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| | |
|---|---|
| **ADDENDUM** | No. 01 |
| **CONTRACT NUMBER:** | JW 14466 |
| **CONTRACT TITLE:** | **JW 14466 OLIFANSVLEI WASTEWATER TREATMENT WORKS: INFRASTRUCTURE RENEWAL PLAN REFURBISHMENT AND REPAIR OF THE VAN WYKSRUST SEWER PUMPSTATION CONTRACT** |
| **SUBJECT** | Addendum 1 |
| **Date** | 29 April 2025 |
| **Sender** | Peter Louw 011 688 1676 peter.louw@jwater.co.za<br>Nthabiseng more 011 688 1512 nthabiseng.more@jwater.co.za |

` **Tenderers are required to incorporate the following amendments into the tender document and return the Addendum:**

- Revised BoQ, Updated Volume 1 part of the tender documents and Specifications.
- Extension of the closing date from 05 May 2025 at 10:30 to 19 May 2025 at 10:30

Yours faithfully

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Ithuteng Tabe

**Acting General Manager: Supply Chain Management**

**Addendum Received**

**Name of Tenderer**:……

**Signatory**:……

**Signature:**……

**Date**:……

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | **1** | **PRELIMINARY AND GENERAL** | | | | |
| SABS 1200 AA | **1.1** | **GENERAL (SMALL WORKS)** | | | | |
| 8.3 | | **Scheduled fixed-charge and value-related items:** | | | | |
| 8.3.1 | 1.1.1 | **Contractual requirements** | Sum | 1 | | |
| 8.3.2 | | **Provision of facilities on Site:** | | | | |
| | 1.1.2 | (a) Facilities required by Engineer, as described in project specification PSAB | Sum | 1 | | |
| | 1.1.3 | (b) Facilities required by Contractor | Sum | 1 | | |
| | | Nameboards as per Drawing No. BW1400-RHD-C1-11-D-C-1101 | No | 2 | | |
| 8.3.3 | | **General responsibilities and other** | | | | |
| | 1.1.4 | **fixed-charge obligations** | Sum | 1 | | |
| | | Provision for Socio-economic Development | Sum | 1 | | |
| 8.3.4 | 1.1.5 | **Removal of Site establishment** | Sum | 1 | | |
| 8.4 | | **Scheduled time-related items:** | | | | |
| 8.4.1 | 1.1.6 | **Contractual requirements** | Rate/ month | 18 | | |
| 8.4.2 | | **Operation and maintenance of facilities on Site:** | | | | |
| | 1.1.7 | (a) Facilities for Engineer | Rate/ month | 18 | | |
| | 1.1.8 | (b) Facilities for Contractor | Rate/ month | 18 | | |
| 8.4.3 | 1.1.9 | **General responsibilities and other time-related obligations** | Rate/ month | 18 | | |
| | 1.1.10 | Provision for Socio-economic Development (time related) | Rate/ month | 18 | | |
| PSAA 8.5 | | **Provisional sums, prime cost items, daywork and temporary works** | | | | |
| PSAA 8.5.1 | | **Temporary Works Dealing with Water on the Works (Incl. flow accomodation)** | | | | |
| | 1.1.11 | a) General flow accomodation (flow diversion, creating a dry environment for construction work). | Sum | 1 | | |
| | 1.1.12 | b) Draining and waterjetting/cleaning flooded, existing pump station and influent channels. | Sum | 1 | | |
| | 1.1.13 | c) Draining of existing Van Wyksrust rising mains and disposal. | Sum | 1 | | |
| | 1.1.14 | d) Subsoil drainage and/or other temporary measures surrounding the pump station | Prov Sum | 1 | R 5 000 000,00 | R5 000 000,00 |
| | 1.1.15 | Percentage mark-up on provisional sum item 1.1.14 above | % | | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| PSAA 8.5.2 | 1.1.16 | a) Daywork<br>i) Unskilled labour | Rate/hr | 200 | | |
| | | ii) Skilled labour | Rate/hr | 200 | | |
| | 1.1.17 | b) Plant<br>i) TLB | Rate/hr | 200 | | |
| | | ii) Mobile Crane (5t) | Rate/hr | 200 | | |
| PSAA 8.5.4 | 1.1.18 | Ground penetrating radar (GPR) survey at | | | | |
| | | (i) all areas of construction (Contract 1) | Prov Sum | 1 | R 150 000,00 | R150 000,00 |
| | | (ii) areas for future Contract 2 | Prov Sum | 1 | R 100 000,00 | R100 000,00 |
| | | Percentage mark-up on provisional sum items above | % | | | |
| PSAA 8.5.5 | 1.1.19 | Topographical survey | | | | |
| | | (i) Rising mains (x3) | Prov Sum | 1 | R 150 000,00 | R150 000,00 |
| | | (ii) Substation C and Van Wyksrust p/stn road | Prov Sum | 1 | R 70 000,00 | R70 000,00 |
| | | (iii) Scope related to contract 2 | Prov Sum | 1 | R 250 000,00 | R250 000,00 |
| | | Percentage mark-up on provisional sum items above | % | | | |
| | 1.1.20 | Flow logging as directed. | Prov Sum | 1 | R 100 000,00 | R100 000,00 |
| | 1.1.21 | Percentage mark-up on provisional sum item 1.1.20 above | % | | | |
| PS 7 | **1.2** | **Compliance with the Occupational Health and Safety Act and applicable regulations:** | | | | |
| | 1.2.1 | i. Provision of a Health and Safety Plan | Sum | 1 | | |
| | 1.2.2 | ii. Provision of Health and Safety file | Sum | 1 | | |
| | 1.2.3 | iii. Provision of construction supervisors | Sum | 1 | | |
| | 1.2.4 | iv. Provision of a safety officer (full-time) | Sum | 1 | | |
| | 1.2.5 | v. Health and Safety training | Sum | 1 | | |
| | 1.2.6 | vi. Provision of personal protective clothing and equipment (incl. for the Engineer, assistants and visitors) | Sum | 1 | | |
| | 1.2.7 | vii. Provision of safety fences, signs and barricades | Sum | 1 | | |
| | 1.2.8 | Medical assessment of all employees | Sum | 1 | | |
| | 1.2.9 | HIV/AIDS Awareness: Compliance with requirements of SANS 1921-6 | Sum | 1 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | 1.2.10 | Compliance with the Occupational Health and Safety Act, applicable regulations and any other costs not allowed for anywhere else. | Sum | 1 | | |
| PS 8 | **1.3** | **Environmental management during construction** | | | | |
| | 1.3.1 | Environmental awareness campaign | Sum | 1 | | |
| | 1.3.2 | Water pollution control | Sum | 1 | | |
| | 1.3.3 | Compliance with relevant environmental legislation | Sum | 1 | | |
| PS 6.5 | 1.3.4 | Compulsory postponement of the issuing of the Certificate of Completion | Rate/day | 10 | | |
| | 1.3.5 | Address feedback (requirements) from authorities | Prov Sum | 1 | R 5 000 000,00 | R5 000 000,00 |
| | 1.3.6 | Percentage mark-up on provisional sum item 1.3.5 above | % | | | |
| PSSC | **1.4** | **SUB-CONTRACTORS** | | | | |
| PSSC 1 | 1.4.1 | Value of Sub-Contracted Works | Sum | 1 | | |
| PSSC 2 | 1.4.2 | Overhead, charges and profit fee for the Main Contractor to oversee sub-contracted works. | % | | | |
| PSSC 3 | 1.4.3 | Fixed-charge items for the sub-contractors Contractual Requirements | Sum | 1 | | |
| PSSC 4 | 1.4.4 | Overhead, charges and profit for the Main Contractor to provide for fixed-charge items for the sub-contractors Contractual Requirements. | % | | | |
| PSSC 5 | 1.4.5 | Time Related items for the sub-contractors Contractual Requirements | Sum | 1 | | |
| PSSC 6 | 1.4.6 | Overhead, charges and profit for the Main Contractor to provide for time related items for the sub-contractors Contractual Requirements | % | | | |
| PSSC 7 | 1.4.7 | Training for SMMEs | Prov Sum | 1 | R 250 000,00 | R250 000,00 |
| PSSC 8 | 1.4.8 | Overhead, charges and profit for the Main Contractor to provide for training for SMMEs | % | | | |
| PSSC 9 | 1.4.9 | For Contractor to make direct payment on behalf of SMME | Prov Sum | 1 | R 200 000,00 | R200 000,00 |
| PSSC 10 | 1.4.10 | Overhead, charges and profit for the Main Contractor to make direct payment on behalf of SMME | % | | | |
| | **1.5** | **Miscellaneous** | Prov | | | |
| | 1.5.1 | Community Liason Officer (CLO) | Sum | 1 | R 250 000,00 | R250 000,00 |
| | 1.5.2 | Percentage mark-up on provisional sum item 1.5.1 above | % | | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | 1.5.3 | Temporary site security measures / risk mitigation | Prov Sum | 1 | R 3 000 000,00 | R3 000 000,00 |
| | 1.5.4 | Percentage mark-up on provisional sum item 1.5.3 above | % | | | |
| | 1.5.5 | Security Guards (refer to Scope of work, PS 6.1) | Rate/m | 18 | | |
| | 1.5.6 | Conduct investigations and assessment of damaged or missing existing infrastructure such as Manhole covers; etc | Sum | 1 | | |
| | 1.5.7 | Conduct Geotechnical investigations which includes tests deemed necesserary by the Geotechnical Enginneer | Prov Sum | 1 | R 350 000,00 | R350 000,00 |
| | 1.5.8 | Percentage mark-up on provisional sum item above | % | | | |
| | 1.5.9 | Forward Cover (add 10% of Total Value of Imported Content) Equipment Schedule - Form | Sum | 1 | | |
| | 1.5.10 | Standing time | Rate/d | 20 | | |
| | 1.5.11 | Conduct a concrete integrity test on the existing Van Wyksrust pump station (drone 3D scan, etc). | Prov Sum | 1 | R 120 000,00 | R120 000,00 |
| | 1.5.12 | Percentage mark-up on provisional sum item above | % | | | |
| | **1.6** | **Socio-economic Development** | | | | |
| PSAA 8.5.3 | 1.6.1 | Accredited training programmes are targeted which will provide the beneficiaries with significant and recognized credit value | Prov Sum | 1 | R 250 000,00 | R250 000,00 |
| | 1.6.2 | Percentage mark-up on provisional sum item above | % | | | |
| | 1.6.3 | Corporate Social Responsibility programs aimed at improving the livelihood of the community | Prov Sum | 1 | R 300 000,00 | R300 000,00 |
| | 1.6.4 | Percentage mark-up on provisional sum item above | % | | | |
| | | **TOTAL SECTION 1 CARRIED TO SUMMARY** | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | **2** | **CIVILS** | | | | |
| | | **VAN WYKSRUST PUMP STATION AND SUBSTATION C** | | | | |
| SABS 1200 C | **2.1** | **SITE CLEARANCE** | | | | |
| 8.2.1 | 2.1.1 | Clear and grub as designated by the Engineer | | | | |
| | | i. Van Wyksrust p/stn | ha | 0,42 | | |
| | | ii. Substation C | ha | 0,04 | | |
| 8.2.2 | | **Remove and grub all trees and tree stumps regardless of girth (Prov.)** | | | | |
| | 2.1.2 | (a) Over 1,0 m and up to and including 2,0 m | No | 4 | | |
| | 2.1.3 | (b) Over 2,0 m and up to and including 3,0 m | No | 3 | | |
| 8.2.5 | 2.1.4 | **Take down existing fences** | km | 0,08 | | |
| 8.2.7 | 2.1.5 | **Dismantle and remove pipelines, electricity transmission lines, cables, etc.** | | | | |
| | | i. existing small diameter (<DN100) HDPE pipes (Provisional) | m | 100 | | |
| | | ii. Existing DN700 steel pipe installed on existing concrete plinths traversing the wetland | m | 550 | | |
| 8.2.9 | 2.1.6 | **Transport materials and debris to unspecified site and dump** | t.km | 300 | | |
| PSC 8.2.10 | 2.1.7 | **Remove topsoil to nominal depth of 150 mm and stockpile** | | | | |
| | | Van Wyksrust p/stn | $m^3$ | 215 | | |
| | | Substation C | $m^3$ | 15 | | |
| PSC 8.2.12 | 2.1.8 | **Temporary fencing closures** | m | 30 | | |
| PSC 8.2.14 | 2.1.9 | **Demolish and remove structures/buildings and dismantle steelwork, etc** | | | | |
| | | i. Existing concrete skip slab | $m^3$ | 15 | | |
| | | ii. Existing steel crawl beam (SWL 3T) | No. | 1 | | |
| | | iii. Existing splitter chamber brickwork | $m^3$ | 10 | | |
| | | iv. Existing splitter chamber concrete lid | $m^3$ | 5 | | |
| | | v. Existing disused chambers at Substation C | $m^3$ | 10 | | |
| | | vi. Existing pump station staircase | $m^3$ | 2 | | |
| | | vii. Existing apron at Substation C | $m^3$ | 10 | | |
| PSC 8.2.15 | 2.1.10 | **Demarcation fencing** | m | 260 | | |
| PSC 8.2.16 | 2.1.11 | **Childproof barrier** | m | 260 | | |
| PSC 8.2.17 | 2.1.12 | **Remove existing precast kerbing to approved dump site** | m | 200 | | |
| PSC 8.2.18 | 2.1.13 | **Remove existing concrete block paving** | $m^2$ | 200 | | |
| SABS 1200 DA PSDA 8.3.1 | **2.2** | **EARTHWORKS (SMALL WORKS)** | | | | |
| | | **Excavation:** | | | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | (b) Excavate in all materials and use for embankment or backfill or dispose, as ordered (see Fig DA-1) | | | | |
| | 2.2.1 | For backfill | | | | |
| | | i. New bypass channel | m³ | 75 | | |
| | | ii. Splitter chamber extension | m³ | 55 | | |
| | | iii. Bypass manhole installation | m³ | 60 | | |
| | | iv. Sump extension | m³ | 25 | | |
| | | v. Screenings facility | m³ | 25 | | |
| | | vi. Generator bunded area and sump | m³ | 10 | | |
| | | vii. Guardhouse platform | m³ | 12 | | |
| | | viii. Perimeter walls; Van Wyksrust p/stn | m³ | 1965 | | |
| | | Substation C | m³ | 590 | | |
| | 2.2.2 | For embankment (provisional) | | | | |
| | | i. New bypass channel | m³ | 7 | | |
| | | ii. Splitter chamber extension | m³ | 6 | | |
| | | iii. Bypass manhole installation | m³ | 6 | | |
| | | iv. Sump extension | m³ | 3 | | |
| | | v. Screenings facility | m³ | 5 | | |
| | | vi. Generator bunded area and sump | m³ | 3 | | |
| | | vii. Guardhouse platform | m³ | 3 | | |
| | | viii. Perimeter walls | m³ | 50 | | |
| | 2.2.3 | For disposal | | | | |
| | | i. New bypass channel | m³ | 60 | | |
| | | ii. Splitter chamber extension | m³ | 85 | | |
| | | iii. Bypass manhole installation | m³ | 50 | | |
| | | iv. Sump extension | m³ | 30 | | |
| | | v. Screenings facility | m³ | 175 | | |
| | | vi. Generator bunded area and sump | m³ | 35 | | |
| | | vii. Guardhouse platform | m³ | 35 | | |
| | | viii. Perimeter walls | m³ | 630 | | |
| | 2.2.4 | (c) Extra over for: | | | | |
| | | i. Intermediate excavation | m³ | 280 | | |
| | | ii. Hard rock excavation | m³ | 150 | | |
| PSDA 8.3.2 | | **Restricted excavation (see Fig DA-2):** | | | | |
| | 2.2.5 | Excavate for restricted foundations, footings and trenches in all materials and use for backfill or embankment or dispose | | | | |
| | | i. Downstand/ground beams | m³ | 10 | | |
| | | ii. Generator slab sump | m³ | 1 | | |
| | 2.2.6 | (c) Extra over for: | | | | |
| | | i. Intermediate excavation | m³ | 7 | | |
| | | ii. Hard rock excavation | m³ | 4 | | |
| PSDA 8.3.4 | 2.2.7 | **Importing of materials from commercial sources :** | | | | |
| | | (a) For Embankment Construction | m³ | 250 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | (b) For Backfilling around Structures | | | | |
| | | i. G7 material compacted to 95% Mod. AASHTO | | | | |
| | | New bypass channel | m³ | 17 | | |
| | | Splitter chamber extension | m³ | 28 | | |
| | | Bypass manhole installation | m³ | 12 | | |
| | | Sump extension | m³ | 6 | | |
| | | Screenings facility | m³ | 110 | | |
| | | Generator bunded area and sump | m³ | 25 | | |
| | | Guardhouse platform | m³ | 30 | | |
| | | ii. G8 material compacted to 90% Mod. AASHTO (Provisional) | m³ | 1500 | | |
| | | iii. C4 Quality stabilized base compacted to 97% Mod. AASHTO maximum density | | | | |
| | | Perimeter walls | m³ | 360 | | |
| | | 150 mm foundation layer below all structures- Rip and recompact to 93% Mod AASTO Density | m³ | 165 | | |
| 8.3.6 | 2.2.8 | **Topsoiling** | m² | 1325 | | |
| 8.3.7 | 2.2.9 | **Grassing or other vegetation cover** | m² | 1325 | | |
| PSDA 8.3.9 | 2.2.10 | **Additional compaction** | m³ | 420 | | |
| PSDA 8.3.11 | 2.2.11 | **Protection of structures: buildings** | Sum | 1 | | |
| SABS 1200 DB 8.3.1 | **2.3** | **EARTHWORKS (PIPE TRENCHES)** | | | | |
| | | **Site clearance and(if specified) removal of topsoil:** | | | | |
| | 2.3.1 | (a) Clear vegetation and trees of girth up to 1,0 m | m | 65 | | |
| | 2.3.2 | (c) Remove topsoil up to 200 mm in depth | m² | 180 | | |
| PSDB 8.3.2 | | **Excavation:** | | | | |
| | 2.3.3 | (a) Excavate in all materials for trenches, backfill, compact and dispose of surplus material | | | | |
| | | (i) DN700 pipes (Provisional) | m³ | 350 | | |
| | | (ii) DN1050 bypass pipe | m³ | 500 | | |
| | 2.3.4 | (b) Extra over item (a) above for: | | | | |
| | | (i) Intermediate excavation | m³ | 45 | | |
| | | (iii) Hand excavation and backfill only where ordered by the Engineer | m³ | 170 | | |
| | | (iv) Backfill stabilised with 5% cement where directed by the Engineer (for trenches across road surfaces) | m³ | 40 | | |
| | 2.3.5 | (c) Excavate and dispose of unsuitable material from trench bottom (provisional) | m³ | 45 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| PSDB 8.3.3 | | **Excavation ancillaries:** | | | | |
| PSDB 8.3.3.1 | | **Make up deficiency in backfill material** | | | | |
| | 2.3.6 | (c) By importation from commercial or off-site sources selected by the contractor | m³ | 220 | | |
| 8.3.4 | | **Particular items:** Short trench opposite structure or service (Prov.) | m | 400 | | |
| PSDB 8.3.5 | | **Existing services that intersect or adjoin a pipe trench:** | | | | |
| | 2.3.7 | (a) Services that intersect a trench (angles between centre-lines in plan of 45 - 90°) | No | 10 | | |
| | 2.3.8 | (b) Services that adjoin a trench (parallel to or at a angle between centre-lines in plan of less than 45°) | m | 150 | | |
| SABS 1200 GA 8.2 | **2.4** | **CONCRETE (STRUCTURAL)** **FORMWORK** | | | | |
| 8.2.1 | 2.4.1 | **Rough:** | | | | |
| | | (i) Splitter box extension walls external faces (up to 150mm below FGL) | m² | 50 | | |
| | | (ii) Bypass channel walls external faces (up to 150mm below FGL) | m² | 45 | | |
| | | (iii) Sump tie-in walls external faces | m² | 20 | | |
| | | (iv) Perimeter walls foundation | m | 630 | | |
| 8.2.2 | 2.4.2 | **Smooth:** | | | | |
| | | (i) Splitter box extension walls internal faces (from 150mm below FGL) | m² | 40 | | |
| | | (ii) Bypass channel walls internal faces (from 150mm below FGL) | m² | 30 | | |
| | | (iii) Sump tie-in walls external faces | m² | 15 | | |
| 8.2.3 | 2.4.3 | narrow width (less than 500mm wide): | | | | |
| | | (i) Screenings facility, upstand beams (smooth finis | m | 75 | | |
| | | (ii) Generator bunded area (smooth finish) | m | 45 | | |
| | | (iii) Trolly beam (smooth finish) | m | 70 | | |
| | | (iv) Guardhouse slab and stubs | m | 30 | | |
| | | (v) Splitter box extension floor | m | 24 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | (vi) Sump extension floor | m | 5 | | |
| | | (vii) Screenings facility downstand beam | m | 35 | | |
| | | (viii) Bypass channel floor | m | 15 | | |
| 8.2.4 | 2.4.4 | **Box out holes/form voids:** | | | | |
| | | (a) Small, circular of diameter up to and including 0,35 m: | | | | |
| | | (i) Up to 0,5 m deep (Prov.) | No | 3 | | |
| | | (b) Small, other than circular, of area up to and including 0,1 m²: | | | | |
| | | (i) Up to 0,5 m deep (Prov.) | No | 3 | | |
| | | (c) Large, circular, of diameter over 0,35 m up to and including 0,7 m: | | | | |
| | | (i) Up to 0,5 m deep | No | 8 | | |
| | | (d) Large, other than circular, of area over 0,1 m² and up and including to 0,5 m²: | | | | |
| | | (i) Up to 0,5 m deep (Prov.) | No | 10 | | |
| 8,3 | 2.4.5 | **REINFORCEMENT** | | | | |
| 8.3.1 | | (a) Mild steel | t | 4 | | |
| | | (b) High-tensile steel | t | 34 | | |
| 8.3.2 | 2.4.6 | **High tensile welded mesh** | | | | |
| | | REF 617 | m² | 200 | | |
| | 2.4.7 | REF 888 | m² | 885 | | |
| PSGA 8.4 | | **CONCRETE** | | | | |
| 8.4.2 | 2.4.8 | **Blinding layer 50mm thick in grade 15/19 under structures** | | | | |
| | | (a) Perimeter walls | m² | 380 | | |
| | | Sub C | m² | 125 | | |
| | | (b) Guardhouse slab | m² | 25 | | |
| | | (c) Splitter box extension | m² | 30 | | |
| | | (d) Bypass channel | m² | 10 | | |
| | | (e) Screenings facility | m² | 165 | | |
| | | (f) Generator bunded area | m² | 30 | | |
| | | (g) Sump extension | m² | 5 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| 8.4.3 | 2.4.9 | **Strength concrete, grade 30/19** | | | | |
| | | (i) Guardhouse slab | m³ | 12 | | |
| | | (ii) Screenings facility | m³ | 70 | | |
| | | (iii) Generator bunded area | m³ | 10 | | |
| | | (iv) Thickening at screens installations (Prov.) | m³ | 5 | | |
| | 2.4.10 | **Strength concrete, grade 35/19** | | | | |
| | | (i) Splitter box extension | m³ | 22 | | |
| | | (ii) Bypass channel | m³ | 15 | | |
| | | (iii) Sump extension | m³ | 10 | | |
| | 2.4.11 | **Strength concrete, grade 25/19** | | | | |
| | | (i) Perimeter walls foundation | m³ | 105 | | |
| | | Sub C | m³ | 35 | | |
| 8.4.4 | | **Unformed surface finishes:** | | | | |
| | 2.4.12 | (a) Wood-floated finish | | | | |
| | | (i) Perimeter walls foundation | m² | 415 | | |
| | | (ii) Guardhouse slab | m² | 25 | | |
| | 2.4.13 | (b) Steel floated | | | | |
| | | (i) Splitter box extension | m² | 35 | | |
| | | (ii) Bypass channel | m² | 10 | | |
| | | (iii) Sump extension | m² | 5 | | |
| | | (iv) Generator bunded area | m² | 30 | | |
| | 2.4.14 | (c) Power floated surfaces | | | | |
| | | (i) Screenings facility | m² | 150 | | |
| 8.5 | | **Joints:** | | | | |
| | 2.4.15 | Contraction joints (Prov.) | m | 50 | | |
| | 2.4.16 | Expansion joints (Prov.) | m | 50 | | |
| | 2.4.17 | Control joints | m | 30 | | |
| 8.7 | 2.4.18 | **Grouting:** | | | | |
| | | (a) Under bases (or beds) | m³ | 8 | | |
| | | (b) HD bolts, etc | m³ | 5 | | |
| PSGA 8.9.1 | 2.4.19 | Concrete coring | No | 11 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| PSGA 8.9.2 | 2.4.20 | Grouting of pipes/specials through walls or slabs | m³ | 5 | | |
| SABS 1200 GE 8.2.1 | **2.5** | **PRECAST CONCRETE (STRUCTURAL)**<br>Supply, deliver and build-in, high security pull-out concrete doors complete with all accessories (shop details incl.) | | | | |
| | 2.5.1 | (a) Double door | No | 2 | | |
| | 2.5.2 | (b) Double door, slotted for crawl beam | No | 2 | | |
| | 2.5.3 | (c) Single door | No | 2 | | |
| | 2.5.4 | Supply, deliver and build-in, high security concrete ventilation panels complete with all accessories (shop details incl.) | | | | |
| | | (i) Approximately 2 x 2m panel | No | 3 | | |
| | | (ii) Approximately 5 x 5m panel | No | 4 | | |
| SABS 1200 H 8.3.1.1 | **2.6** | **STRUCTURAL STEELWORK**<br>Preparation of shop detail drawings | Sum | 1 | | |
| 8.3.1.2 | | Supply and fabrication of steelwork | | | | |
| | 2.6.2 | Supply, fabrication, delivery and erection of elevated, armoured Level B6, guardhouse including support and ladder, complete. Designed and Approved by a Professional Engineer. | Sum | 1 | | |
| SABS 1200 HA 8.3.1 | **2.7** | **STRUCTURAL STEELWORK (SUNDRY ITEMS)**<br>Supply and erect, with stop end, all fixings, complete, including corrossion protection, crawl beam to match existing. (SWL 3t, approx. 18 m long) | No. | 1 | | |
| SABS 1200 PSL 8.2.1 | **2.8** | **MEDIUM-PRESSURE PIPELINES**<br>Supply, lay, and bed pipes complete. | | | | |
| | | (i) DN1050, Class 50D, spigot and socket concrete pipe. (Bypass pipe) | m | 70 | | |
| M21.27 | | (ii) Design, drawings, manufacture, supply, off loading and storage of the new washwater main, SANS 62, flanged to SANS 1123 table 1600/3 DN100, Medium duty, GMS above ground. | m | 1600 | | |
