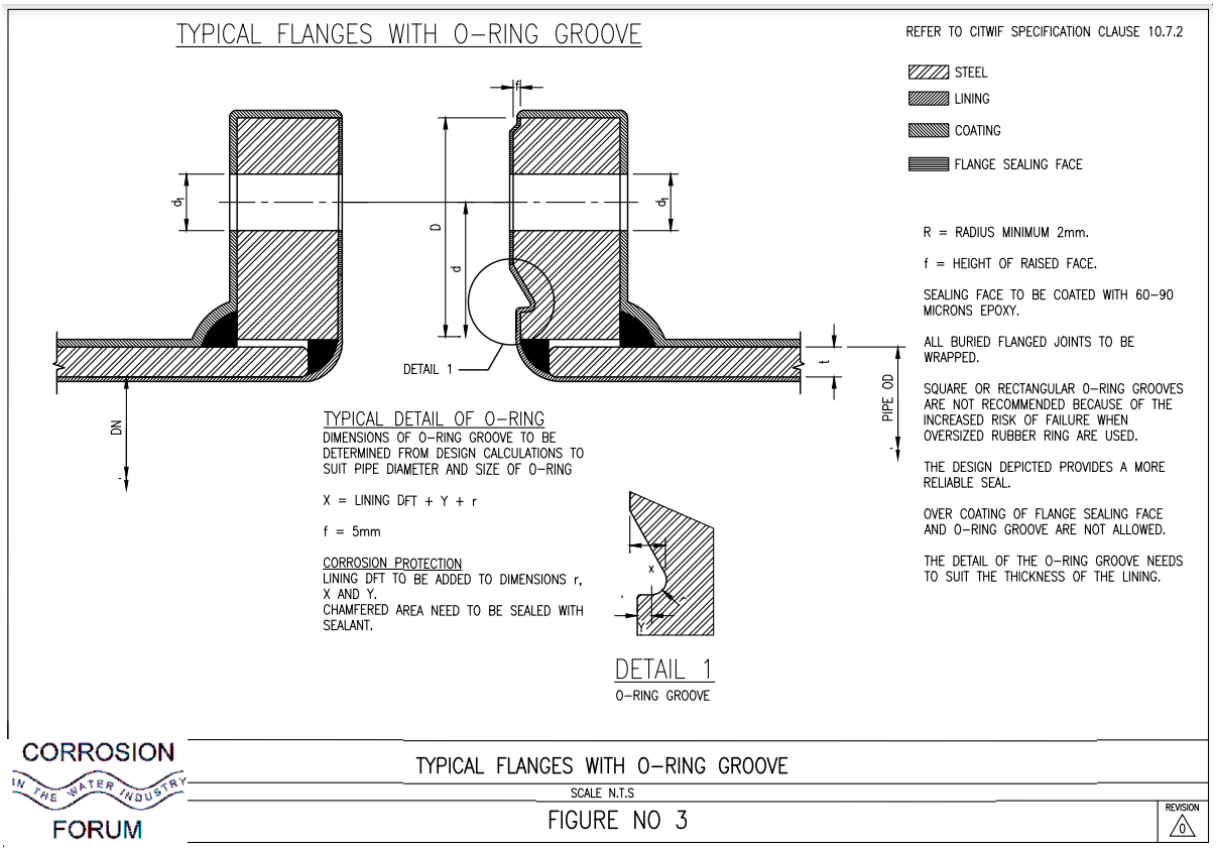
Typical Flat Face Flange



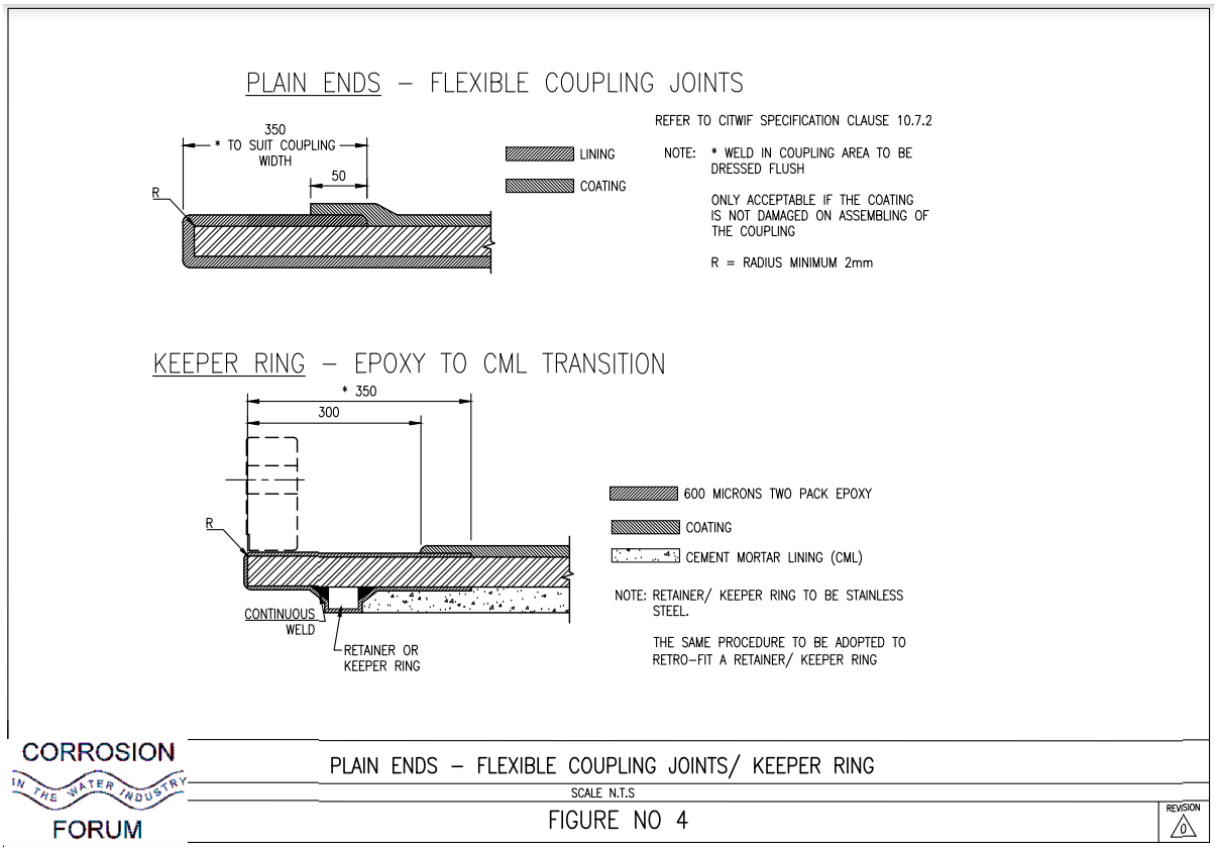
Typical Weld on Raised Face Flanges



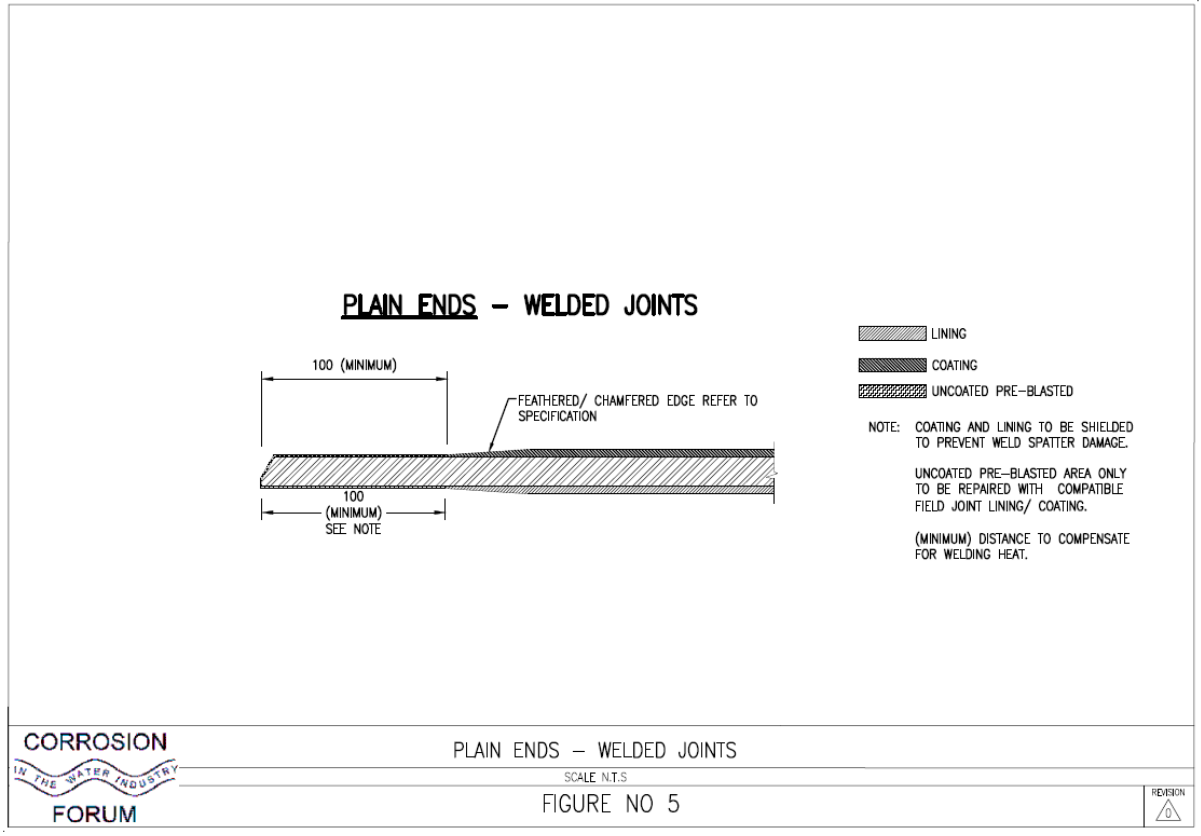
Typical Flanges with O-Ring Groove



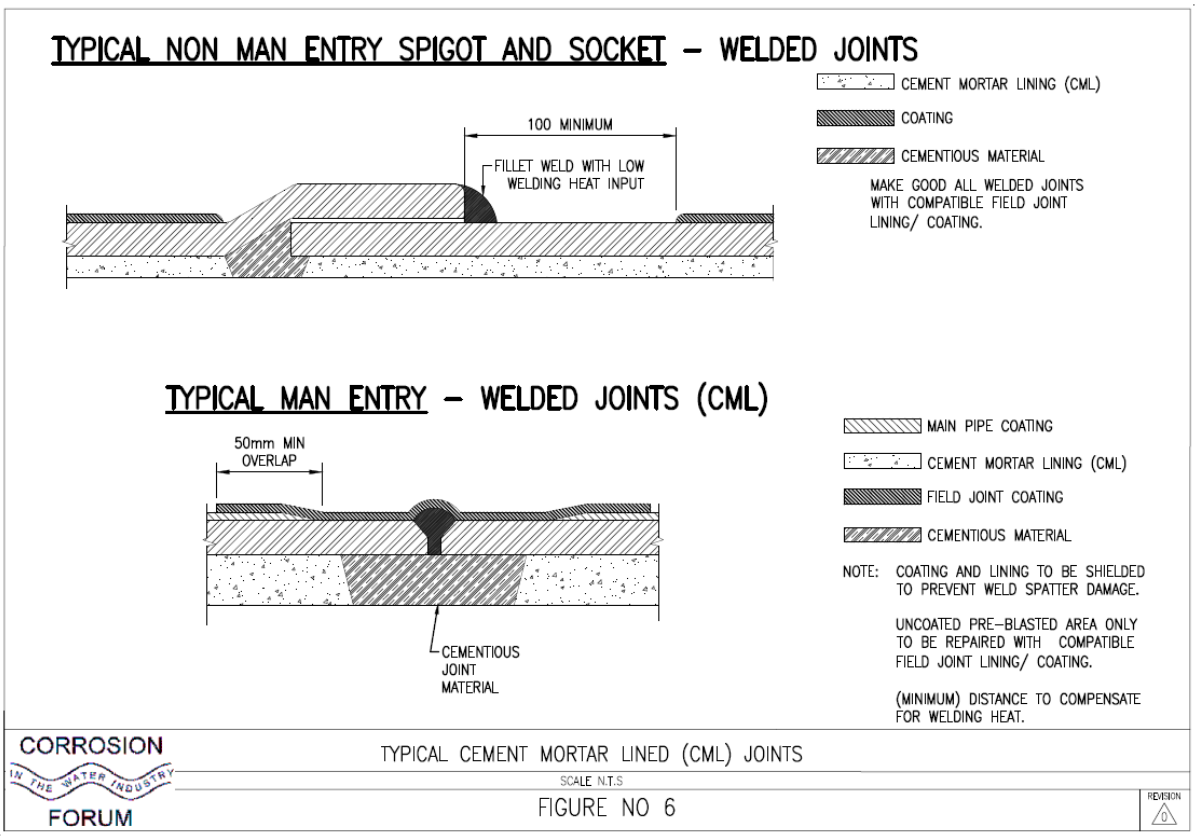
Typical Plain Ends – Flexible Coupling Joints