| | | (iii) DN700 MS, 8 mm wall thickness including coating and lining, as specified (Coating; System B1A-high build two component epoxy coating followed by two coats of polyurethane and Lining; System C1-high build two component solvent-based coal tar Epoxy). | m | 710 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | (iv) DN160 Slotted HDPE drain pipes (Prov.) | m | 600 | | |
| M21.27 | 2.8.2 | Installation, site testing and commissioning of | | | | |
| | | (i) DN100, new washwater main. | m | 1600 | | |
| | | (ii) DN700, rising mains | m | 3500 | | |
| PSL 8.2.1.3 | 2.8.3 | Extra over 8.2.1 for cutting pipe as closure (Prov.) | No | 5 | | |
| | 2.8.4 | Extra over 8.2.1 for the supplying, laying, and bedding of specials including specified corrossion protection. (Prov.) | No | 7 | | |
| PSL 8.2.1.5 | 2.8.5 | Extra over 8.2.1 for couplings for DN700 MS | No | 95 | | |
| SABS 1200 LB | **2.9** | **BEDDING (PIPES)** | | | | |
| PSLB 8.2.1 | | Provision of bedding from trench excavation: | | | | |
| | 2.9.1 | (a) Without the need for screening: | | | | |
| | | (i) Selected granular material | $m^3$ | 50 | | |
| | | DN700 (Prov.) | $m^3$ | 310 | | |
| | 2.9.2 | (b) Including for screening: | | | | |
| | | (ii) Selected granular material | $m^3$ | 100 | | |
| PSLB 8.2.2 | | Provision of bedding by importation: | | | | |
| | 2.9.3 | (a) Including for screening and/or other treatment: | | | | |
| | | (i) Selected granular material | $m^3$ | 200 | | |
| | 2.9.4 | Padding sand to specified bedding dimensions (Prov.) | $m^3$ | 50 | | |
| PSLB 8.2.4 | | Encasing of pipes in concrete | | | | |
| | 2.9.5 | (i) For DN1050 Bypass pipe, with 20Mpa concrete ( | $m^3$ | 4 | | |
| PSLB 8.2.6 | | Drainage layer: | | | | |
| | 2.9.6 | (a) Stone filling | $m^3$ | 75 | | |
| | 2.9.7 | (b) Geofabric filter material (Bidim Grade A4 or similar) | $m^2$ | 620 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| SABS 1200 LD 8.2.3 | **2.10** 2.10.1 | **SEWERS** Construct DN1800 precast concrete manholes including cast in situ floors complete with channeling, building in pipe ends, precast concrete cover slabs with medium duty acess covers and frames in the following depth increments | | | | |
| | | (c) 3 - 4 m | No | 1 | | |
| 8.2.4 | 2.10.2 | Extra over item 8.2.3 for backdrops, missing covers, etc. | No | 2 | | |
| SABS 1200 MK | **2.11** | **KERBING AND CHANNELLING** | | | | |
| 8.2.1 | 2.11.1 | Concrete Kerbing, . Prov. a) Figure 8c kerbs, straight complete (Grade 25MPa concrete ) | m | 70 | | |
| 8.2.2 | 2.11.2 | Concrete Kerbing and Channelling Combined down chutes and kerb inlets, straight, complete Grade 25MPa concrete). | m | 70 | | |
| 8.2.5 | 2.11.3 | Chutes | m | 10 | | |
| PQA | **2.12** | **BRICKWORK, BLOCKWORK AND PLASTERING** | | | | |
| PQA 15.1 | 2.12.1 | Brickwork | | | | |
| | | (i) 345 mm thick facebrick both sides (to suit existing buildings) for 2,7 m high perimeter walls, inclusive of joints. | m² | 950 | | |
| | | (ii) 345 mm thick general purpose foundation brickw for 2,7 m high perimeter walls, inclusive of joints. | m² | 375 | | |
| | | (iii) 230 mm thick brickwork repairs to pump station suit existing) | m² | 50 | | |
| | | (iv) 230 mm thick brickwork repairs to splitter chamb to suit existing) | m² | 15 | | |
| PQA 15.3 | 2.12.2 | Building in window frames, door frames, pipes, steelwork, etc | No | 15 | | |
| PQA 15.4 | 2.12.3 | Damp proof course (345 mm thick walls) | m² | 150 | | |
| PQA 15.5 | 2.12.4 | Lintels (Prov.) | m | 10 | | |
| PQA 15.6 | 2.12.5 | Extraction fans (Prov.) | No | 2 | | |
| PQA 15.7 | 2.12.6 | Chases in brickwork (Prov.) | m | 20 | | |
| PQA 15.9 | 2.12.7 | Brickforce brick reinforcement (345 mm thick walls) | m | 3850 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| PQA 15.10 | 2.12.8 | Underfloor Waterproofing | m² | 200 | | |
| PQA 17 | 2.12.9 | PLASTERING | Prov Sum | 1 | R 25 000,00 | R25 000,00 |
| | 2.12.10 | Percentage mark-up on item above | % | | | |
| PQB | **2.13.1** | **FLOOR FINISHES AND WALL TILING** | Prov Sum | 1 | R 55 000,00 | |
| | 2.13.2 | Percentage mark-up on item above | % | | | |
| PQF | **2.14.1** | **PLUMBING** | | | | |
| PQF 5.1 | 2.14.2 | Provision of all materials, plant and labour necessary to complete the required installation and testing, including sanitary ware. | Prov. Sum | 1 | R 100 000,00 | |
| | 2.14.3 | Percentage mark-up on item above | % | | | |
| PQH | **2.15** | **PAINTING** | | | | |
| PQH 4.1 | 2.15.1 | Provision of all materials, plant and labour necessary to prepare the surfaces and complete the painting work as per existing painted surfaces of the pump station and Substation C buildings | Prov. Sum | 1 | R 80 000,00 | R80 000,00 |
| | 2.15.2 | Percentage mark-up onitem above | % | | | |
| PZA | **2.16** | **CLEANING OF SEWERS** | | | | |
| PZA 5.1 | | **Cleaning sewer pipes and manholes:** | | | | |
| | 2.16.1 | (a) Cleaning of sewer using mechanical means (Prov.) | | | | |
| | | (i) DN700 steel pipe (lined and coated) | m | 1700 | | |
| | | (ii) DN1400 steel pipe (lined and coated) | m | 1250 | | |
| | 2.16.2 | (b) Extra over for levels of silting greater than 20% of the pipediameter | m | 590 | | |
| | 2.16.3 | (c) Cleaning of sewer using high pressure jet cleaning | | | | |
| | | (i) DN700 steel pipe (lined and coated) | m | 3400 | | |
| | | (ii) DN1400 steel pipe (lined and coated) | m | 2500 | | |
| | 2.16.4 | (d) Extra over for levels of silting greater than 20% of the pipe diameter | m | 1180 | | |
| | 2.16.5 | (e) 'Cleaning of manholes/chambers, irrespective of internal dimensions using high pressure jet cleaning | No | 4 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| PZE | **2.17** | **TRENCHLESS REPLACEMENT OF EXISTING PIPES** | | | | |
| PZE 8.1 | 2.17.1 | Trenchless replacement (lining) of existing pipes (MS DN700) with HDPE DN630 PN16 | m | 1100 | | |
| PZE 8.3 | 2.17.2 | Launching and receiving trenches | Sum | 1 | | |
| PZE 8.4 | 2.17.3 | Road reinstatement (Prov.) | m² | 145 | | |
| PZE 8.5 | 2.17.4 | Site establishment | Sum | 1 | | |
| PZE 8.6 | 2.17.5 | Method statement | Sum | 1 | | |
| PZE 8.7 | 2.17.6 | CCTV Inspections Existing MS DN700 pipes | m | 3740 | | |
| | **2.18** | **MISCELLANEOUS ITEMS** | | | | |
| | 2.18.1 | Minor civil modifications, repairs or additions associated with M, E&I works (Provisional) | Prov Sum | 1 | R 100 000,00 | R100 000,00 |
| | 2.18.2 | Percentage mark-up on item above | % | | | |
| | 2.18.3 | Preparation and repair of deteriorated concrete walls and/or floors, including but not limited to cracks (minor/major), holes/voids, overcoating. (by use of cementitous, chrystalline slurry, mortar or other suitable means, as approved by the Engineer) | Prov Sum | 1 | R 1 240 000,00 | R1 240 000,00 |
| | 2.18.4 | Percentage mark-up on item above | % | | | |
| | | Provision of all materials, plant and labour necessary to supply, prepare the surfaces and apply epoxy for acid attack prevention on concrete surfaces | | | | |
| | 2.18.5 | (a) Skip bunded area | m² | 180 | | |
| | 2.18.6 | (b) New screen channel section | m² | 40 | | |
| | 2.18.7 | Supply and install GRP hand and knee rails, (each rail shall be measured separately along the centre line) including bends,offsets and closures, complete with fixings. (38 mm tube) | | | | |
| | | (i) Horizontal - Van Wyksrust pump station | m | 450 | | |
| | 2.18.8 | Flooring complete, installed with frames and all fixings. Open grid GRP floors (38 x 38 x 38 mm) | m² | 10 | | |
| | 2.18.9 | Allowance for supplementary existing pipe concrete thrust blocks and plinths repairs | Prov. Sum | 1 | R 200 000,00 | R200 000,00 |
| | 2.18.10 | Percentage mark-up on item above | % | | | |
| | 2.18.11 | Existing potable water pipe repairs | Prov. Sum | 1 | R 50 000,00 | R50 000,00 |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | 2.18.12 | Percentage mark-up on item above | % | | | |
| | 2.18.13 | Reinstatement of existing stormwater infrastructure (channels, drains, etc) | Prov. Sum | 1 | R 50 000,00 | R50 000,00 |
| | 2.18.14 | Percentage mark-up on item above | % | | | |
| | 2.18.15 | Entrance gates to suit perimeter walls, including vehicular and pedestrian type provision, at Van Wyksrust pump station and Substation C. | Prov. Sum | 1 | R 145 000,00 | R145 000,00 |
| | 2.18.16 | Percentage mark-up on item above | % | | | |
| | 2.18.17 | Existing building roof repairs (Van Wyksrust pump station) | Prov. Sum | 1 | R 30 000,00 | R30 000,00 |
| | 2.18.18 | Percentage mark-up on item above | % | | | |
| | 2.18.19 | Alternative pumps arrangement: Independent steel platform may be installed close to ground level, within the existing double volume space of the Van Wyksrust pump station building. Pumps capable of dry-priming may be installed on this higher level platform. (Provisional) | Prov. Sum | 1 | R 6 000 000,00 | R6 000 000,00 |
| | 2.18.20 | Percentage mark-up on item above | % | | | |
| | 2.18.21 | Address conditions and/or restrictions as required/imposed by the findings of the dolomite investigation (by others) | Prov. Sum | 1 | R 2 000 000,00 | R2 000 000,00 |
| | 2.18.22 | Percentage mark-up on item above | % | | | |
| | | **TOTAL SECTION 2 CARRIED TO SUMMARY** | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | **3** | **ELECTRICAL, CONTROL AND INSTRUMENTATION** | | | | |
| | | Schedule No 1<br>**MV System Upgrade** | | | | |
| | **3.1** | Manufacture, supply, off loading and installation of Van Wyks MV Reticulation - 12kV Metal-clad MV Switchgear Boards and RMU's 800A, 25kA. As detailed in the specifications | | | | |
| E13.26 | | (a) Incomer circuit breaker | No | 2 | | |
| E13.26 | | (b) Feeder circuit breaker | No | 1 | | |
| E13.26 | | (c) Battery tripping unit, wired fully installed | No | 1 | | |
| E13.26 | | (d) 11kV 3-way Ring Main Unit | No | 1 | | |
| | **3.2** | MV Cable<br>Supply and installation XLPE Type A copper conductor cables strapped to cable ladders. (trenches, sleeves and cable terminations measured elsewhere) | | | | |
| E12.9 | | (a) 185 $mm^2$ x 3 core | m | 1000 | | |
| E12.9 | | (b) 70 $mm^2$ x 3 core | m | 190 | | |
| E12.9 | | (c) 120 $mm^2$ Kwena earthing conductor. | m | 1000 | | |
| E12.9 | | (d) 70 $mm^2$ Kwena earthing conductor. | m | 190 | | |
| | **3.3** | MV Cable Termination<br>Supply and installation of MV cable termination XLPE Type A copper conductor cables | | | | |
| E06.7.4 | | (a) 185 $mm^2$ x 3 core | No | 2 | | |
| E06.7.4 | | (b) 70 $mm^2$ x 3 core | No | 6 | | |
| E06.7.4 | | (c) 120 $mm^2$ Kwena earthing conductor. | No | 2 | | |
| E06.7.4 | | (d) 70 $mm^2$ Kwena earthing conductor. | No | 6 | | |
| | **3.4** | MV Cable Joint<br>Supply and installation of MV cable joint XLPE Type A copper conductor cables | | | | |
| E06.6.2 | | (a) 185 $mm^2$ x 3 core | No | 3 | | |
| E06.6.2 | | (b) 70 $mm^2$ x 3 core | No | | | Rate only |
| | **3.5** | MV CABLE Installation Accessories | | | | |
| | | (a) Trenching including backfill and compaction - 800X1000mm | Prov. Sum | 1 | R 252 000,00 | R252 000,00 |
| | | (b) Percentage mark-up on item above | % | | | |
| E06.4.14 | | (c) Cable protection tiles (762x500x50) | ea | 1100 | | |
| E06.4.17 | | (d) Cable route Markers | ea | 14 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | **3.6** | Overhead Line - 11kV Fox Conductor<br>Substation C to Van Wyks Pump station<br>Design, supply, handling, inspection,<br>the overhead line and equipment earthing,<br>including soil resistivity testing, | | | | |
| E20.8 | | (a) Supply and deliver overhead line | m | 650 | | |
| E20.8 | | (b) Supply and deliver earthing system | No | 1 | | |
| E20.8 | | (c) Install, commission and test overhead line | No | 1 | | |
| | | Removal of existing equipment | | | | |
| | **3.7** | (a) Remove existing RMU's & MV Switchegar and transport to designated store, 5km maximum. | Prov. Sum | 1 | R 25 000,00 | R25 000,00 |
| | | (b) Percentage mark-up on item above | % | | | |
| | **3.8** | (c) Remove existing MV cable<br>and transport to designated store, 5km maximum | Prov. Sum | 1 | R 25 000,00 | R25 000,00 |
| | | (d) Percentage mark-up on item above | % | | | |
| | | **Schedule No 2**<br>**Van Wyks Pump Station Electrics** | | | | |
| E04.19 | **3.9** | MOTOR CONTROL CENTRE<br>Manufacture, supply, off loading and installation of Van Wyks Pump Station MCC including PLC connections , marshalling tier and commissioning as detailed in the specifications and drawings | No | 1 | | |
| | **3.10** | PLC PANEL<br>Manufacture, supply, off loading and<br>Pump Station PLC panel fully equipped including PLC hardware, power supplies, network switch fibre patch panel, terminals, trunking wiring etc, including commissioning as detailed in the specifications and drawings. | No | 1 | | |
| E16.10 | **3.11** | UPS<br>Supply, off loading, installation and commissioning of 3kVA, 230V UPS, with battery back-up | No | 1 | | |
| | **3.12** | LV CABLE<br>Supply and installation of PVC/SWA/PVC copper conductor cables strapped to cable ladders | | | | |
| E05.9 | | (a) 185mm$^2$ x 3 core | m | 120 | | |
| E05.9 | | (b) 120mm$^2$ x 3 core | m | | | Rate only |
| E05.9 | | (c) 95mm$^2$ x 3 core | m | 260 | | |
| E05.9 | | (d) 16mm$^2$ x 4 core | m | 80 | | |
| E05.9 | | (e) 4mm$^2$ x 4 core | m | 30 | | |
| E05.9 | | (f) 2.5mm$^2$ x 7 core | m | 1000 | | |
| E05.9 | | (g) 2.5mm$^2$ x 4 core | m | 1520 | | |
| E05.9 | | (h) 2.5mm$^2$ x 3 core | m | 50 | | |
| E05.9 | | (i) 1.5mm$^2$ x 3 core | m | 180 | | |
| E05.9 | | (j) 6mm$^2$ x 3 core surfix | m | 200 | | |
| E05.9 | | (k) 2.5mm$^2$ x 3 core surfix | m | 400 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | **3.13** | LV CABLE TERMINATION<br>Supply and installation of PVC/SWA/PVC Exe corrosion guard cable glands (IP68) complete including conductor& earth termination, lugs, tapes, drilling etc | | | | |
| E06.7 | | (a) 185mm$^2$ x 3 core | No | 14 | | |
| E06.7 | | (b) 120mm$^2$ x 3 core | No | | | Rate only |
| E06.7 | | (c) 95mm$^2$ x 3 core | No | 32 | | |
| E06.7 | | (d) 16mm$^2$ x 4 core | No | 6 | | |
| E06.7 | | (e) 4mm$^2$ x 4 core | No | 4 | | |
| E06.7 | | (f) 2.5mm$^2$ x 7 core | No | 36 | | |
| E06.7 | | (g) 2.5mm$^2$ x 4 core | No | 104 | | |
| E06.7 | | (h) 2.5mm$^2$ x 3 core | No | 4 | | |
| E06.7 | | (i) 1.5mm$^2$ x 3 core | No | 12 | | |
| E06.7 | | (j) 6mm$^2$ x 3 core surfix | No | 14 | | |
| E06.7 | | (k) 2.5mm$^2$ x 3 core surfix | No | 46 | | |
| | **3.14** | LOCAL ISOLATOR/ STOP/START STATIONS | | | | |
| E03.6 | | (a) Supply and installation of Local Isolator Station, including isolator and Stop/Start buttons.<80A | No | 11 | | |
| E03.6 | | (b) Supply and installation of Local Isolator Station, including isolator and Stop/Start buttons.>80A | No | 6 | | |
| E03.6 | | (c) Screen & compactor forward/ reverse local isolator station IP65, complete with emergency stop push | No | 5 | | |
| E03.6 | | (d) 3CR12 support stands for the above items. | No | 22 | | |
| | **3.15** | HIGH MAST LIGHTING | | | | |
| E21.10 | | (a) 30m High Mast Light, 6/8 luminaires to achieve Lux level of 50. | No | 2 | | |
| | | (b) Trenching including backfill and compaction - 500X500mm | Prov. Sum | 1 | R 8 000,00 | R8 000,00 |
| | | (b) Percentage mark-up on item above | % | | | |
| | **3.16** | DIESEL GENERATOR<br>Manufacture, supply, off loading, installation and commissioning of a 500kVA, 400V diesel generator including all ancillary equipment to effect a complete installation<br>As detailed in the specifications | | | | |
| E14.14 | | (a) Supply and delivery 500kVA 400V Generator Set, Incl. first fill of fuel, lubrication oil and filters | No | 1 | | |
| E14.14 | | (b) Installation site testing and commissioning, including 12 month maintenance contract | No | 1 | | |
| | | (c) Generator plinth and fencing enclosure | Sum | 1 | | |
| | **3.17** | 630kVA TRANSFORMER<br>Manufacture, supply, off loading, installation and commissioning of a 630kVA, 11kV/400V ONAN Dyn11 Transformer. Including all materials and ancillary equipment to effect a complete installation as detailed in the specifications | | | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| E15.17 | | (a) Supply, delivery and off loading of 630kVA transformer | No | 1 | | |
| E15.17 | | (b) Installation site testing and commissioning | No | 1 | | |
| | **3.18** | JUNCTION BOXES<br>PVC/SWA/PVC Exe 4 way ezee / fit junction box (IP68) complete including terminals, lugs, tapes, drilling etc<br>(glands measured elsewhere). | No | 10 | | |
| | **3.19** | EARTHING & LIGHTNING PROTECTION<br>Design, supply, installation and testing of electrical earthing and lighting protection system for the Van Wyks pump station<br>As detailed in the specifications | | | | |
| E11.16 | | (a) Earth resistivity tests | No | 1 | | |
| E11.16 | | (b) Design of earthing&lightning protection system | No | 1 | | |
| E11.16 | | (c) Supply and Installation of earthing & lightning protection system | No | 1 | | |
| E11.16 | | (d) Testing of earthing&lightning protection system | No | 1 | | |
| | | **SMALL POWER & LIGHTING** | | | | |
| | **3.20** | PLAIN ENDED METALLIC GALVANISED BOSAL CONDUIT<br>Supply and installation of conduit and boxes as specified for lighting, power and auxiliary outlets, including couplings, bushes, locknuts, bending, drawboxes and fixing,etc in accordance with metallic conduit and accessories | | | | |
| E09.19 | | (a) 20 mm on surface of brickwork or concrete galvanised | m | 100 | | |
| E09.19 | | (b) 20 mm round boxes surface mounted galvanised | No | 25 | | |
| E09.19 | | (c) Galvanised box 100 x 50 x 50mm deep galvanised boxes built into brick or concrete | No | 35 | | |
| E09.19 | | (d) Galvanised box 100 x 100 x 50mm deep galvanised boxes built into brick or concrete | No | 30 | | |
| | **3.21** | LIGHT SWITCHES<br>Supply, installation and connection of 16 Amp light switches in flush 50 x 100 x 50mm boxes, including white coloured cover plates. | | | | |
| E09.19 | | (a) Single lever | No | 6 | | |
| E09.19 | | (b) Two lever | No | 4 | | |
| E09.19 | | (c) Single lever, in IP65 Weather- Proof Enclosure | No | 2 | | |
| E09.19 | | (d) Occpancy Sensor | No | 2 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | **3.22** | SWITCHED SOCKET OUTLET<br>Supply, installation and connection of 16Amp switched socket outlets in 100 x 100 x 50mm boxes with white coloured cover plates | | | | |
| E09.19 | | (a) 16A, 3-pin double SSO, with two type M wall mounted | No | 6 | | |
| | **3.23** | LIGHTING<br>Supply, Installation and Commissioning of Luminaires | | | | |
| E21.10 | | (a) 4ft 50W Vapour Proof LED (With Battery backup) | No | 6 | | |
| E21.10 | | (b) 4ft 50W Vapour Proof LED | No | 6 | | |
| E21.10 | | (c) 220W LED Flood lights | No | 6 | | |
| E21.10 | | (d) 50W Bulkheads (internal) | No | 8 | | |
| E21.10 | | (e) 100W LED Flood lights | No | 6 | | |
| E21.10 | | (f) 8m High Light Poles | No | 14 | | |
| | **3.24** | WELDING PLUG<br>Supply, Installation and Commissioning | | | | |
| E07.5 | | (a) 400V, 5 wire welding plug socket | No | 2 | | |
| | **3.25** | PVC CONDUCTORS<br>Supply and drawn in copper PVC insulated conductors in conduit or trunking system in floor or in roof space for lights, plugs and power points, including connection to switches and equipment. For Live, Neutral and Earth. | | | | |
| E08.10 | | (a) 1,5 mm² Live | m | 300 | | |
| E08.10 | | (b) 1,5 mm² Neutral | m | 300 | | |
| E08.10 | | (c) 2,5 mm² Live | m | 300 | | |
| E08.10 | | (d) 2,5 mm² Neutral | m | 300 | | |
| E08.10 | | (e) 2,5 mm² Earth | m | 600 | | |
| | **3.26** | INSTRUMENTATION<br>Includes the supply and installation of the field instrumenation as detailed in the specifications and data sheets, including all installation accessories and mounting brackets. | | | | |
| | | (a) Ultrasonic level transmitters (0.3-15m) | No | 2 | | |
| | | (b) Flow transmitter - clamp on ultra sonic | No | 2 | | |
| | | (c) Level switches - capacitive | No | 2 | | |
| | | (d) Ultrasonic differential level transmitters | No | 5 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | (e) Open channel flow transmitters | No | 4 | | |
| | | (f) Hydrostatic level transmitters (pressure) | No | 2 | | |
| | | (g) Flow switches | No | 8 | | |
| | **3.27** | INSTRUMENT JUNCTION BOXES<br>Manufacture, supply, off loading and installation of 3CR12 SS Instrument Junction Boxes as detailed in the specifications and drawings. | | | | |
| | | (a) Instrument junction boxes | No | 15 | | |
| | | (b) 3CR12 support stands for the above item. | No | 15 | | |
| | **3.28** | INSTRUMENTATION CABLES<br>Supply and installation of SW armoured electronic instrument cable strapped to cable ladder & laid in cable trench (cable ladder, trenching & cable terminations measured elsewhere) | | | | |
| | | (a) 2 pairx0.5mm$^2$ XLPE IAOS PVC SWA PVC Cu | m | 1230 | | |
| | | (b) 4 corex1.5mm$^2$ PVC OS PVC SWA PVC Cu | m | 340 | | |
| | | (c) 12 corex1.5mm$^2$ PVC OS PVC SWA PVC Cu | m | 30 | | |
| | | (d) 24 corex1.5mm$^2$ PVC OS PVC SWA PVC Cu | m | 140 | | |
| | | (e) 3 core x 2.5 mm$^2$ PVC PVC SWA PVC Cu | m | 730 | | |
| | | (f) 3 core x 6 mm$^2$ PVC PVC SWA PVC Cu | m | 60 | | |
| | **3.29** | INSTRUMENTATION CABLE TERMINATION<br>Supply and installation of PVC/SWA/PVC Exe corrosion guard cable glands (IP68) complete including conductor& earth termination, lugs, heatshrink, drilling etc | | | | |
| | | (a)2 pairx0.5mm$^2$ XLPE IAOS PVC SWA PVC Cu | No | 44 | | |
| | | (b) 4 corex1.5mm$^2$ PVC OS PVC SWA PVC Cu | No | 12 | | |
| | | (c) 12 corex1.5mm$^2$ PVC OS PVC SWA PVC Cu | No | 2 | | |
| | | (d) 24 corex1.5mm$^2$ PVC OS PVC SWA PVC Cu | No | 14 | | |
| | | (e) 3 core x 2.5 mm$^2$ PVC PVC SWA PVC Cu | No | 24 | | |
| | | (f) 3 core x 6 mm$^2$ PVC PVC SWA PVC Cu | No | 6 | | |
| | **3.30** | ELECTRICAL CABLE LADDER AND SUPPORTS<br>3CR12 cable ladder powder coated including all accessories, mounted to concrete slabs / walls. | | | | |
| E02.8 | | (a) 1000mm cable ladder | m | 6 | | |