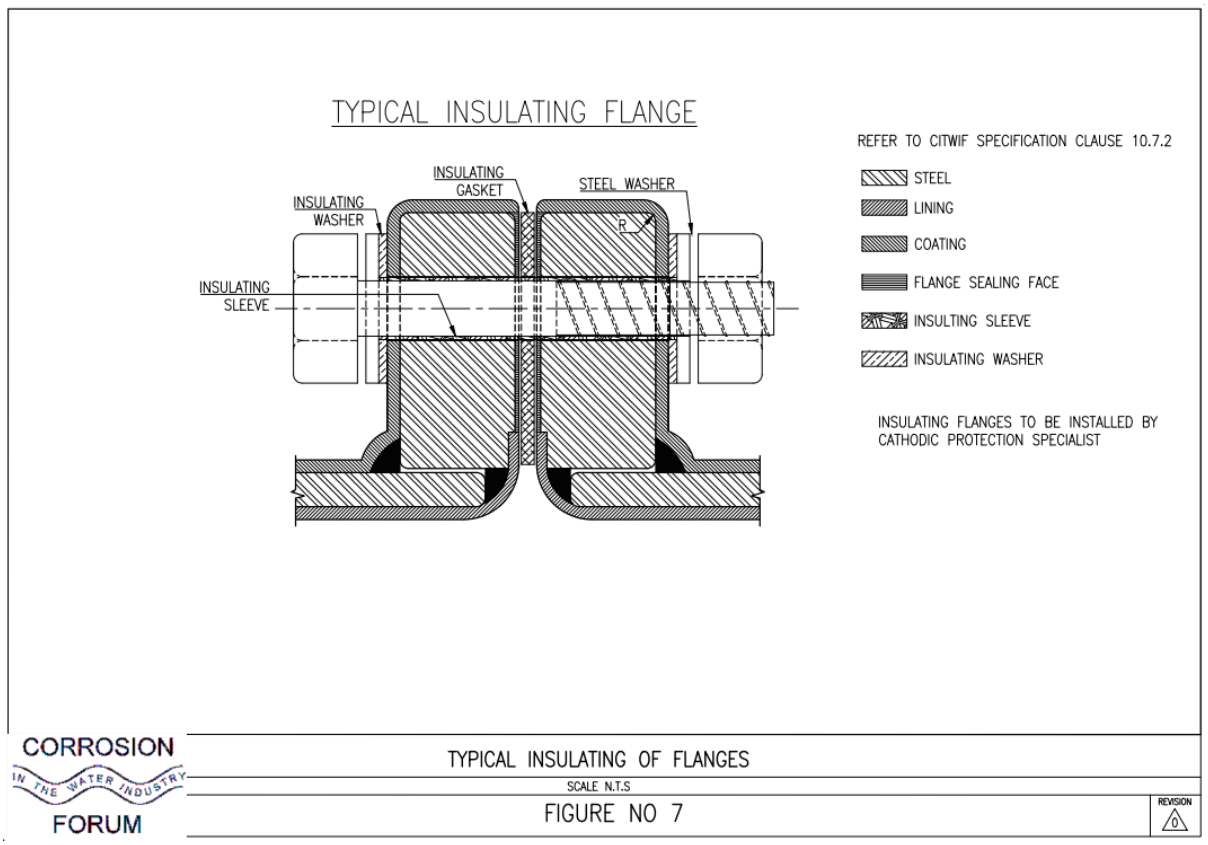
Typical Plain Ends – Welded Joints



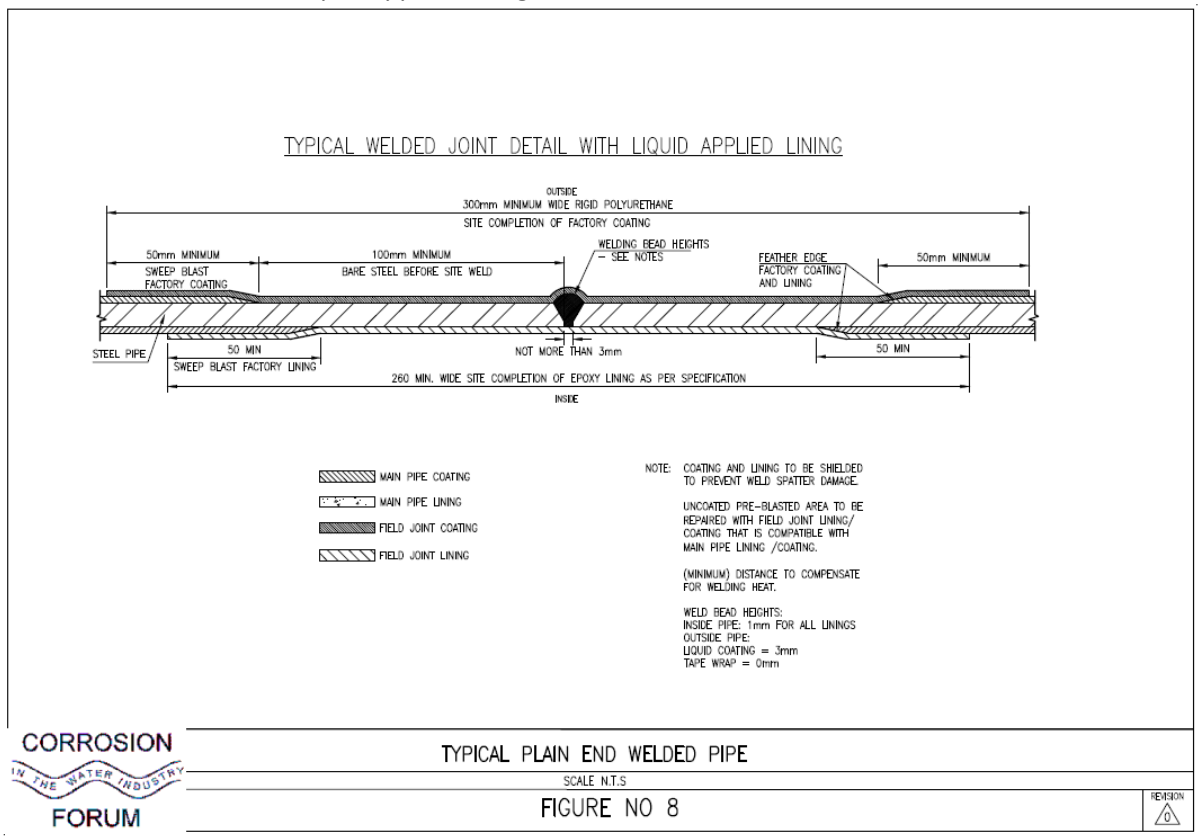
Typical Non-Man Entry Spigot and Socket – Welded Joints



Typical Insulating Flange



Typical Welded Joint Detail with Liquid Applied Lining



ANNEX C: INFORMATION TO BE SUPPLIED BY THE EMPLOYER

(informative)

SUPPLIED BY THE EMPLOYER FOR TENDER	
Pipe size	*e.g. 610mm*
Pipe material	*e.g. API 5L X52*
Preferred Lining & thickness	*e.g. Solvent Free Epoxy – 600 micron*
Preferred Coating & thickness	*e.g. 3LPE 3.2 mm*
Alternative Lining & thickness	*e.g. Reinforced Epoxy -400 micron*
Alternative Coating & thickness	*e.g. Rigid PU – 1.5 mm*
Field Joint Lining & Coating	*e.g. As per factory coated pipe*
Specials Lining & Coating	*e.g. FBE*

The information from the tenderer to be supplied as per the returnable schedules of the tender document.