| E02.8 | | (b) 1000mm 90$^o$ bends | No | 1 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| E02.8 | | (c) 1000mm internal bends | No | | | Rate only |
| E02.8 | | (d) 1000mm T-pieces | No | | | Rate only |
| E02.8 | | (e) 600mm cable ladder | m | 60 | | |
| E02.8 | | (f) 600mm 90$^{o}$ bends | No | 3 | | |
| E02.8 | | (g) 600mm internal bends | No | 1 | | |
| E02.8 | | (h) 600mm T-pieces | No | | | Rate only |
| E02.8 | | (i) 300mm cable ladder | m | 100 | | |
| E02.8 | | (j) 300mm 90$^{o}$ bends | No | 5 | | |
| E02.8 | | (k) 300mm internal bends | No | 2 | | |
| E02.8 | | (l) 300mm T-pieces | No | 1 | | |
| E02.8 | | (m) P1000 channel (3Cr12) | m | 50 | | |
| E02.8 | | (n) Channel steel 100x50x4.5 (3Cr12) | m | 50 | | |
| E02.8 | | (o) Angle steel 30x30x4.5 (3Cr12) | m | 50 | | |
| | **3.31** | C&I CABLE LADDER AND SUPPORTS<br>3CR12 cable ladder powder coated including all accessories, mounted to concrete slabs / walls. | | | | |
| | | (a) 300mm cable ladder | m | 50 | | |
| | | (b) 300mm 90$^{o}$ bends | No | 3 | | |
| | | (c) 300mm internal bends | No | 1 | | |
| | | (d) 300mm T-pieces | No | | | Rate only |
| | | (e) 150mm cable ladder | m | 200 | | |
| | | (f) 150mm 90$^{o}$ bends | No | 8 | | |
| | | (g) 150mm internal bends | No | 3 | | |
| | | (h) 150mm T-pieces | No | 1 | | |
| | | (i) P1000 channel (3Cr12) | m | 30 | | |
| | | (j) Channel steel 100x50x4.5 (3Cr12) | m | 15 | | |
| | | (k) Angle steel 30x30x4.5 (3Cr12) | m | 50 | | |
| | **3.32** | LV Cable Trenching<br>(a) Trenching including backfill and compaction - 600X600mm | Prov. Sum | 1 | R 75 000,00 | R75 000,00 |
| | | (b) Percentage mark-up on item above | % | | | |
| | | (c) Cable protection tiles (762x500x50) | ea | 390 | | |
| | | (d) Cable route Markers | ea | 4 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | Schedule No 3<br>Network Reestablishment & Communication | | | | |
| | **3.33** | FIBRE CABLING<br>Supply and installation of 12 Core Single-Mode cables laid in ducts, trenches, horizontal racks or vertical ducts. Rates shall include the supply and fixing of supports for installation of cables | | | | |
| | | (a) 12 core single mode fibre cable - SWA | m | 750 | | |
| | | (b) 12 core single mode fibre cable - aerial type | m | 704 | | |
| | | (c) 12 core single mode fibre cable - termination (Splicing & OTDR testing) | No | 4 | | |
| | | (d) Fibre patch panel | No | 4 | | |
| | **3.34** | SLEEVES<br>Supply and installation of HDPE sleeves buried in ground as specified for C&I services. | | | | |
| | | (a) 110mm Flexible double walled black corrugated sleeves including 6mm pilot string as draw wire in each sleeve | m | 800 | | |
| | **3.35** | MANHOLES<br>Supply and installation of watertight manholes in ground as specified, including,<br>seals ,bushes, sleeve entries and end caps.<br>Inclusive of cover and frame | | | | |
| | | (a) Manholes | No | 10 | | |
| | **3.36** | FIBRE CABLE TRENCHING | | | | |
| | | (a) Trenching including backfill and compaction - 600X600mm | Prov. Sum | 1 | R 200 000,00 | R200 000,00 |
| | | (b) Percentage mark-up on item above | % | | | |
| | | (c) Cable protection tiles (762x500x50) | ea | 1050 | | |
| | | (d) Cable route Markers | ea | 8 | | |
| | **3.37** | RADIO SYSTEM UPGRADE<br>Supply installation and commissioning of enhancements to the site security radio system | | | | |
| | | (a) Site radio coverage survey | Sum | 1 | | |
| | **3.38** | IP TELEPHONE SYSTEM<br>Supply installation and commissioning of<br>IP Telephone System, connecting into site fibre network | | | | |
| | | (a) Control room base station and software | Sum | 1 | | |
| | | (b) IP Telephone Sets | No | 4 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | Schedule 4 - General | | | | |
| | **3.39** | Provisional Sums | Prov. | | | |
| | | (a) Provisional sum for PLC Programming | Sum | 1 | R 600 000,00 | R600 000,00 |
| | | (b) Provisional sum for SCADA programming | Prov. Sum | 1 | R300 000,00 | R300 000,00 |
| | | (c) Provisional sum for C&I Design | Prov. Sum | 1 | R650 000,00 | R650 000,00 |
| | | (d) Provisional sum for radio system upgrades | Prov. Sum | 1 | R230 000,00 | R230 000,00 |
| | | (e) Provisional sum for ECI site spares | Prov. Sum | 1 | R250 000,00 | R250 000,00 |
| | | (f) Provisional sum for V/Wyks P/S Perimeter | Prov. Sum | | | |
| | | (g) Intruder detection system | Prov. Sum | 1 | R500 000,00 | R500 000,00 |
| | | Contractors markup on Provisional sums 3.9 a to g above | % | | | |
| | **3.40** | AS BUILT DRAWINGS<br>The marking - up of "As Built" drawings during the contract to ensure that accurate "As Built" drawings are submitted to the Engineer at the end of the contract. | sum | 1 | | |
| | **3.41** | OPERATING & MAINTENANCE MANUALS<br>Compilation of an O & M manuals | sum | 1 | | |
| | **3.42** | QA/QC and FAT of equipment (MV Equipment, MCC's and VSD's) | sum | 1 | | |
| | | **TOTAL SECTION 3 CARRIED TO SUMMARY** | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | **4** | **MECHANICAL** | | | | |
| | **4.1** | **Replacement of Pumps** | | | | |
| M18.28 | 4.1.1 | Design, drawings, manufacture, supply, factory testing and storage of the Van Wyk pump station pumpsets (including motors) as specified. | No | 6 | | |
| M18.28 | 4.1.2 | Delivery to site, offloading and installation of the Van Wyk pump station pumpsets | No | 6 | | |
| | **4.2** | **Pipework** | | | | |
| | | Design, drawings, manufacture, supply, testing testing and storage of pipework: | | | | |
| M20.27 | 4.2.1 | VP-S-01 DN450 Bell mouth | No | 6 | | |
| M20.27 | 4.2.2 | VP-S-02 DN450 90 deg short radius bend | No | 6 | | |
| M20.27 | 4.2.3 | VP-S-03 DN450 Puddle pipe | No | 6 | | |
| M20.27 | 4.2.4 | VP-S-05 DN450 Dismantling joint | No | 6 | | |
| M20.27 | 4.2.5 | VP-S-06 DN450-DN300 Eccentric reducer | No | 6 | | |
| M20.27 | 4.2.6 | VP-D-01 DN400-DN300 Eccentric reducer | No | 6 | | |
| M20.27 | 4.2.7 | VP-D-02 DN400 90 deg short radius bend | No | 6 | | |
| M20.27 | 4.2.8 | VP-D-05 DN400 Dismantling joint | No | 6 | | |
| M20.27 | 4.2.9 | VP-D-06 DN400 Straight pipe | No | 1 | | |
| M20.27 | 4.2.10 | VP-D-07 DN400 90 deg medium radius bend | No | 2 | | |
| M20.27 | 4.2.11 | VP-D-08 DN400-DN600 Eccentric reducer | No | 2 | | |
| M20.27 | 4.2.12 | VP-D-09 DN600 Straight pipe | No | 1 | | |
| M20.27 | 4.2.13 | VP-D-10 DN600 Straight pipe | No | 2 | | |
| M20.27 | 4.2.14 | VP-D-11 DN600 Swept tee | No | 4 | | |
| M20.27 | 4.2.15 | VP-D-12 DN600 Straight pipe | No | 1 | | |
| M20.27 | 4.2.16 | VP-D-13 DN400 Straight pipe | No | 1 | | |
| M20.27 | 4.2.17 | VP-D-14 DN600 Straight pipe | No | 1 | | |
| M20.27 | 4.2.18 | VP-D-15 DN600 90 deg short radius bend | No | 4 | | |
| M20.27 | 4.2.19 | VP-D-16 DN600 Straight pipe | No | 2 | | |
| M20.27 | 4.2.20 | VP-D-17 DN400 Straight pipe | No | 1 | | |
| M20.27 | 4.2.21 | VP-D-18 DN400 Straight pipe | No | 1 | | |
| M20.27 | 4.2.22 | VP-D-19 DN400 Straight pipe | No | 2 | | |
| M20.27 | 4.2.23 | Delivery to site, offloading and installation of the pipework (for items 4.2.1 to 4.2.22) | Sum | 1 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | 4.2.24 | Other pipework and supports as directed by Engineer | Prov Sum | 1 | | R460 000,00 |
| | 4.2.25 | Contractors markup on Provisional Sums 4.4.7 | % | | | |
| | **4.3** | **Valves**<br>Design, drawings, manufacture, supply, factory testing and and storage of valves: | | | | |
| M20.21 | 4.3.1 | DN450 PN10 Knife gate valve | No | 6 | | |
| M20.21 | 4.3.2 | DN400 PN10 Knife gate valve | No | 6 | | |
| M20.21 | 4.3.3 | DN400 PN10 Swing check valve | No | 6 | | |
| M20.21 | 4.3.4 | DN600 PN10 Knife gate valve | No | 3 | | |
| M20.21 | 4.3.5 | DN700 PN10 Knife gate valve | No | 2 | | |
| M20.21 | 4.3.6 | DN350 PN10 Knife gate valve | No | 6 | | |
| M20.21 | 4.3.7 | DN200 PN06 Flanged Sewage Air release valve | No | 4 | | |
| M20.21 | 4.3.8 | DN200 PN10 Gate Valve | No | 4 | | |
| | | Delivery to site, offloading and installation of the valves | | | | |
| M20.21 | 4.3.9 | DN450 PN10 Knife gate valve | No | 6 | | |
| M20.21 | 4.3.10 | DN400 PN10 Knife gate valve | No | 6 | | |
| M20.21 | 4.3.11 | DN400 PN10 Swing check valve | No | 6 | | |
| M20.21 | 4.3.12 | DN600 PN10 Knife gate valve | No | 3 | | |
| M20.21 | 4.3.13 | DN700 PN10 Knife gate valve | No | 2 | | |
| M20.21 | 4.3.14 | DN350 PN10 Knife gate valve | No | 6 | | |
| M20.21 | 4.3.15 | DN200 PN10 Flanged Sewage Air release valve | No | 4 | | |
| M20.21 | 4.3.16 | DN200 PN10 Gate Valve | No | 4 | | |
| | **4.4** | **Screening equipment** | | | | |
| M01.15 | 4.4.1 | **Primary screens / Trash racks**<br>Design, drawings, manufacture, supply, factory testing and and storage of the mechanical front raked primary screens. | No | 3 | | |
| M01.15 | 4.4.2 | Delivery to site, offloading and installation of mechanically front raked primary screens. | No | 3 | | |
| M01.15 | 4.4.3 | Design, drawings, manufacture, supply, factory testing and and storage of the primary screens belt conveyor. | No | 1 | | |
| M01.15 | 4.4.4 | Delivery to site, offloading and installation of the primary screens belt conveyor. | No | 1 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | **Secondary screens** | | | | |
| M01.15 | 4.4.5 | Design, drawings, manufacture, supply, factory testing and and storage of the mechanical front raked secondary screens. | No | 2 | | |
| M01.15 | 4.4.6 | Delivery to site, offloading and installation of mechanically front raked secondary screens. | No | 2 | | |
| M01.15 | 4.4.7 | Design, drawings, manufacture, supply, factory testing and and storage of the secondary screens screw conveyor. | No | 1 | | |
| M01.15 | 4.4.8 | Delivery to site, offloading and installation of the secondary screen screw conveyor. | No | 1 | | |
| M01.15 | 4.4.9 | Design, drawings, manufacture, supply, factory testing and and storage of the screenings wash compactor. | No | 2 | | |
| M01.15 | 4.4.10 | Delivery to site, offloading and installation of the screenings wash compactor. | No | 2 | | |
| M01.15 | 4.4.11 | Design, drawings, manufacture, supply, factory testing and storage of the compacted screenings belt conveyor. | No | 1 | | |
| M01.15 | 4.4.12 | Delivery to site, offloading and installation of the storage of the compacted screenings belt conveyor. | No | 1 | | |
| M01.15 | 4.4.13 | Design, drawings, manufacture, supply, and storage of the waste skip trolleys and tracks | No | 1 | | |
| M01.15 | 4.4.14 | Delivery to site, offloading and installation of the waste skip trolleys and tracks | No | 1 | | |
| | **4.5** | **Wash water booster pumps** | | | | |
| | | Design, drawings, manufacture, supply, off loading and storage of the new wash water booster pumps, valves, pipework, including hold down bolts | | | | |
| M18.28 | 4.5.1 | Wash water booster pump sets | No | 2 | | |
| M20.21 | 4.5.2 | DN65 - Isolation Valves | No | 2 | | |
| M20.21 | 4.5.3 | DN65 - Non-return valves | No | 2 | | |
| M21.27 | 4.5.4 | DN65 PN10 Stainless Steel flanged medium pressure pipe | m | 40 | | |
| | | Installation, site testing and commissioning of the new wash water booster pumps, valves, pipework, including hold down bolts | | | | |
| M18.28 | 4.5.5 | Wash water booster pump sets | Sum | 1 | | |
| M21.27 | 4.5.6 | Pipework and valves | Sum | 1 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | **4.6** | **Wash water supply pumps** | | | | |
| | | Design, drawings, manufacture, supply, off loading and storage of the new wash water supply pumps, valves, pipework, including hold down bolts | | | | |
| M18.28 | 4.6.1 | Wash water supply pump sets | No | 2 | | |
| M20.21 | 4.6.2 | DN100 - Isolation valves | No | 2 | | |
| M20.21 | 4.6.3 | DN100 - Non-return valves | No | 2 | | |
| M21.27 | 4.6.4 | DN100 PN10 flanged medium pressure pipe discharge manifold | m | 5 | | |
| | 4.6.5 | 4750l HDPE wash water storage tank | No | 1 | | |
| | 4.6.6 | Skid mount for pumps | No | 1 | | |
| | | Installation, site testing and commissioning of the new wash water supply pumps, valves, pipework, including hold down bolts | | | | |
| M18.28 | 4.6.7 | Wash water supply pump sets, skid and tank | Sum | 1 | | |
| M21.27 | 4.6.8 | Pipework and valves | Sum | 1 | | |
| | **4.7** | **Penstocks**<br>Design, drawings, manufacture, supply, off loading and storage of penstocks | | | | |
| M34.17 | 4.7.1 | 1m wide by 2m high channel mounted | No | 5 | | |
| M34.17 | 4.7.2 | 650mm wide by 650mm height wall mounted | No | 3 | | |
| | | Installation and commissioning of penstocks | | | | |
| M34.17 | 4.7.3 | 1m wide by 2m high channel mounted | No | 5 | | |
| M34.17 | 4.7.4 | 650mm wide by 650mm height wall mounted | No | 3 | | |
| | **4.8** | **Ancillaries** | | | | |
| | 4.8.1 | Supply of screen spares as directed by Engineer | Prov Sum | 1 | R75 000,00 | R75 000,00 |
| | 4.8.2 | Repairs to HVAC as directed by Engineer | Prov Sum | 1 | R150 000,00 | R150 000,00 |
| | 4.8.3 | Repairs to lifting equipment and load testing | Prov Sum | 1 | R300 000,00 | R300 000,00 |
| | 4.8.4 | Fabricated steel pipe supports, staircase and stepovers | Prov Sum | 1 | R400 000,00 | R400 000,00 |
| | 4.8.5 | Contractors markup on Provisional Sums 4.8.1, 4.8.2, 4.8.3, 4.8.4 | % | | | |
| | 4.8.6 | Design, drawings, manufacture, supply, off loading, installation and commissioning of drainage submersible pump installation | No | 1 | | |
| | | **TOTAL SECTION 4 CARRIED TO SUMMARY** | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | **5** | **SECURITY CAMERA SYSTEM** | | | | |
| | **5.1** | **Cameras and poles** | | | | |
| | | (a) Galvanised 100 x 100mm tubing 5m | No. | 28 | | |
| | | (b) Earthing | No. | 28 | | |
| | | (c) Camera - 4MP Bullet 100m | No. | 28 | | |
| | | (d) Pole Bracket & Pole Cap | No. | 28 | | |
| | | (e) Camera Junction Box | No. | 28 | | |
| | | (f) Camera Network Switch | No. | 28 | | |
| | | (g) Power Supply | No. | 28 | | |
| | | (h) SFP MM | No. | 56 | | |
| | | (i) Battery - 12V 24Ah | No. | 28 | | |
| | | (j) Fibre Splice Box | No. | 28 | | |
| | | (k) Ethernet Patch Cables | No. | 28 | | |
| | | (l) Fibre Patch Cables | No. | 56 | | |
| | **5.2** | **Video Recorder,Fibre Optic,Cable&Trenching** | | | | |
| | | (a) Digital video recorder 64 channel, 32G storage | No. | 2 | | |
| | | (b) DVR Switch | No. | 1 | | |
| | | (c) 4 Fibre Unit MM OM2 | m | 250 | | |
| | | (d) 4 core single mode fibre cable - aerial type | m | 350 | | |
| | | (e) 1 Way 8/5 Microduct | m | 250 | | |
| | | (f) 2.5mm x 3c Cable | m | 700 | | |
| | | (g) 2.5mm x 3c Cable ends | No. | 28 | | |
| | | (h) 4mm x 3c Cable | m | 700 | | |
| | | (i) 4mm x 3c Cable ends | No. | 28 | | |
| | | (j) FO Terminations | No. | 60 | | |
| | | (k) Pigtails | No. | 120 | | |
| | | (l) Cable Cover Slabs (38mm thick paving blocks or precast wall slabs) | m | 250 | | |
| | | (m) 110mm Cable Sleeve | m | 100 | | |
| | | (n) Trenching 500x500mm (W x D) - hand excavatic | m | 250 | | |
| | | (o) Sifted Sand Bedding | $m^3$ | 30 | | |
| | | (p) Cable warning tape | m | 250 | | |
| | | (q) Backfilling (insitu material) | $m^3$ | 70 | | |
| | **5.3** | **Power Links** | | | | |
| | | (a) Circuit Breakers in existing DB | Sum | 1 | | |
| | | (b) 25mm Galvanised Conduit | m | 20 | | |
| | | (c) 25mm Galvanised Saddles | No. | 20 | | |
| | **5.4** | **Testing & Commissioing** | Sum | 1 | | |
| | **5.5** | **Associated Preliminary & General** | Sum | 1 | | |
| | | **TOTAL SECTION 5 CARRIED TO SUMMARY** | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| **PSCP** | **6** | **PIPES INVESTIGATION, DESIGN, REPORT (Existing DN700's & DN1400 rising main pipes)** | | | | |
| | 6.1 | See items described below | Prov. Sum | 1 | R2 400 000,00 | R2 400 000,00 |
| | 6.2 | Percentage mark-up on item above | % | | | |
| | | **Preliminary and General:** | | | | |
| | 6.3 | Allowance for compliance with all contractual requirements, including site establishment, transport, access to the site, equipment, security measures, insurances, all disbursements, overheads and any other costs not allowed for anywhere else. | | | | |
| | 6.4 | GPR (Ground penetrating radar) Survey and mapping of the existing pipes and other related services | | | | |
| | | **Pipe condition inspection** | | | | |
| | 6.5 | The point of lowest soil resistivity is to be used to select a cut-out that requires testing. Crown of the pipe to be cut to provide a suitable size for metallurgical testing purposes (6 off). Opening to be made good upon completion of the investigation stage. | | | | |
| | | **CP and AC investigations** | | | | |
| | 6.6 | Inspection of the existing pipelines coatings | | | | |
| | 6.7 | Excavation for inspection, as required. | | | | |
| | | **Soil Resistivity Survey:** | | | | |
| | 6.8 | Provide all necessary equipment for carrying out the soil resistivity survey | | | | |
| | 6.9 | Provide technical site staff (say 85 off), take measurements, record the soil resistivity, taking and recording GPS coordinates | | | | |
| | | **Stray Current Survey:** | | | | |
| | 6.10 | Ascertain if there are any stray currents | | | | |
| | 6.11 | Provide data loggers for stray current survey if required | | | | |
| | 6.12 | Provide technical site staff, install and remove data loggers | | | | |
| | | **Current Drainage Survey:** | | | | |
| | 6.13 | Provide technical site staff and carry out current drainage survey on the existing pipelines | | | | |
| | 6.14 | a. Install temporary continuity measures to enable the current drainage survey (as required) | | | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | 6.15 | Tabulate and analyse all field data<br><br>**Design and Report:**<br><br>Prepare an options analysis of feasible repair/replacement methods for the existing pipelines, including related costing and firm recommendations, based on tests and visual assessment. | | | | |
| | 6.16 | Existing DN700 pipes (x2) | | | | |
| | 6.17 | Existing DN1400 pipe (x1) | | | | |
| | 6.18 | Carry out the design of the CP system(s) and AC mitigation measures. | | | | |
| | 6.19 | Prepare an estimate of the capital cost of the CP system(s) and AC mitigation measures that will be required | | | | |
| | 6.20 | Prepare an estimate of the operating costs of the CP system(s) and AC mitigation measures. | | | | |
| | 6.21 | Preparation and submission of the report including and having addressed all objectives outlined throughout the documents. | | | | |
| | | **TOTAL SECTION 6 CARRIED TO SUMMARY** | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | **7** | **ROADS PAVING SLABS** | | | | |
| | **7.1** | **MASS EARTHWORKS** | | | | |
| **B33.04** | 7.1.1 | **Cut to spoil, including all haul. Material obtained from:** | | | | |
| | | (a) Soft excavation | m³ | 200 | | |
| | | (b) Intermediate excavation | m³ | 100 | | |
| | | (c)Hard excavation | m³ | 10 | | |
| | | (d) Boulder excavation class A | m³ | | | |
| | | (e)Boulder excavation class B | m³ | 10 | | |
| **B33.07** | 7.1.2 | **Removal of unsuitable material, including all haul:** | | | | |
| | | (a) In layer thicknesses of 200 mm and less: | | | | |
| | | i. Stable material | m³ | 200 | | |
| | | ii. Unstable material | m³ | 100 | | |
| | | (b) In layer thicknesses exceeding 200 mm: | | | | |
| | | i. Stable material | m³ | 10 | | |
| **33.10** | 7.1.3 | **Roadbed preparation and the compaction of material:** | | | | |
| | | (b) Compaction to 93% of modified AASHTO density | m³ | 300 | | |
| | | (d) Compaction of sand roadbed to 100% of modified AASHTO density | m³ | 10 | | |
| **B33.20** | 7.1.4 | **Fill constructed with material obtained from commercial sources or sources provided by the contractor, including all haul:** | | | | |
| | | Gravel material in compacted layer thicknesses of 200 mm and less: | | | | |
| | | Compacted to 90% of modified AASHTO density | m³ | 100 | | |
| | | Compacted to 93% of modified AASHTO density | m³ | 100 | | |
| **B34,15** | **7.2** | **PAVEMENT LAYERS OF GRAVEL MATERIAL** | | | | |
| | 7.2.1 | **Pavement layers constructed from gravel obtained from commercial sources or approved sources provided by the contractor, including all haul:** | | | | |
| | | (a) Gravel selected layer compacted to: | | | | |
| | | i. 93% of modified AASHTO density for a compacted layer thickness of 150 mm, G7 quality | m³ | 300 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | | ii. 95% of modified AASHTO density for a compacted layer thickness of 150 mm, G5 quality | m³ | 100 | | |
| | | (b) Gravel subbase (unstabilised gravel) compacted to: | | | | |
| | | i. 97% of modified AASHTO density for a compacted layer thickness of 150 mm, G5 quality | m³ | 300 | | |
| **3500** | | **STABILISATION** | | | | |
| | | **Chemical stabilisation extra over unstabilised compacted layers:** | | | | |
| | | (a) Gravel subbase, 150 mm thick | m³ | 300 | | |
| **B35.02** | | **Chemical stabilising agent:** | | | | |
| | | (b) Portland blast-furnace cement (CEM 11/B-L32.5N) | t | 26 | | |
| **35,04** | | **Provision and application of water for curing** | kilolitre | 16 | | |
| **B35.14** | | **Sampling of in situ material for mix design procedure** | Number | 3 | | |
| . | **7.3** | **CONCRETE PAVEMENTS** | | | | |
| **71.01** | | **Concrete trial pavement:** | | | | |
| | 7.3.1 | (a) Mechanical construction, 150 mm thick | m² | | | Rate only |
| | 7.3.2 | (b) Manual construction, 150 mm thick | m² | | | Rate only |
| **71.02** | 7.3.3 | **Concrete pavement 150mm thick excluding texturing and curing (Class 30/19)** | m² | 2 000 | | |
| **71.03** | 7.3.4 | **Extra over item 71.02 for concrete pavement requiring hand placing** | m² | 300 | | |
| **71.04** | 7.3.5 | **Texturing and curing the concrete pavement:** | | | | |
| | | (a) Burlap-dragged and grooved texture | m² | 2 000 | | |
| | | (b) Curing | m² | 2 000 | | |
| **71.05** | 7.3.6 | **Variation in the rate of application of the curing compound** | litre | 20 | | |
| **71.06** | | **Joints:** | | | | |
| | 7.3.7 | (a) Expansion joints complete (excluding dowels - *"See Detail B on the tender drawings "* | m | 200 | | |
| | 7.3.8 | (b) Sealed transverse contraction joints sawn in two separate operations (widths as shown on the drawings) | m | 200 | | |
| | | Carried forward | | | | |

| Payment refers to | Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|---|
| | | Brought forward | | | | |
| | 7.3.9 | (c) Diamond Plate Dowel<br>*"See Detail D on the tender drawings "* | | | | |
| | 7.3.10 | (i) Installed in new concrete | No | 420 | | |
| | 7.3.11 | (d) Tapered Plate Dowel bars<br>*"See Detail C on the tender drawings "* | | | | |
| | 7.3.12 | (ii) Installed in new concrete | No | 560 | | |
| **71.07** | | **Drilling and testing of cores:** | | | | |
| | 7.3.13 | (a) 100 mm cores drilled from the pavement | No | 5 | | |
| **71,08** | | **Steel reinforcement in concrete pavement:** | | | | |
| | 7.3.14 | (a) Mild-steel bars | t | | | Rate only |
| | 7.3.15 | (b) High tensile steel bars | t | | | Rate only |
| | 7.3.16 | (c) Welded steel fabric, Ref 311 | kg | 6 000 | | |
| | **7.4** | **TESTING MATERIALS AND WORKMANSHIP** | | | | |
| **B81.02** | 7.4.1 | **Other special tests requested by the Engineer** | Prov Sum | 1 | R 50 000,00 | R 50 000,00 |
| | 7.4.2 | Percentage mark-up on item above | % | | | |
| | | **TOTAL SECTION 7 CARRIED TO SUMMARY** | | | | |