ANNEX D: PIPE LININGS

(informative)

1 Linings

The lining to be used is dependent upon the nature of the medium being carried, the velocity of the medium, and the geometry of the pipeline. The thickness of the lining material will usually be constant throughout, although additional thickness may be applied at tees and bends to compensate for additional abrasion. Additional thickness may also be applied in areas of high velocity jetting such as valves, valve reducers, pumps or in areas of turbulent flows such as downstream of vortex breakers and tees. Therefore, at the discretion of the Corrosion Engineer, pipes specials may have a thicker lining. Due consideration should be given to joints and ease of repair of large bore and all-welded pipelines.

Grey water applications will require additional information before selecting a suitable lining material.

2 Treatment of pipe ends

2.1 Extension of lining

For flanged pipes or specials and pipes or specials intended for joining with flexible couplings or for site welding by means of double sleeve weld-on couplings, the lining extends to the ends of pipes and specials including edges and returns by at least 300 mm on the outside of the pipe. External coatings should overlap the returned lining material on the outside by at least 25 mm.

2.2 Butt weld edges

For pipes or specials intended for site butt welding, lining and coating shall extend up to a distance of 100 mm from the pipe ends.

ANNEX E:

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ANNEX F: QUALITY CONTROL PLAN TEMPLATES

(Informative)

The following templates may be used for the preparation of project specification documentation:

The templates shall be customized to meet the requirements of Section 4.4 (QUALITY PLAN AND DOCUMENTATION).

The customized templates shall be subject to the revision and Approval process described in Chapter 4 (QUALITY REQUIREMENTS AND TESTING PROCEDURES) before corrosion protection shall commence.

List of Quality Control Plan (QCP) Templates	
1	Liquid Applied Epoxy Coating (Chapter 12-13)
2	Powder Applied Coating – Fusion Bonded - FBE (Chapter 14)
3	Polymer Modified Bitumen Coatings – PMB (Chapter 15)
4	Plastic Tape Wrap / Armouring (Chapter 17)
5	Petrolatum Tape (Chapter 18)
6	3LPE – Layer Polyethylene (Chapter 19)
7	Sintered Polyethylene – PE (Chapter 20)
8	Cement Mortar Lining – CML (Chapter 21)
9	Rigid Polyurethane Coating – PU (Chapter 22)
10	Viscoelastic Coatings (Chapter 23)
11	Rubber Lining (Chapter 24)
12	Hot Dip Galvanising (Chapter 25)
13	Duplex Galvanised Coatings (Section 25.7)
List of Record Sheets	
1	Record of Material Batch Numbers
2	Atmospheric Conditions record sheet
3	Surface Preparation
4	Salt Test Record
5	Dust and Debris Tape Test Record
6	Dry Film Thickness Measurement (Internal Lining)
7	Dry Film Thickness Measurement (External Intermediate or Final Coat)
8	Holiday Test Record
9	Quality Release Certificate

Quality Control Plan – QCP Templates

QCP - Templates Rev 00 - 6 Sept 2022 comb_opt.pdf

Record Sheets

Record Sheets Rev 00 - 6 Sept 2022.pdf

ANNEX G: SUBSTRATE IMPERFECTIONS - EN 14879

EN 14879-1:2005 (E)

Table 4 — Substrate imperfections

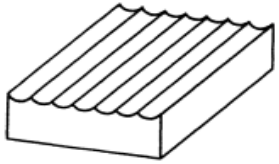
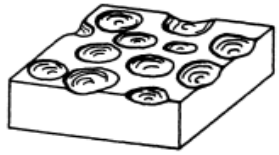
No.	Type of imperfection (illustration not to scale)		Substrate requirements (requirement class)				
			A1	A2	A3	A4	A5
			For a nominal coating thickness of 50 µm up to 200 µm	For a nominal coating thickness over 200 µm up to 1 000 µm	For a nominal coating thickness over 1 000 µm	For a nominal lining thickness (natural or synthetic rubber or phenol-formaldehyde resin sheeting) over 1 000 µm	For a nominal lining thickness (thermoplastic sheeting) over 1 000 µm
1	Grooves 	Regular or irregular indentations or tracks with relatively sharp edges. They can occur singly or in groups, either in parallel or criss-crossing. They can be produced even when properly carrying out machining processes such as turning, grinding or planing.	Permitted where $R_z \leq 50$ µm.	Permitted where $R_z \leq 100$ µm.	Permitted where $R_z \leq 160$ µm.	For autoclave vulcanised rubber, permitted where $R_z \leq 160$ µm; otherwise, permitted where $R_z \leq 100$ µm.	With contact adhesives, permitted where $R_z \leq 100$ µm; with reactive adhesives permitted where $R_z \leq 160$ µm.
For R_z see EN ISO 1302							
2	Pits 	Localized, more or less defined irregular depressions in the surface, being round or square, single or clustered. They can be caused by mechanical action or result from wide pitting.	Single, localized shallow pits with a smooth surface are permitted.	Shallow pits with a smooth surface are permitted.	Shallow pits are permitted.	Shallow pits with a width/depth ratio of 30 or higher are permitted.	Not permitted.
3	Localized corrosion	Localized concentration of corrosion products.	Permitted when the initial condition of the substrate does not correspond to a rust grade higher than B as in EN ISO 12944-4.	Permitted when the initial condition of the substrate does not correspond to a rust grade higher than C as in EN ISO 12944-4.	Permitted when the initial condition of the substrate does not correspond to a rust grade higher than C as in EN ISO 12944-4.	Permitted when the initial condition of the substrate does not correspond to a rust grade higher than C as in EN ISO 12944-4.	Permitted when the initial condition of the substrate does not correspond to a rust grade higher than C as in EN ISO 12944-4.

Table 4 (*continued*)

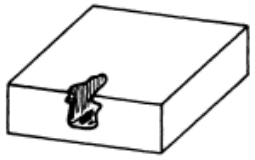
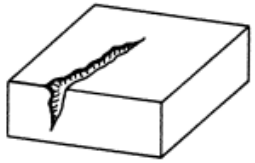
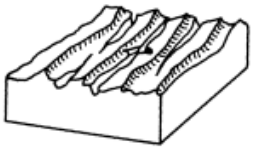
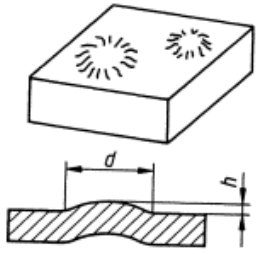
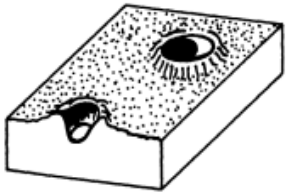
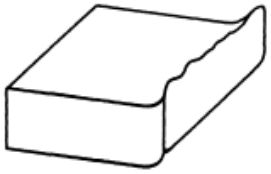
			A1	A2	A3	A4	A5
4	Shrinkage cavities and pores 	Sharply defined point-like depressions with a depth much larger than their diameter. They can be single or clustered and may also occur in welds.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
5	Cracks 	Localized discontinuities in the material structure, of minor width but often of considerable length and depth; also occur in welds. Cracking can result from internal or external stresses or from corrosion.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
6	Scores and scratches 	Trough-like irregular tracks that are clearly visible and tangible. They can be produced by improper handling such as incorrect freehand grinding or during transport.	Permitted where $R_z \leq 50$ µm.	Permitted where $R_z \leq 100$ µm.	Permitted where $R_z \leq 160$ µm.	For autoclave vulcanised rubber, permitted where $R_z \leq 160$ µm, otherwise permitted where $R_z \leq 100$ µm.	With contact adhesives, permitted where $R_z \leq 100$ µm, with reactive adhesives permitted where $R_z \leq 160$ µm.
7	Projections 	Localized raised areas (e.g. defects on castings due to defects in the mould surface).	Permitted for flat sections.	Permitted for flat sections.	Permitted for flat sections.	Permitted for flat sections if $d/h \geq 10$.	Not permitted.

Table 4 (*continued*)

			A1	A2	A3	A4	A5
8	Stepped surface	Lamellar, flaky and veined surface, which can be produced by lamellar corrosion or rolling defects.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
9	Dents 	Crater-like localized depressions, usually with a bulged edge. They can be produced by impacts, blows, when blast cleaning or as centring marks.	Not permitted.	Permitted if the dents are not too deep, the edges are ground down, and the coating/lining material will completely fill the dent without forming bubbles.	Permitted if the dents are not too deep, the edges are ground down, and the coating/lining material will completely fill the dent without forming bubbles.	Permitted if the dents are not too deep, the edges are ground down, and the coating/lining material will completely fill the dent without forming bubbles.	Permitted if the dents are not too deep, the edges are ground down, and the coating/lining material will completely fill the dent without forming bubbles.
10	Scales	Localized laminations of the material. They are due to imperfections in the material or result from the manufacturing process.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
11	Burrs 	Sharp raised edges produced by machining or due to mechanical damage.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.

ANNEX H: WELD IMPERFECTIONS - EN 14879

Table 5 — Weld imperfections

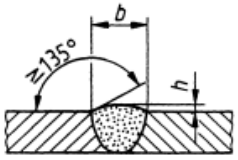
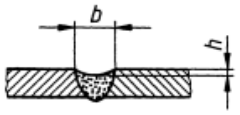
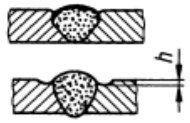
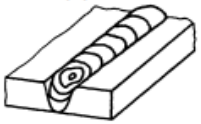
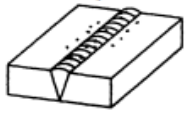
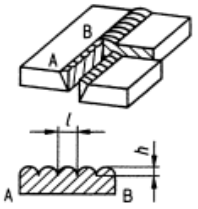
No.	Type of imperfection (illustration not to scale)		Substrate requirements (requirement class)				
			A1	A2	A3	A4	A5
			For a nominal coating thickness of 50 µm up to 200 µm	For a nominal coating thickness over 200 µm up to 1 000 µm	For a nominal coating thickness over 1 000 µm	For a nominal lining thickness (natural or synthetic rubber or phenol-formaldehyde resin sheeting) over 1 000 µm	For a nominal lining thickness (thermoplastic sheeting) over 1 000 µm
1	Excess weld metal and overlap 	Excessive cover run, but with smooth transition to parent metal.	Permitted if the weld has a regular shape.	Permitted.	Permitted where $b/h \geq 4$ (for laminate coatings, only in some cases). Not permitted for trowelled coatings or fillet welds.	Permitted where $b/h \geq 10$. Not permitted for fillet welds or tubes with a nominal size of DN 500 or lower.	Not permitted.
2	Incompletely filled groove 	Intermittent or continuous channel in the surface of a weld.	Permitted if channel is not too deep, its edges are rounded and $b/h \geq 4$.	Permitted if channel is not too deep, its edges are rounded and $b/h \geq 4$.	Permitted if channel is not too deep, its edges are rounded and $b/h \geq 4$. For laminate coatings, permitted only in some cases.	Permitted where $b/h \geq 10$. Not permitted for tubes with a nominal size of DN 500 or lower.	Not permitted.
3	Undercuts 	Continuous or intermittent irregular groove in the parent metal caused by welding.	Not permitted.	Permitted if edges can be smoothed by blast cleaning.	Permitted if edges can be smoothed by blast cleaning.	Permitted where h is not greater than 0,1 mm if edges can be smoothed by blast cleaning.	Permitted if edges can be smoothed by blast cleaning.

Table 5 (*concluded*)

			A1	A2	A3	A4	A5
4	End crater pipe 	Depression due to shrinkage at the end of a weld run.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
5	Slag inclusions	Slag entrapped in the weld metal.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
6	Spatter or stray flash 	Weld spatters expelled during welding; damage of the parent metal resulting from the accidental striking of an arc away from the weld (stray flash).	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
7	Open joints or excess penetration bead	Open joints or excess weld metal protruding through the root of weld made from one side only.	Not permitted.	Not permitted.	Not permitted.	Not permitted.	Not permitted.
8	Rippled weld 	Weld with rippled surface (e.g. in vertical welds, or manual electrode welding).	Not permitted.	Permitted where $l/h \geq 4$.	Permitted where $l/h \geq 4$. Permitted only in some cases for laminate coatings. Not permitted for trowelled coatings.	Permitted where $h \leq 0{,}3$ mm, if $l/h \geq 30$.	Not permitted.

NOTE For Rz see EN ISO 1302.

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Crossman, Pape & Associates

Consulting Geotechnical Engineers & Engineering Geologists

P.O.Box 3557 Cramerview 2060. Tel: (011) 465-1699. Fax: (011) 465-4586. Cell 082 556 7302 & 076 966 8445

REPORT NO 15/119/D **AUGUST 2015**

GEOTECHNICAL INVESTIGATION FOR PROPOSED 10 MEGA LITRE WATER RESEVOIR CARLSWALD

1. INTRODUCTION AND NATURE OF DEVELOPMENT

At the request of Mrs. J Heera of Zitholele Consulting we have carried out a geotechnical investigation for the proposed Carlswald 10ML Resevoir Project, Midrand. Confirmation of our appointment to proceed with the investigation was received via a sub-consultant agreement from Zithole Consulting. Copies of the site locality plan as well as three site layout options were received to facilitate the investigation.

The proposed reservoir will comprise either a 50m diameter by 5,5m high circular concrete structure or two 35m diameter by 5,5m high circular concrete reservoirs. The exact layout and positioning of the reservoirs is still to be finalized. Exact earthworks details are unknown at this stage.

2. TERMS OF REFERENCE

The terms of reference for the investigation are as follows:

i) to establish the nature and relevant engineering properties of the upper soil and rock strata underlying the site.

ii) to comment on suitable excavation procedures for cut terrace excavations and for the installation of services.

iii) to present comments on the use of the on-site soils in the construction of bulk fill terraces and as layerworks for access roads / parking areas.

iv) to give foundation recommendations for the proposed reservoir(s).

v) to comment on any other geotechnical aspects that may affect the development.