# Johannesburg Water (SOC) Ltd

## CONTRACT NO: JW14466

## OLIFANTSVLEI WASTEWATER TREATMENT WORKS INFRASTRUCTURE RENEWAL PLAN REFURBISHMENT OF VAN WYKSRUST PUMP STATION

## VOLUME 2B

## PART 3: SCOPE OF WORK (Particular Specifications)

## C3 SCOPE OF WORK

### GENERAL

This section specifies and describes the supplies, services and engineering and construction works which are to be provided and any other requirements and constraints relating to the manner in which the contract work is to be performed.

### SCOPE

The Scope of the Work is set out in six portions:

Portion 6: PARTICULAR SPECIFICATIONS FOR MECHANICAL WORK

Portion 7: PARTICULAR SPECIFICATIONS FOR ELECTRICAL WORK

Portion 8: PARTICULAR SPECIFICATIONS FOR CONTROL WORK

(Portions 1, 2, 3, 4 and 5 is in Volume 2A)

Should any requirement of the Project Specification conflict with any requirement of the standard or particular specifications, the requirements of the Project Specifications shall prevail.

# PORTION 6: PARTICULARS SPECIFICATIONS FOR MECHANICAL WORKS

Particular Mechanical Specifications

| | | |
|---|---|---|
| PSX2 | - | General mechanical engineering |
| PSX3 | - | Operation and maintenance manuals |
| PSX4 | - | Machine mounts |
| PSX5 | - | Grid floors, guard rails and ladders |
| PSX6 | - | Nuts, bolts and fastening sets |
| G01 | - | Colour coding |
| G02 | - | Corrosion protection specification |
| M01 | - | Mechanical Screens |
| M08 | - | Gearboxes |
| M16 | - | Conveyor equipment |
| M18 | - | Mechanical Centrifugal pumps |
| M20 | - | Valves |
| M21 | - | Pressure pipework |
| M34 | - | Sluice gates |

# PARTICULAR MECHANICAL SPECIFICATIONS

## PSX2 GENERAL MECHANICAL ENGINEERING

### TABLE OF CONTENTS

## PSX2.1 SCOPE

This specification sets out the general requirements applicable to mechanical installations and shall apply where it is relevant to the Contract unless it is superseded by the project specification.

## PSX2.2 DESIGN SPECIFICATION

### PSX2.2.1 General

This Specification lays down the performance, quality and overall system requirements of the Works. Deviation from the Specification will only be considered if the Employer's Agent considers such deviation an improvement.

### PSX2.2.2 Safety

Safety shall be an all important and overriding consideration and proper attention shall be paid to this aspect at the design stage. Equipment which is potentially dangerous shall be designed in accordance with a relevant South African or international Standard.

Hazards must be avoided or guarded. Nip points shall be guarded; sharp corners shall be rounded off; operating handles, supports and protrusions shall be kept clear of access ways.

Moving parts shall be properly guarded to the satisfaction of the Employer's Agent.

An emergency stop button shall be installed in a convenient position next to each machine. The installation shall be designed to provide immediate access without the danger of accidental operation. In addition, trip wires which will stop the driving motor when pulled shall be provided along the accessible side/s of moving conveyor belts, chains and the like irrespective of operating speed and irrespective of guards provided.

Where, in the opinion of the Employer's Agent, an installation is not safe, the Contractor shall remedy such defect at his own cost to the satisfaction of the Employer's Agent.

### PSX2.2.3 Design factors

A high quality standard is demanded and reliability, long life, trouble free operation, efficiency, ease of maintenance and operation, and neatness are essential.

All plant and equipment shall be of robust construction and the design shall, as applicable, be based on:

- the full range of duties which can be reasonably anticipated;
- the power and torque transmitted by the driver system under full load and stalled conditions;

- the maximum pressure or vacuum which can be produced by pumps, blowers and compressors under all conditions including blocked or closed inlet and outlet circuits;
- conservative service and safety factors based on approved standards or laid down in the printed specifications of reputable and approved manufacturers;
- a safety margin of at least 20% in addition to any service or safety factors which apply;
- twenty four hour per day operation;
- a minimum life of 100 000 hours before repair or major part replacement; and
- prevention of serious damage from normal operational problems such as blockages, blinding, jamming, seizure, malfunction and, as far as is practical, maloperation; if these occurrences cannot be avoided by good design.

Machines with non-overloading characteristics shall be selected wherever possible; e.g.: motors shall be sized so that they cannot be overloaded by the driven machine.

### PSX2.2.4 Fail-safe operation and protections

Where damage can occur from normal operational or other foreseeable problems, plant, equipment and systems must be designed to be fail safe; i.e. must have built-in redundant elements, or be fail-to-safe; i.e. must return to a safe condition where no further damage can be done in the event of a failure, malfunction, maloperation, overload and, as far as practical, misuse. All reasonable and economically justifiable protections to prevent or limit damage to plant and equipment, particularly in high risk situations, must be incorporated. Protections shall:

- be directed at the source of the problem, limit forces to safe levels and act quickly enough to prevent;
- stop or prevent from starting all equipment at risk;
- activate an alarm with a labelled indicator on the control panel whenever a protection operates;
- not permit unauthorised tampering; and
- operate reliably after long inactive periods exposed to corrosive and dirty conditions.

### PSX2.2.5 Moving parts

The following general requirements apply not only to machines but to all equipment with moving parts such as headstocks, extension spindles, swivelling davits, heavy duty hinges, pivots and the like:

All rotating or swivelling shafts, pins and the like, shall be adequately supported, guided and restrained by lubricated or self-lubricating bearings, collars and/or bushes.

Swivelling joints on linkages and the like shall be of the "universal" or fork and rod type with bearings or bushes fitted to the eyes or forks.

On abrasive applications abrasion resistant materials and slow speed operation shall be utilised.

Susceptibility to fatigue failure shall be minimised by proper design and manufacturing procedures. In particular, changes in section shall be radiused and care must be taken to avoid the use of welded components in areas of fluctuating stress.

The locking of nuts and pins in position shall be done to the approval of the Employer's Agent.

Wearing parts shall be designed for interchangeability and ease of removal and replacement.

### PSX2.2.6 Arrangement and mounting

The arrangement and general design shall take the following requirements into consideration:

Lifting eyes, lugs, hooks, etc., shall be provided on heavy or large items to facilitate handling.

Castings or fabrications shall have machined pads for seating and be mounted on either soleplates or baseplates as appropriate.

Where accurate alignment is required, positioning pins and/or jacking screws shall be provided.

The needs of operation and maintenance including neatness, access, working space, safety, cleaning, adjustment, handling, assembly, alignment, disassembly, removal, etc.

With plant and equipment to be mounted on or against concrete or brick structures, provision shall be made for adjustment in the mechanical design. Any special accuracy requirements must be specified on the Contractor's Drawings.

### PSX2.2.7 Lifting equipment

All lifting equipment shall comply with the following requirements unless otherwise stated:

All aspects of lifting equipment, including design, fabrication and installation work shall be full in accordance with the relevant aspects of the Occupational Health and Safety Act and Regulations.

Lifting equipment shall be designed and constructed in accordance with a generally accepted technical standard.

The safe working load (SWL) shall be marked clearly on all items.

The complete installation shall be inspected and shall be tested over its complete lifting range using a load which is at least 125 % of the safe working load.

High-tensile or alloy steel chains shall have a factor of safety of at least four.

Chains shall have a factor of safety of at least five.

Steel-wire ropes shall have a factor of safety of at least six.

Man made fibre ropes or woven webbing shall have a factor of safety of at least six.

Natural fibre ropes shall have a factor of safety of at least ten.

## PSX2.3 MATERIALS OF CONSTRUCTION

### PSX2.3.1 Installation

PSX2.3.1.1 General

The Works shall comply with the following:

When erected and installed, the plant and equipment shall be of neat and workmanlike appearance, solidly and evenly supported, true to line, level, plumb and in proper working order.

The requirements of Sub-clause "Arrangement and Mounting" must be noted.

The Contractor shall provide all foundation bolts, supports, hangers, brackets, etc. required for the support and fixing of equipment.

The Contractor is not responsible for grouting puddle pipes which pass through liquid retaining walls or slabs but shall be responsible for all other grouting necessary for all plant and equipment.

The use of more than three shims in the alignment of equipment will not be permitted. Machined spacers shall be prepared where necessary. Shims and spacers shall be of a corrosion resistant material such as stainless steel.

Corrosion protection requirements shall be carefully attended to and the relevant paragraphs of Sub-clause "Paint Application" (see Clause "Corrosion Protection: Paint

Coatings) must be noted. All mating faces must be coated before and sealed after assembly.

Fastener threads must be coated with a nickel-based, anti-seize compound before assembly.

Crevices which are formed between two surfaces shall be filled, prior to final fastening, with a suitable formable packing. This applies particularly to stainless steel.

PSX2.3.1.2 Alignment of shafts

Shafts for drives, such as motors, with an output above 150 kW shall be aligned to the driven shaft as follows:

Final alignment shall be done after installation and before commissioning, shall be checked in the presence of the Engineer and shall be to his approval. Alignment shall be sufficiently accurate to ensure that no initial pre-load is placed on the shaft coupling.

Each motor shall be aligned to its pump using laser aligning equipment.

The use of pourable epoxy resin chocks shall be acceptable. If pourable chocks are used, the baseplate feet do not have to be machined but each machine foot shall be provided with a screw for vertical alignment. The chock thickness shall not be less than 20 mm.

PSX2.3.1.3 Materials

Materials – generally

All materials used in the manufacture and construction of plant and equipment shall be new, unused and shall be the best of their respective kinds. The Contractor shall ensure that the materials are selected in accordance with the best engineering practice to suit the working conditions and the extremely corrosive environment.

Steel

All structural steel shall comply with the requirements of SANS 1431 grade 300W or equivalent and shall be legibly marked with the maker's name or trade mark and identification marks.

Plastics

Thermoplastics and fibre reinforced polymers shall be UV resistant, have adequate tensile strength and high impact strength and generally suit the application. PVC is regarded as too brittle and shall not be used unless called for in this Specification or approved in writing by the Engineer before supply.

PSX2.3.1.4 Castings

Castings shall comply with the relevant South African or British Standard for the material used, including the following:

| | | | |
|---|---|---|---|
| Grey Cast Iron Castings | - | SANS 1034 | BS.1452 |
| S.G. Iron Castings | - | SANS 936/7 | BS.2789 |
| Steel Castings (General Purpose) | - | SANS 1465 | BS.3100 |
| Aluminium Castings | - | SANS 989/992 | BS.1490 |
| Copper and Copper Alloy Castings | - | SANS 200 | BS 1400 |

Particular attention shall be paid to cleanliness, soundness and neat fettling and dressing of castings. Surfaces shall be smooth and irregularities caused by mould washaways, and the presence of porosity and sand and slag inclusions will not be tolerated. Areas under bolt heads, nuts and washers, shall be machined or spot faced to ensure a flat and smooth pressure bearing area, and sufficient space shall be provided for the use of ring or socket spanners.

All pressure retaining castings shall be hydrostatically tested to not less than 1,5 times the maximum working pressure after machining and shall be pressure tight.

No repairs shall be undertaken to castings without the written permission of the Engineer and welding will not be permitted on cast iron castings.

Castings shall be heat treated to provide optimum corrosion resistance and toughness combined with reasonable machinability. In particular stainless steel castings shall be heat treated so as to ensure that all carbides are in solution, to ensure optimum grain size and to provide maximum corrosion resistance.

The Contractor shall provide a test certificate for each casting or batch of castings, except for those made of grey cast iron, giving details of the material analysis, the heat treatment and any mechanical tests carried out.

PSX2.3.1.5 Fabrication of carbon steels

**Standards**

Steelwork shall be constructed, fabricated and erected in accordance with SANS 1200H where applicable.

**Finish**

Weld spatter and other protrusions shall be removed. Sharp edges shall be rounded to a radius of at least 2 mm.

**Requirements for corrosion protection**

In addition to finishing requirements, the requirements of corrosion protection application shall be taken into consideration. All surfaces must be accessible for surface preparation and coating. Inaccessible pockets, open hollow sections or the like shall not be permitted

except where hot-dip galvanizing (without painting) is called for. Surfaces which cannot be properly prepared after fabrication must be abrasive blasted and coated with a two-pack epoxy pre-weld primer before fabrication.

**Inspections**

The Contractor shall arrange for the Employer's Agent to inspect fabrications, including fabricated pipework, in the fabrication workshop and prior to corrosion protection.

PSX2.3.1.6 Fabrication of stainless steels

The requirements regarding the fabrication of carbon steels apply to the fabrication of stainless steels as well. In addition, the following requirements apply to the fabrication of stainless steels.

Surfaces which become contaminated with steel or otherwise stained or otherwise marked so as to be of uneven colour, shall be cleaned by pickling or electro-cleaning rather than by grinding.

The Contractor shall arrange for the Employer's Agent to inspect fabrications, including fabricated pipework, in the fabrication workshop.

PSX2.3.1.7 Welding

General Welding Requirements

Standards**:** Standards complying with good modern practice, and acceptable to the Engineer, shall be adopted. These include the following:

BS 5135 - Arc welding carbon and carbon manganese steelwork.

BS 4677 - Arc welding austenitic stainless steel pipework.

BS 2633 - Class 1 Arc welding of steel pipework.

BS 2971 - Class II Arc welding of steel pipework.

BS 806 - Design and construction of ferrous piping in connection with land boilers (used for arc welding specification of all pipe flanges).

Welders shall be experienced competent artisans approved in accordance with BS 4872.

Welding to be continuous: All welding shall be continuous on all sides of any joint unless otherwise approved in writing by the Engineer. No crevices will be permitted and where stitch welding has been approved by the Engineer, the crevices so left shall be sealed with an approved filling compound after priming but before further painting.

Weld appearance: Welding shall be free of blowholes and all welding flux shall be removed. All weld spatter and other sharp imperfections shall be removed prior to abrasive blasting. Prior to painting, weld beads with a surface irregularity exceeding

3 mm or with sharp crests having a radius under 2 mm shall be ground. Weld grinding must not be performed on 304L or 316L stainless steel, however, unless unavoidable.

Site welding**:** Site welding shall be kept to a minimum and shall only be undertaken with the approval of the Employer's Agent.

Type of stainless steel: Austenitic stainless steels to be welded shall be of the low carbon grade (i.e.: 304L, 316L, etc.).

Welding rods: The welding rods used shall be the most suitable for the metal and purpose. Type 309 stainless steel welding rods shall be used for welding 3CR12 unless otherwise approved in writing.

Welders: Only welders experienced with welding stainless materials shall be used.

General: All possible steps shall be taken to ensure maximum corrosion resistance, strength of the welds and welded material. Special care shall be taken to avoid prolonged heating. Welds shall be passivated. Discolouration and steel contamination must be removed by pickling or electro-cleaning as approved by the Employer's Agent but should rather be avoided by taking the appropriate measures.

PSX2.3.1.8 Guards

Guards shall comply in all respects with the Occupational Health and Safety Regulations and the following points shall also be noted: -

Guards are required to cover all moving or revolving components of machinery. Guards which do not adequately cover moving protrusions such as keys, lock-nuts, lockwashers, setscrews, etc., or irregularities such as keyways, will under no circumstances be accepted.

Guards shall be neatly and rigidly constructed and fixed and shall not vibrate or cause noise during operation.

Where expanded metal or similar mesh is used, the mesh opening shall not permit a circular object 10 mm or larger to penetrate.

Mesh shall not be used for chain guards but on belt drives the side of the guard most conveniently sited for inspection shall be constructed of expanded metal or similar. Mesh should similarly be used in other situations where inspection or ventilation is required.

Guards shall completely enclose drives and shall entirely prevent a person from touching any moving protrusion.

Allowance must be made for adjustment on belt guards or where adjustment will be required.

It shall be possible to remove the guard easily for maintenance purposes.

Guards shall preferably be fabricated of 316 stainless steel (uncoated) but may also be hot-dip galvanized, zinc-sprayed or aluminium-sprayed carbon steel, coated to specification in all these cases. Fasteners shall be M10 or larger and shall be of 316 stainless steel.

PSX2.3.1.9 Machine vibration levels

The mechanical vibration of machines measured at all important points such as bearings shall be lower than that specified as "good" for that class of machine in BS 7854 (ISO 10816).

PSX2.3.1.10 Noise control

Noise levels

The noise level of the complete installation shall not exceed the following:

- a maximum noise level at the Site boundaries not exceeding an equivalent continuous sound level of 55 dB(A) when all equipment installed is being operated; and
- a maximum noise level at a distance of 1 m of each sound producing mechanical equipment of 80 dB(A).

Where the Contractor is unable to restrict the noise level of the machines to the maximum specified, by the appropriate selection of suitable equipment; e.g. by selecting slow speed or silent type machines, quiet type cooling fans, suitable silencers, etc. then an alternative solution, such as an acoustic hood or similar shall be offered.

PSX2.3.1.11 Bearings

Bearing systems shall be designed to provide safe shut down without damage under normal stoppages as well as electrical supply failure.

PSX2.3.1.12 Lubrication

Grease lubrication

Grease lubrication is preferred and all greasing points must be easily accessible.

Equipment with multiple greasing points shall be provided with grease lines which are piped, separately, to a single easily accessible position.

In cases in which motorised lubrication is provided to more than one destination, a distributor shall be provided. The distributor shall be a positive displacement device which ensures equal, successive lubrication to all destinations.

Pipework for grease distribution shall be of stainless steel or non-ferrous metal.

Oil lubrication

Oil level indicators shall be fitted for visual checking. Drain cocks, including 316 SS fittings where necessary to permit convenient draining, and plugged at the end, shall be provided for oil reservoirs exceeding 1,5 litre capacity. Drains shall be from the lowest point and syphon type drains are unacceptable.

Lubrication systems shall be designed to exclude dirt and moisture. Air vents on the oil reservoir shall contain an air filter.

## PSX2.4 MEASUREMENT AND PAYMENT

The provision of all general mechanical design, construction and material requirements as specified within this standard specification shall be included for in the overall price of equipment offered.

# PARTICULAR MECHANICAL SPECIFICATIONS

## PSX3 OPERATION AND MAINTENANCE MANUALS

### TABLE OF CONTENTS

## PSX3.1 SCOPE

This specification covers the supply of Operation and Maintenance manuals as called for in the schedule of pricing. The specification sets out the general requirements applicable to the Operation and Maintenance manuals and shall apply where it is relevant to the Contract unless it is superseded by the project specification.