3. SITE DESCRIPTION

The area of investigation occurs across the eastern portions of the area of open land to the east of the intersection of Whisken Avenue and Walton Road,

Carlswald. The site slopes moderately to the south and is covered by veld grass and large trees across the eastern portions of the site.

4. NATURE OF INVESTIGATION

4.1 Fieldwork

Six test pits (TP15 to TP20) were excavated across the site on 13 July 2015 using a Cat 422E tractor-loader-backhoe (backactor). The test pits were excavated to refusal or to the excavation limit of the machine. All test pits were profiled in situ by an engineering geologist and where necessary disturbed soil samples were obtained for laboratory testing. The positions of the test pits are shown on the site plan enclosed in Appendix A. Copies of the recorded test pit soil profiles are presented in Appendix B.

4.2 Laboratory Testing

The following laboratory tests are currently being carried out on the soil samples recovered from the test pits during the field investigation.

(i) Atterberg limits and particle size distribution analyses to determine basic engineering properties and to effect classification.

(ii) Moisture/density and California Bearing Ratio (CBR) tests to evaluate compaction and related strength characteristics.

(iii) Soil chemistry tests to determine the pH and electrical conductivity of the in situ soils.

The report will be suitably amended and resubmitted once the laboratory test results become available.

5. SITE GEOLOGY/SOIL PROFILE

Available geological maps indicate that the area of investigation is underlain by **granite** of the Johannesburg Granite Dome. This was confirmed during the current investigation. Residual soils have developed from the weathering of the granite bedrock. The general soil profile is described below.

The upper soil layer across the site comprises 0,3m to 0,4m of loose to medium dense intact silty sand of **transported hillwash** origin. The hillwash is underlain by loose to medium dense / medium dense intact silty sand with abundant quartz gravel. This gravel layer represents the **transported pebble marker**. The pebble marker extends to depths varying between 0,55m and 0,7m.

The pebble marker is underlain by medium dense and dense in places cemented and ferruginised silty sand **reworked residual granite.** The reworked residual granite extends to depths varying between 1,0m and 1,3m. Refusal of the backactor was obtained upon very dense reworked residual granite at 1,3m depth in test pit TP16. The reworked residual granite is underlain by medium dense to dense jointed silty sand **residual granite.** Refusal of the machine was obtained upon dense residual granite / very soft rock granite at depths varying between 1,0m and 2,3m (average depth 1,7m). The excavation limit of the backactor was obtained at 3,0m depth within the residual granite in test pit TP18.

No perched water table or zones of seepage were noted in any of the test pits excavated across the site.

6. EXCAVATION PROCEDURES

Excavation procedures for earthworks and for the installation of services have been evaluated according to the South African National Standards standardized classifications for excavations (SANS 1200D, DA & DB). According to this classification the area of investigation classifies as **soft excavation** to depths varying between 1,0m and 2,3m (average depth 1,7m).

Below these depths the site classifies as **intermediate excavation** material on very dense reworked / residual granite and/or very soft rock granite. The intermediate excavation material is envisaged to be of the order of 0,5m to 1,0m thick and could be removed using medium to heavy earthmoving equipment and / or power tools.

Hard rock excavation on granite bedrock is envisaged below the intermediate excavation material. The hard rock excavation material would require excavation by **blasting.**

An exception to the above was noted in the vicinity of test pit TP18 where the soft excavation material extends to depths in excess of 3,0m.

7. MATERIALS USAGE

Laboratory testing is currently being carried out on the upper soil layers to assess their suitability for use in the construction of bulk fill terraces and as layerworks for access roads / parking areas. However, based on a visual assessment from the fieldwork the following comments are considered pertinent to the on-site soils with regards to the above operations.

- The upper 150mm of in situ soils across the site contains abundant organic matter and is unsuitable for use as construction material. This material should be removed to spoil. It is envisaged that in the vicinity of the large trees,that

at least the upper 0,5m of in situ soil would have to be spoiled owing to the presence of abundant tree roots. This depth would have to be verified upon commencement of the site cleaning.

- The in situ soils (hillwash, pebble marker and reworked / residual granite) are suitable for use as general fill and selected layer material. Should these soils be required for use as subbase then they would have to be stabilised. Further laboratory testing would however have to be carried out to establish suitable stabilising agents and to optimize mix ratios.

8. EVALUATION OF FOUNDING CONDITIONS AND FOUNDATION RECOMMENDATIONS

8.1 Areas of Cut

The hillwash and pebble marker soils are considered to be potentially highly compressible / collapsible. These soil layers are thus unsuitable for use as founding layers, even for proposed lightly loaded structures.

An allowable bearing pressure of 200kPa could be utilized for the medium dense or better reworked / residual granite. These founding layers occur at depths varying between 0,55m and 0,7m below current ground level. Under the above load conditions total settlements of the order of 5mm to 10mm are envisaged. Differential settlements should be taken as 50% of the total settlements. Conventional strip / spread foundations could be employed for the proposed reservoir structure(s).

8.2 Areas of Fill

Consideration could be given to placing strip / spread foundations within engineered fill with the following provisos:

- The fill must be compacted in 150mm layers to 95% of Mod AASHTO density at optimum moisture content.

- Allowable bearing pressures must be limited to 150kPa.

- All hillwash and pebble marker soils would have to be removed in their entirety to stockpile below the footprint of the reservoir within areas of the fill and to 1,0m beyond the edge of the reservoir footprint. Levels must then be reinstated within this removed hillwash / pebble marker in 150mm layers to 95% of Mod AASHTO density at optimum moisture content. This would have to be undertaken to prevent the sphere of influence of the foundation load extending down into the underlying collapsible hillwash / compressible pebble marker.

- It is important that a **high degree of engineering quality control** is implemented on the site with regard to the recompaction of the hillwash and the overlying bulk fill. **Density testing** using a suitable calibrated nuclear gauge device (Troxler) should be carried out on all compacted layers. The natural moisture content of the soils should be determined by oven drying in a soils laboratory, that is, the Troxler device should not be used to determine the natural moisture content of the engineered fill material. It is recommended that the density testing be carried out by an **independent soils laboratory.**

9. ACCESS ROADS AND PARKING AREAS

The following comments are pertinent to the design and construction of the access roads and parking areas.