## PSX3.2 GENERAL

The Contractor must submit one full set of provisional Operation and Maintenance manuals to the engineer for checking and remarks, at least one month before any commissioning and testing exercises are undertaken. The manuals will be returned to the Contractor, who is to incorporate the changes and comments into the final manuals, before re-submittal.

Three sets of the final Operation and Maintenance manuals must be submitted to the engineer once the manuals have received final approval. The engineer will thereafter distribute these final manuals to Client accordingly.

## PSX3.3 LAYOUT OF THE MANUALS

### PSX3.3.1 Appearance

The manuals are to be firmly bound in plastic covered files suitable for A4 sized paper, information leaflets, suppliers' information and manuals. The Operation and Maintenance manuals are to have the following information on their covers and spines:

- Operation and maintenance manual for the specific project;
- Contractors name, address and contact details; and
- Date at which the plant was handed over to the client.

All relevant information that is not of A4 size or which is of A4 size and cannot be bound / filed into the manual is to be folded / filed into an A4 plastic sleeve which in turn is to be bound into the final manual.

Drawings on large format paper are to be neatly folded and placed in plastic sleeves so as to be removed and replaced easily.

All sections of the Operation and Maintenance manuals are to be clearly labelled and neatly partitioned.

The Operation and Maintenance manuals are to be sorted in accordance to the way the plant has been segregated into various working areas and / or stations. Repeated equipment is to be referenced or cross-referenced to the appropriate section of the manual where the relevant information for the equipment is filed.

### PSX3.3.2 Contents

The following details / information shall be included in the manuals:

a) Maintenance Requirements

- A summary, in tabular form, is to be provided for the major and minor services of the equipment supplied. Time intervals are to be clearly indicated.
- A summary, in tabular form, is to be provided for the standard inspection and adjustment of equipment supplied. Time intervals are to be clearly indicated.

These summaries shall specify the recommended consumables and quantitative adjustments for the equipment including contact details of the relevant suppliers. Suppliers of spares if different are to be provided along with the original equipment manufacturers details. If specialized services or maintenance is to be carried out on the equipment, the contact details of these specialists are to be provided.

b) Technical

A detailed technical description / specifications shall be provided for all equipment supplied under this Contract. This shall as a minimum include:

i. Tag number;
ii. Details of the design of the equipment including working drawings and the description of the equipment;
iii. Scope of operation including performance curves, where applicable;
iv. Electrical requirements, where applicable;
v. Materials of construction including corrosion protection specification;
vi. List of spares and where necessary additional tools.
vii. Installation details; and
viii. Condition monitoring specifications and requirements.

## PSX3.4 OPERATION AND MAINTENANCE

The following procedures, operational philosophies and functions of the equipment shall be provided:

- For all equipment, the startup procedures shall be described including pre-start checks. This includes for equipment that automatically starts.
- Shut down procedures for all equipment is to be described.
- The operational time for each piece of equipment supplied shall be detailed.
- The maintenance schedule, regularity of maintenance along with the time intervals between maintenance periods shall be clearly stated.

- The checking of lubricant and coolant levels along with adjustment of machines shall be clearly described.
- Standard inspections, services and adjustments shall be described clearly along with time intervals of when these procedures are to occur.
- Major inspections, services and adjustments shall be described clearly along with time intervals of when these procedures are to occur.

## PSX3.5 MEASUREMENT AND PAYMENT

All costs sustained from the compilation of the Operation and Maintenance manuals shall be deemed to be included in the schedule of pricing, where called for in the supply of these documents.

The tendered sum shall include for the supply of a complete set of Operation and Maintenance manuals per set of equipment supplied. Final payment for these manuals will only be transferred once the engineer has approved and received the final documents along with the relevant plant drawings.

# PARTICULAR MECHANICAL SPECIFICATIONS

## PSX4 MACHINE MOUNTINGS

### TABLE OF CONTENTS

## PSX4.1 SCOPE

This specification covers the requirements for machine mountings which are to be included with all equipment offered and not as separate items.

## PSX4.2 DESIGN SPECIFICATIONS

### PSX4.2.1 Common baseplates

Both direct-coupled and belt-driven machines shall be mounted with their drivers on common cast iron or fabricated steel baseplates of rigid construction.

### PSX4.2.2 Corrosion protection

Steel baseplates shall be hot-dip galvanized unless specified otherwise.

### PSX4.2.3 Machined mounting pads

Baseplate shall incorporate machined mounting pads at the support and fixing positions of each item of plant and equipment to be mounted on the baseplate. On fabricated baseplates this machining shall be done after fabrication, stress relieving (if applicable) and hot-dip galvanizing are complete. The thickness of the solid pads shall be not less than 1,25 times the diameter of the holding down bolts. The pads shall not be provided with threaded holes for machine screws but shall be drilled for inserting through-bolts and adequate provision shall made for reaching the nut with a suitable spanner. In the period between machining and installation of the equipment, the machined surface shall be protected against corrosion by a removable coating. After installation, a non-hardening compound, Tectyl or equivalent, shall be applied to exposed machined surfaces and to the crevice formed at the foot of the equipment.

The above design may be suitably modified if the Contractor uses a pourable resin based chocking system. Such chocks shall be at least 15 mm thick.

### PSX4.2.4 Fasteners

Anchor fasteners shall be of grade 316 stainless steel with threads coated with a nickel-based, anti-seize compound before assembly.

### PSX4.2.5 Alignment

Preliminary alignment shall be done at the factory to ensure that the baseplate has been correctly manufactured, but final alignment shall always be done on site after installation and grouting has been completed. Alignment shall be accurate and to the approval of

the Employer's Agent and a final alignment check witnessed by the Employer's Agent must be carried out by the Contractor prior to start up.

### PSX4.2.6 Shimming

Not more than three shims may be used at any point and these must be made of a corrosion resistant material.

### PSX4.2.7 Jacking screws

At least two diagonally opposed jacking screws shall be provided for belt tensioning in the case of belt-driven units. Direct-coupled motors above 10 kW shall be provided with jacking screws for horizontal alignment and direct-coupled motors above 150 kW shall be provided with jacking screws for vertical alignment as well. Jacking screws shall be of grade 316 stainless steel.

### PSX4.2.8 Grouting

Baseplates shall be designed and grouted as to eliminate collection points for water or dirt. Except where otherwise approved in writing by the Employer's Agent, all baseplates on concrete plinths shall be fully grouted in. Grouting holes must be provided on baseplates having a continuous top plate. Tapped holes and fixing setscrew protrusions shall be suitably protected.

The material used for grouting shall be a non-shrink, cementitious grout. The initial grouting shall be overseen by the supplier's technical representative.

### PSX4.2.9 Soleplates

In applications where baseplates are not practical, machined soleplates, suitably fixed and grouted to the concrete plinths, shall be provided. No machine may be mounted directly onto a concrete base without the use of either a baseplate or soleplate.

## PSX4.3 MEASUREMENT AND PAYMENT

All mountings are to be included in the price for the item of equipment offered. Mountings are to be included as ancillary equipment where reference is made to "ancillary equipment"

# PARTICULAR MECHANICAL SPECIFICATIONS

## PSX5 GRID FLOORS, GUARD RAILS AND LADDERS

TABLE OF CONTENTS

## PSX5.1 SCOPE

This specification covers the supply, delivery, offloading, transport, double handling (if required), storage, erection, installation, commissioning, testing, adjustment, handing over in complete working order and upholding during the Defects Liability Period of all grid floors, guard rails and ladders.

## PSX5.2 DESIGN SPECIFICATION

### PSX5.2.1 Grid flooring

All grid flooring shall be Mentis type RS40 or equal approved with bearer bars across the shorter span. The depth of bearer bars shall not be less than 30 mm with a bearer bar pitch of not greater than 40 mm. Panels are to be set level and fixed down in angle frames so as to prevent rocking. All cut-outs in grid flooring for pipes, valve spindles and the like are to be banded and made before any corrosion protection is done. The edges of removable grid access covers must also be banded.

### PSX5.2.2 Guard railing

Guard railing shall be provided in accordance with legislated requirements and shall be provided generally in positions where the vertical change in level is 1 000 mm or greater.

Guard railing shall comply with SANS 0104.

All guard railing shall be of grade 316 stainless steel and shall comprise hand and knee rails not less than 32 mm diameter and stanchions spaced at not more than 1,8 m except where specifically directed otherwise in writing by the Engineer.

On platforms, walkways, landings or around dangerous areas the vertical height, measured from the top of the hand rail to the floor or surface, shall be at least 1 000 mm.

On stairways and fixed ladders the rails shall be parallel to the stringers, and the vertical height, measured from the top of the hand rail to the nosing of the tread, shall be at least 900 mm.

For applications covered by this Specification, the rails and stanchion shall withstand, without permanent deflection, a proof force of 890 N and 1780 N respectively, applied at any point and in any direction. Contractors shall provide proof that their guard railing has been tested and withstands these loads. The loads specified in SANS 10160 for guard railing and stanchions are to be adhered to.

Stanchions and rails shall be smoothly finished and free from sharp corners, edges and projections which may injure persons or damage clothing. Stanchion bases shall have the corners rounded or sheared off.

Railing, if tubular, shall be joined using the slip-jointing method with separate and neatly fitting tubular inserts fitted into the railing bore. If used, pins shall have their ends peened over and smoothed or, if taper pins are used, shall be filed off flush with the rail. The joint shall withstand the loads specified above when situated in any position including centrally between two stanchions. Joints shall preferably be located inside the stanchion balls. All joints shall be sealed.

Railings shall be ended off with positively fixed (pinned) closure bends. At corners, short radius bends with stanchions on both ends shall be employed or, alternatively, stanchions specifically designed for such a position shall be employed. No sharp endings will be permitted.

Stanchions shall generally be base-mounted to suit the arrangement requirements and shall be of solid or welded construction. Welding shall be compatible with the material, shall not impair the strength or corrosion resistance of the material, shall be continuous and shall be smoothly finished and then passivated.

Stanchions shall be self-draining to suit the mounting arrangement.

Holes for the rails to go through the stanchions shall have a diametral clearance not exceeding 1 mm but preferably 0,5 mm. On stairways with stanchions vertically mounted, the hole shall be angled to suit and shall accurately fit the angled rail with the abovementioned clearances. The crevices caused by rails passing through the stanchions shall be sealed.

Stanchion feet which are attached to metallic surfaces shall have minimum dimensions of 150 mm X 60 mm. Two fasteners, of minimum size M16, shall be used to attach the foot. Foot material thickness shall be not less than 8 mm. Neatly fitting packing shall be fitted under stanchion feet to prevent the formation of crevices.

Stanchion feet which are attached to non-metallic surfaces shall have minimum dimensions of 150 mm X 150 mm. In instances where the horizontal surface to which the foot is to be fastened is less than 150 mm wide, the foot shall be designed to be seated on at least two surfaces. Four fasteners, of minimum size M16, shall be used to attach the foot to the concrete. Foot material thickness shall be not less than 10 mm. Non-shrink, cementitious grout shall be applied under the foot just prior to final tightening of nuts.

PSX5.2.2.1 Guard railing in public places

The requirements for guard railing at equipment installations shall also apply for guard railing for public places. The following specific requirements must also be complied with:

The structural design shall be done in accordance with the requirements of SANS 0104.

No opening in guard railing installed in public places shall allow the passage of a ball of 100 mm diameter.

## PSX5.2.3 Permanent ladders and stairs

PSX5.2.3.1 General

Permanent ladders shall comply, primarily, with the requirements of the OSH Act and, secondarily, with SANS 10400.

PSX5.2.3.2 Permanent ladders

Ladders shall comply with the following detail design aspects:

Access points to the head of ladders from platforms and walkways shall be protected by self-closing gates or by chains.

No part of the ladders shall project into the passageway.

The clear width between stringers shall be between 450 mm and 550 mm.

A minimum clear space of 230 mm must be allowed behind the rungs.

The diameter of the rungs shall be between 20 mm and 50 mm.

Additional rungs shall be provided in the same horizontal plane as the top rung in order to close the gap between the platform and the ladder. Sufficient rungs shall be provided to ensure a maximum gap of 75 mm. These top rungs shall be at the same level as the floor or platform to which access is being provided.

Stringers shall be formed from flat bar. The vertical distance between the ladder support brackets shall not exceed 1 800 mm.

The stringers shall extend to 1 100 mm above the floor or platform and shall be matched with any guard rail protections at this level. Connections between hot-dip galvanized steel ladders and stainless steel guard railing shall be bolted. Unless laterally supported by the guard rails, these stringers shall be supported by vertical structural sections (not flat bar) whose footings shall comply with this Specification for guard rail stanchion feet.

All rises in a flight shall be uniform and the surface of the top rung shall be level with the top platform or landing. The height chosen for the rise shall be between 225 mm and 255 mm.

Except on chimneys, the height of a ladder should not exceed 6 000 mm. Greater heights shall be provided with intermediate landings between each 6 000 mm ladder section.

If the height between start and end levels is over 4 000 mm, the ladder shall be fitted with a safety cage. The safety cage shall extend at least 1 000 mm above the higher landing. The cage shall be no more than 700 mm away from the plane of the rungs. The cage shall comprise no fewer than seven vertical elements.

Anchor bolts shall be of grade 316 stainless steel and shall be no smaller than M16.

Stringers, rungs and anchor brackets shall be of solid structural sections (e.g. flat bar, round bar, square bar, angles, etc.) and no hollow sections will be accepted for any part of the ladder.

PSX5.2.3.3 Stairs

Stairs shall comply with BS 5395

## PSX5.3 MATERIALS OF CONSTRUCTION

### PSX5.3.1 Grid flooring

Grid flooring and frames shall be hot-dip galvanized after fabrication. Painting shall be done to suit the relevant safety codes.

Where grid flooring bears onto painted surfaces, strips of rubber insertion material shall be secured under the grid flooring to protect the paint.

The fixing clip set (saddle clamp and locking plate) shall be of hot-dip galvanised steel but all fasteners shall be of grade 316 stainless steel.

### PSX5.3.2 Guard railing

All guard railing shall be of grade 316 stainless steel.

Stanchion feet shall be epoxy-coated.

A nickel-based, anti-seize compound shall be applied to all threads before fastening.

All components shall be supplied in the pickled and passivated condition which may also be polished. All surfaces must be uncontaminated and unmarked to ensure maximum corrosion resistance. A manufacturer's test certificate shall be provided for each batch of stainless steel giving the chemical analysis of the material.

Inserts for internal slip joints may be of non-corrosive material using steel reinforcing provided the steel is completely enclosed.

Where kickplates are required by legislation, these shall extend to 150 mm above the walkway level.

### PSX5.3.3 Permanent ladders and stairs

Unless other materials are specified, ladders and stairs shall be of carbon steel and hot-dip galvanized after all fabrication has been completed.

## PSX5.4 TESTING AND COMMISSIONING

### PSX5.4.1 Works testing

Where applicable an inspection of the assembled units will be conducted at the manufacturer's premises to check material integrity, corrosion protection and fabrication soundness. Material certificates are to be issued to the engineer before deliver to site of the equipment.

### PSX5.4.2 Tests on completion

Performance testing will be carried out on the equipment after commissioning and adjustment. All tests are to be witnessed by the Employer's Agent, and Contractors must give the Engineer 14 days notice prior to any test. The Contractor must cover the cost of any tests that need to be repeated as a result of the equipment not being able to meet the requirements outlined below.

The tests will be performed on the equipment over a single 8 hour shift. They shall consist of the following:

1. An inspection will be carried out to ascertain that the equipment has been installed correctly and with due diligence.
2. Any load testing required.

The equipment will be considered acceptable when:

1. Equipment has been correctly installed and satisfies the Employer's Agent.
2. The equipment passes any load tests called for.

During the Defects Liability Period

Checks on all equipment will be conducted for correct operation and functioning at 1 month, 6 months and 12 months after plant take-over.

## PSX5.5 MEASUREMENT AND PAYMENT

The unit of measurement shall be for the unit supplied including all ancillary equipment and accessories as specified.

The tendered rates shall include for full compensation for design, procurement, manufacture, factory testing, supply, delivery, off loading, storage, installation, commissioning and testing of all equipment, including holding down bolts and ancillary equipment.

The tendered rates shall include for full compensation for the fixing of corrosion protection where needed and for all other costs and actions that are necessary for obtaining an efficient and complete working system.

# PARTICULAR MECHANICAL SPECIFICATIONS

## PSX6 NUTS, BOLTS AND FASTENING SETS

### TABLE OF CONTENTS

## PSX6.1 SCOPE

This specification covers the requirements for fasteners and fastening sets which are to be included with all equipment offered and not as separate items.