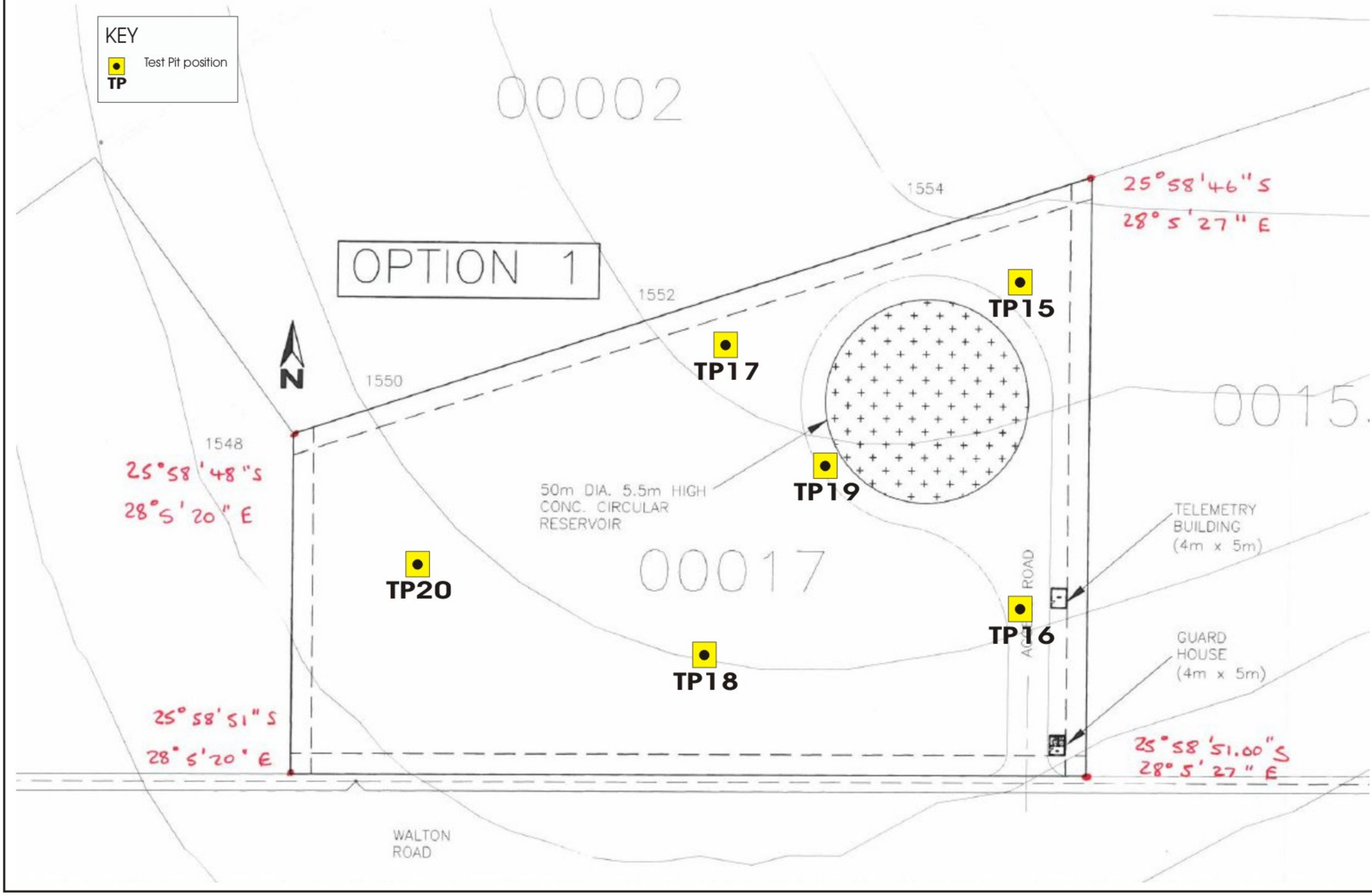
- For pavement design purposes, it is estimated that the upper in situ subgrade material would have a CBR of the order of 10 percent if compacted to 90% of Mod AASHTO density at optimum moisture content, and of the order of 15 percent if compacted to 93% of Mod AASHTO density at optimum moisture content.

- If access roads and parking areas comprise brick paving it is recommended that the layer immediately below the brick paving and bedding sand be stabilised. The purpose of the stabilised layer immediately below the bedding sand would be to seal the layerworks from stormwater ingress from ground surface.

M CROSSMAN Pr Eng **J DAVEL Pr.Sci.Nat**
CROSSMAN, PAPE & ASSOCIATES

APPENDIX A

SITE LAYOUT PLAN



PROJECT: 15/119/D
OML RESERVOIR CARSLWALD

SITE PLAN INDICATING
APPROXIMATE POSITIONS OF TEST PITS

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Consulting Geotechnical Engineers & Engineering Geologists
PO Box 3557 Cramerview 2060. Tel: (011) 465- 1699. Fax: (011) 465- 4586. Cell 082 556 7302 & 076 966 8445

Scale: Not to scale

Date: AUGUST 2015

APPENDIX B

TEST PIT SOIL PROFILES

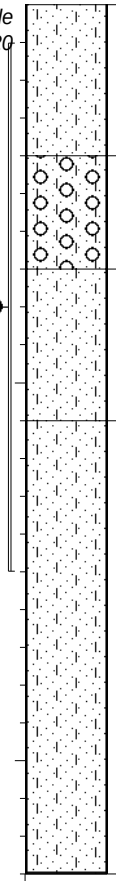
Crossman, Pape and Associates
Consulting Geotechnical Engineers and Engineering Geologists

Zitholele Consulting
10ML Resevoir Carlswald

HOLE No: TP15
Sheet 1 of 1

JOB NUMBER: 15/119/TP

Scale 1:20



0.00	Moist light brown loose to medium dense intact silty sand. Hillwash. Also contains abundant roots in the upper 0,15m.
0.40	As above but contains abundant fine to coarse quartz gravel. Pebble marker.
0.70	Moist mottled and blotched red orange brown medium dense cemented and ferruginised silty sand. Reworked residual granite.
1.10	Moist orange brown speckled yellow dark brown medium dense to dense jointed silty sand. Residual granite.
2.30	

NOTES

1) Refusal at 2,3m on very dense residual granite / very soft rock granite.

2) No evidence of water.

3) Disturbed sample taken at 0,1--1,5m.

CONTRACTOR :
MACHINE : Cat 522E
DRILLED BY :
PROFILED BY : Justin Davel

TYPE SET BY : Renee
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/07/2015

DATE : 06/08/2015 12:17
TEXT : ..OMLResevoirCarlswald.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP15

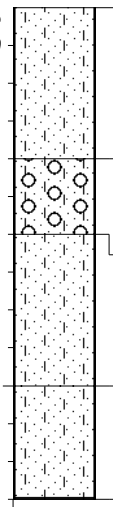
Crossman, Pape and Associates
Consulting Geotechnical Engineers and Engineering Geologists

Zitholele Consulting
10ML Resevoir Carlswald

HOLE No: TP16
Sheet 1 of 1

JOB NUMBER: 15/119/TP

Scale 1:20



0.00	Slightly moist light brown loose to medium dense intact silty sand. Hillwash. Also contains abudant roots in the upper 0,15m.
0.40	As above but contains abundant fine to coarse quartz gravel. Pebble marker.
0.60	Moist orange brown mottled red brown grey medium dense cemented and ferruginised silty sand. Reworked residual granite.
1.00	As above but dense.
1.30	

NOTES

1) Refusal at 1,3m on very dense reworked residual granite.

2) No evidence of water.

CONTRACTOR :
MACHINE : Cat 522E
DRILLED BY :
PROFILED BY : Justin Davel
TYPE SET BY : Renee
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/07/2015
DATE : 06/08/2015 12:17
TEXT : ..OMLResevoirCarlswald.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP16

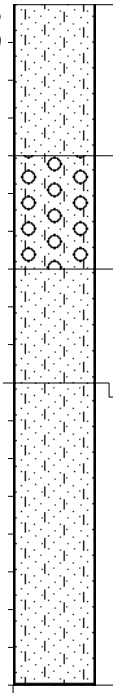
Crossman, Pape and Associates
Consulting Geotechnical Engineers and Engineering Geologists

Zitholele Consulting
10ML Resevoir Carlswald

HOLE No: TP17
Sheet 1 of 1

JOB NUMBER: 15/119/TP

Scale 1:20



0.00	Slightly moist dark brown loose to medium dense intact silty sand. Hillwash. Also contains abudant roots in the upper 0,15m.
0.40	As above but contains abundant fine to coarse quartz gravel. Pebble marker.
0.70	Moist orange brown mottled grey brown medium dense cemented and ferruginised silty sand. Reworked residual granite with zones of residual granite.
1.00	Moist orange brown speckled yellow dark brown medium dense to dense jointed silty sand. Residual granite.
1.80	

NOTES

1) Refusal at 1,8m on very dense residual granite / very soft rock granite.

2) No evidence of water.

CONTRACTOR :
MACHINE : Cat 522E
DRILLED BY :
PROFILED BY : Justin Davel

TYPE SET BY : Renee
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/07/2015

DATE : 06/08/2015 12:17
TEXT : ..OMLResevoirCarlswald.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP17

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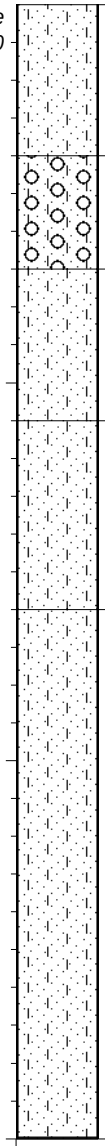
HOLE No: TP18
Sheet 1 of 1

JOB NUMBER: 15/119/TP

Scale 1:20



0.00	Moist light brown loose to medium dense intact silty sand. Hillwash. Also contains abundant roots in the upper 0,15m.
0.40	As above but medium dense with abundant fine to coarse quartz gravel. Pebble marker.
0.70	Moist orange brown blotched grey brown mottled red brown medium dense and medium dense to dense in places cemented and ferruginised silty sand. Reworked residual granite with zones of residual granite.
1.10	Moist orange brown mottled grey red brown medium dense to dense jointed silty sand. Residual granite with zones of reworked residual granite.
1.60	As above but medium dense and medium dense to dense in places with no zones reworked residual granite.
3.00	

NOTES

1) No refusal at 3,0m.

2) No evidence of water.

CONTRACTOR :
MACHINE : Cat 522E
DRILLED BY :
PROFILED BY : Justin Davel

TYPE SET BY : Renee
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/07/2015

DATE : 06/08/2015 12:17
TEXT : ..OMLResevoirCarlswald.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP18

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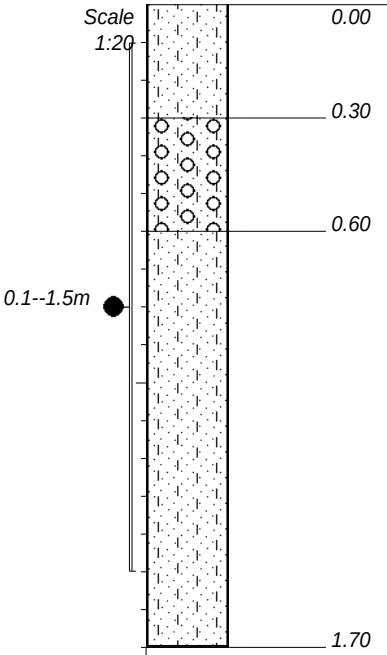
Consulting Geotechnical Engineers and Engineering Geologists

Zitholele Consulting
10ML Resevoir Carlswald

HOLE No: TP19
Sheet 1 of 1

JOB NUMBER: 15/119/TP



Slightly moist light brown loose to medium dense intact silty sand. Hillwash. Also contains abundant roots in the upper 0,15m.

As above but contains abundant fine to coarse quartz gravel. Pebble marker.

Moist orange brown speckled yellow brown dark brown medium dense to dense and dense in places jointed silty sand. Residual granite with scattered zones of reworked residual granite.

NOTES

1) Refusal at 1,7m on very soft rock granite.

2) No evidence of water.

3) Disturbed sample taken at 0,1--1,5m.

CONTRACTOR :
MACHINE : Cat 522E
DRILLED BY :
PROFILED BY : Justin Davel

TYPE SET BY : Renee
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/07/2015

DATE : 06/08/2015 12:17
TEXT : ..OMLResevoirCarlswald.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP19

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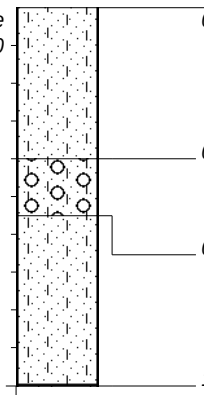
HOLE No: TP20
Sheet 1 of 1

JOB NUMBER: 15/119/TP

Scale 1:20



0.00 Slightly moist dark brown loose to medium dense intact silty sand. Hillwash. Also contains abundant roots in the upper 0,15m.

0.40 As above but contains abundant fine to coarse quartz gravel. Pebble marker.

0.55 Slightly moist orange brown speckled off white dark brown dense jointed silty sand. Residual granite.

1.00

NOTES

1) Refusal at 1,0m on very soft rock granite.

2) No evidence of water.

CONTRACTOR :
MACHINE : Cat 522E
DRILLED BY :
PROFILED BY : Justin Davel

TYPE SET BY : Renee
SETUP FILE : STANDARD.SET

INCLINATION :
DIAM :
DATE :
DATE : 17/07/2015

DATE : 06/08/2015 12:17
TEXT : ..OMLResevoirCarlswald.txt

ELEVATION :
X-COORD :
Y-COORD :

HOLE No: TP20

Crossman, Pape and Associates
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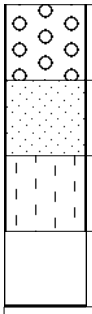
LEGEND
Sheet 1 of 1

JOB NUMBER: 15/119/TP



	GRAVEL	{SA02}
	SAND	{SA04}
	SILTY	{SA07}
Name ●	DISTURBED SAMPLE	{SA38}

CONTRACTOR :
MACHINE :
DRILLED BY :
PROFILED BY :

INCLINATION :
DIAM :
DATE :
DATE :

ELEVATION :
X-COORD :
Y-COORD :

TYPE SET BY : Renee
SETUP FILE : STANDARD.SET

DATE : 06/08/2015 12:17
TEXT : ..OMLResevoirCarlswald.txt

LEGEND
SUMMARY OF SYMBOLS