## PSX6.2 DESIGN SPECIFICATIONS

### PSX6.2.1 Fasteners general

PSX6.2.1.1 Standards

Bolts and nuts shall be hexagon head type complying with SANS 1700 with threads of the coarse pitch series. Allen head screws of any type shall not be used without the Employer's Agent's written consent.

PSX6.2.1.2 Fasteners M12 and smaller

All fasteners M12 and smaller shall be manufactured of grade 316 stainless steel.

PSX6.2.1.3 Fasteners larger than M12 - in corrosive areas

All fasteners in corrosive areas shall be manufactured of 316 SS. Corrosive areas shall be taken to include any moist or wet area such as in and above settling tanks, in or in the vicinity of open channels, where a continuous spray can be expected and all internal and external areas in the vicinity of the inlet works of a wastewater treatment works. All fasteners embedded in brick, concrete or soil shall also be of 316 SS.

PSX6.2.1.4 Fasteners larger than M12 - Non-corrosive areas

Fasteners larger than M12 which are in non-corrosive areas shall, except when specified otherwise, be hot-dip galvanized.

PSX6.2.1.5 High tensile bolts

Where high tensile bolts are required by the design, they shall be hot-dip galvanized and painted. The bolt holes and crevices shall be filled and sealed prior to painting.

PSX6.2.1.6 Material compatibility

Fastener material shall always be of equal or better corrosion resistance than the items being fastened, e.g. 316 stainless steel bolts must be used to fasten together 316 stainless steel fabrications or flanges.

PSX6.2.1.7 Washers

Washers of similar material to the bolts shall be provided under each nut and setscrew head. Multiple washers or shims shall not be used. Spring washers or other approved locking arrangement shall be used on all fasteners subject to vibration.

PSX6.2.1.8 Anti-seize compound

Before assembly, threads shall be treated with a nickel based, anti-seize/corrosion protection compound; Chesterton 725: Nickel Anti-Seize Compound, or equivalent. The thread shall be treated in the area under the final position of the nut. Compound on the exposed thread shall be cleaned off after installation. If it is found during inspection that compound has not been applied, the Contractor shall disassemble all fasteners and comply with this requirement.

PSX6.2.1.9 Thread projection

Bolt threads shall project between 1 and 6 mm from the head of the nuts when fixed. Longer projections will only be allowed if the Contractor can show that bolts of a more suitable length are not manufactured.

PSX6.2.1.10 Corrosion protection

After installation the exposed surfaces of bolts not made of 316 stainless steel shall be coated as for the items being fastened. If the use of Allen head or similar fasteners has been approved by the Engineer, the recessed heads shall be filled with a suitable non-hardening sealing compound.

## PSX6.2.2 Anchor fasteners

PSX6.2.2.1 Type and material

All anchor fasteners shall be of grade 316 stainless steel.

Anchor fasteners for water retaining structures and for brickwork shall be of the chemical anchor fastening type. Anchor fasteners for other applications may be of the expanding type or chemical anchor type.

PSX6.2.2.2 Hook bolts

Grade 316 stainless steel hook bolts shall be supplied and grouted by the Contractor into pockets which will be provided in the concrete structure in accordance with the information to be supplied by the Contractor. The grouting products shall be used strictly in accordance with the manufacturer's instructions.

PSX6.2.2.3 Alternative anchor bolts

The use of 316 stainless steel "Hilti Kwik Bolt" stud bolts or similar may be used as an alternative where approved by the Engineer. If steel reinforcing bars are encountered while the holes are being drilled, the Contractor shall knock a hole in the concrete around the steel and grout in a stainless steel hook bolt as described above.

PSX6.2.2.4 Through-bolt anchors

Where machinery is anchored by studs or bolts which extend through the supporting structure and is therefore fastened down with the use of nuts from both sides, these, together with associated washers and brackets, shall also be of grade 316 stainless steel.

PSX6.2.2.5 Anti-seize compound

All threads shall be coated with an approved nickel-based, anti-seize/corrosion protection compound before assembly.

## PSX6.3 MEASUREMENT AND PAYMENT

All fasteners and fastening sets are to be included in the price for the item of equipment offered. The unit item offered will include the price of the fastener and fastening sets. Fasteners are to be included as ancillary equipment where reference is made to “ancillary equipment.”

# PARTICULAR MECHANICAL SPECIFICATIONS

## G01 COLOUR CODING OF EQUIPMENT

### CONTENTS

## 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:** | | | |

| Contents of Pipeline | Basic Colour | Colour Coding Indicator | |
|---|---|---|---|
| | | Single Band | Second Band |
| 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 | |
| **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 | |

| Contents of Pipeline | Basic Colour | Colour Coding Indicator | |
|---|---|---|---|
| | | Single Band | Second Band |
| Hydraulic oil<br>Lubricating<br>Transformer | Golden brown<br>Golden brown<br>Golden brown | Salmon Pink<br>Brilliant Green<br>Crimson | |
| **Other Liquids**<br>Polyelectrolyte<br>Cooling liquid | <br>Golden Yellow<br>White | <br>Jacaranda | |

**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 from the applicator shall be included for. No separate measurement item shall be included for the application of these coatings.

# JOHANNESBURG WATER

# PARTICULAR MECHANICAL SPECIFICATIONS

## G02 CORROSION PROTECTION SPECIFICATION

**Corrosion Protection Specification for Civil, Mechanical and Electrical Engineering Construction, 2006 Edition, by Golder Associates Africa (Pty) Ltd, shall be applicable to this Contract.**

**A copy of the above specification shall be made available to the Contractor after Contract award.**

# JOHANNESBURG WATER - MECHANICAL SPECIFICATIONS

## PARTICULAR SPECIFICATION: M01: H.O.W MECHANICAL SCREENING EQUIPMENT

## CONTENTS

## M01.1 SCOPE

This specification covers detailed design parameters, manufacture, supply, off-loading on site installation, testing and commissioning of "trash" screens, inclined coarse mechanical front raked screens, screenings conveyor and screenings screw compactor for the screening of raw sewage incoming to a wastewater treatment works. The Specification shall be read in conjunction with the Project Specification and other relevant Particular Specifications.

## M01.2 INTERPRETATIONS

This specification shall be interpreted as follows:

- For the Employer design components, it shall be regarded as a specification.
- For the Contractor design components obligations, it shall be regarded as an Employer's requirements.

### M01.2.1 Definitions

For the purpose of this Specification the following definitions apply:

a) "**Manufacture**" includes, as applicable, the purchase of materials or goods, fabrication and assembly, any specified corrosion protection measures and any off-site inspection or testing of materials or parts.

b) "**Supply**" includes, as applicable, the purchase of materials or goods, manufacture and fabrication, any specified corrosion protection measures and all required off-site inspection or testing.

c) "**Installation**" includes, as applicable, all handling and transport from storage, erection and aligning of Works.

d) "**Factory Acceptance Test (FAT)**" shall refer to all tests done on Plant or Plant items at the factory to ensure its functionality

e) "**Screenings**" shall refer to all debris or solid materials removed from the influent raw sewage in a wastewater treatment plant.

f) **"Trash Screen"** shall refer a mechanical screen with a minimum of 100mm bar spacing raked by a mechanical device, which is installed upstream of the coarse mechanical screens to remove large and heavy objects

g) "**Coarse Screen**" shall refer to a bar screen with a 12mm bar screen spacing which can be either mechanically or manually raked installed at an angle sufficient for ease of screening removal.

h) "**Screenfield**" shall refer to the portion of any screen type where screening of wastewater will take place on the effective screening area of the screen.

i) "**Fine Screen**" shall refer to a perforated screen with a screen perforation diameter of 6mm which is driven by a mechanical system to remove the screenings.

## M01.3 ABBREVIATIONS

In this Specification the following abbreviations will apply:-

| | |
|---|---|
| °C | : Temperature in degrees Celsius |
| A | : Ampere |
| AC | : Alternating Current |
| AGMA | : American Gear Manufactures Association |
| ANSI | : American National Standards Institute |
| API | : American Petroleum Institute |
| ASCE | : American Society of Civil Engineers |
| ASME | : American Society of Mechanical Engineers |
| ASTM | : American Society for Testing and Materials |
| BS | : British Standards Institution |
| BSPT | : British Standard pipe thread |
| CAD | : Computer Aided Drawing |
| CAM | : Computer Aided Manufacturing |
| CIP | : Cleaning in Place |
| COC | : Certificate of Conformance |
| Dia | : Diameter |
| dB(A) | : Sound pressure level, “A” weighed in decibels |
| DCS | : Distributed Control System |
| DFT | : Dry Film Thickness |
| DIN | : Deutsch Industry Normen |
| DN | : Nominal diameter |
| DP | : Differential Pressure |
| Eff. | : Filter efficiency in % |
| EPDM | : Ethylene Propylène Diène Monomer |
| ERW | : Electrical resistance weld |
| ETP | : Effluent Treatment Plant |
| FA | : Flange adaptor |
| FAT | : Factory Acceptance Tests |
| FBE | : Flanged both ends |
| FOE | : Flanged one end |
| FW | : Field weld |
| HDPE | : High Density Polyethylene |
| HoW | : Head of Works |
| ID | : Inside diameter |
| ISO | : International Organisation for Standardization |
| JW | : Johannesburg Water |
| ℓ/s | : Flow in litres per second |
| LV | : Low Voltage |
| m | : Distance in metre |
| m.a.s.l | : Metres above (mean) sea level |
| m/s | : Speed in metres per second |
| MCC | : Motor Control Centre |
| mm | : Dimension in millimetres |
| MPVC | : Modified Polyvinyl Chloride Pipes |
| MV | : Medium Voltage |

| | |
|---|---|
| N+1 | : No of units in operation + 1 installed spare |
| $Nm^3/hr$ | : Normal cubic meters per hour |
| O&M | : Operation and Maintenance |
| OD | : Outside diameter |
| OHS | : Occupational Health and Safety |
| Pa | : Pressure in Pascals |
| PBE | : Plain both ends |
| PE | : Plain end |
| PN | : Nominal pressure (Rating) |
| PPE | : Personal Protective Equipment |
| PQP | : Project Quality Plan |
| PSV | : Pressure Safety Valve |
| QCP | : Quality Control Plan |
| RFA | : Restrained flange adaptor |
| rpm | : Rotational speed in revolutions per minute |
| SAECC | : South African Electrolytic Corrosion Committee |
| SANS | : South African National Standards |
| SAT | : Site Acceptance Tests |
| SAW | : Submerged arc weld |
| SCADA | : Supervisory Control and Data Acquisition |
| SIS | : Swedish Institute of Standards |
| SOC | : Slip-on coupling |
| SS | : Stainless Steel |
| STP | : Standard Temperature and Pressure (i.e. T = 20°C, P = 101, 3 kPa). |
| w.t. | : Wall thickness of pipes |
| TDS | : Total Dissolved Solids |
| uPVC | : Unplasticised Polyvinyl Chloride |
| VSD | : Variable Speed Drive |
| WP (B) | : Weld preparation (Butt) |

## M01.3.1 Standards

All design standards for the front raked screen equipment shall be subject to the latest amendments and editions of the following standard specifications: -

| | | |
|---|---|---|
| SANS 10400 | : | National Building Regulations |
| (PD 5304:2014) | : | Guidance on safe use of machinery (British Standards Institution) |
| SANS 9606-1 | : | Testing of welders, where applicable to the type of welding required |
| BS ISO1312-1:2018 | : | Rolling bearings. Accessories for sleeve type linear ball bearings. Boundary dimensions, geometrical product specifications (GPS) and tolerances for series 1 and 3 (British Standards Institution) |
| SANS 10162-4 | : | Structural use of Steel Part 4: The design of cold-formed stainless steel structural |
| SANS 15614-1 | : | Specification and qualification of welding procedures for metallic materials - Welding procedure test Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys. |
| SANS 10064 | : | The preparation of steel surfaces for coating |
| SANS 10102-14 | : | Selection of pipes for buried pipelines Part 1: General Provisions |
| SANS 10104 | : | Hand railing and balustrading (safety aspects) |

| | | |
|---|---|---|
| SANS 10111-2-1 | : | Engineering Drawing Part 1: General principles Engineering Drawing Part 2: Geometric Tolerancing Section 1 |
| SANS 10341 | : | Installation and maintenance of bearings – General guidelines |
| 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 |
| ISO 281 | : | Rolling bearings -- Dynamic load ratings and rating life (International Organization for Standardization) |
| BS 4999 | : | General requirements for rotating electrical machines. Specification for standard dimensions (British Standards Institution) |
| SIS 05 59 00 | : | Pictorial Surface Preparation Standards for Painting Steel Surface (Swedish Standards Institution) |

### M01.3.2 Other Referenced Particular Specification

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

E01: Particular Specification for Electric Motors
E03: Particular Specification for Isolator Push Button
G01: Particular Specification for Colour Codes
G02: Particular Specification for Corrosion Protection
M08: Particular Specification for Gearboxes
M16: Particular Specification for Conveyor Equipment
M17: Particular Specification for Actuator equipment
M34: Particular Specification for Sluice Gates, Adjustable Weirs and Hand Stops
Volume 1: Automation and Control Design Standards SCADA
Volume 6: Automation and Control Design Standards Cabling
Volume 9: Automation and Control Design Standards Level Measurement

## M01.4 DESIGN OF SCREENS

### General Design Parameters

The Screening equipment shall be designed such that the following requirements are met:-

- To ensure reasonable standards of engineering in design, materials selection and construction processes.
- To facilitate manufacture, inspection, installation, maintenance, cleaning and repairs,
- Ensure safe and satisfactory operation for an acceptable life expectation of 15 years under the ambient conditions prevailing at the Site,
- The offered equipment shall be support in forms of spares by the original equipment manufacturer for at least 15 years in alignment with the specified life expectation of 15 years from project installation.
- The minimum availability of the equipment shall be 99 %;
- Prevent undue stresses being produced by expansion due to temperature changes,
- Keep maintenance costs to a minimum that represent the value for money in both the initial purchase and subsequent running costs.

- To comply with the legal such as the Occupational Health & Safety Act no. 85 of 1993 and Regulations requirements in respect of safety as well as the prevention of water and air pollution,
- To satisfy any specific requirement contained in the latest editions of the published statutory codes and legislation,
- Suitable for operation 365 days per year, 24 hours per day under specified design conditions, and
- To operate without undue vibration and excessive noise with maximum noise level of 75dBA measured at 1 metre generated from operating the equipment.

### M01.4.1 Specific Design Parameters

The screening equipment shall remove the screenings from raw sewage to minimise the subsequent damage to equipment or that may result in unsatisfactory operation of downstream unit processes. This shall be considered as a pre-treatment process.

The influent characteristics received at the Head of Works (HoW) for the particular wastewater treatment works shall be given in the Project Specification.

### M01.4.2 Head of Works (HoW) Screens Design Parameters

The design loads of the screenings for the head of works screens shall be based on the influent sewage characteristics at the particular wastewater treatment works.

The average daily screenings production rate is 0.025 m3 of dry screenings per mega litres.

The peak screening production shall be equal to 5 times that of the average daily load.

The inflow channel shall not be divided into more than two channels at any division of a channel to maintain the minimum required inlet flow velocity. No fewer than two screens shall be in parallel, but the total number of screens shall be based on the influent flow characteristics or in accordance with and the project specification, the screening design shall be subject to approval by the Employer's Agent or employer's Representatives.

### M01.4.3 Head of Work (HOW) Screen Isolation

The head of works screens are to be supplied with an Isolation gates as referenced in the M34 particular specification upstream and downstream of each screen for ease of isolation.

### M01.4.4 Types of Screens

The incoming wastewater flow from the main sewer outfall to the Head of Works shall split into channels and screening sections. Refer to the Project Specific plant layout Tender Drawings.

Five (5) Types of bar screens are covered under this particular specification namely: -

1. Coarse Hand Rake Screen(s) (where applicable)
2. Coarse Hand Rake Screen(s) in Emergency Bypass Channels
3. Trash rake screen(s)
4. Coarse Inclined Front Rake Bar Screen(s)s (mechanical screen)
5. Fine or Perforated Screen(s)

NB. Inclined **Back** Rake Screens will not be considered.

## M01.5 COARSE HAND RAKE SCREEN(S) (WHERE APPLICABLE)

### M01.5.1 Design and Performance Requirements

1. Screenfield bars having a clear spacing between the bars of 100 mm minimum shall be installed at the head of works. with a minimum bar width of 10mm and a minimum depth of 40mm.
2. Manually hand raked screens shall be installed at an inclination of 60°from the horizontal unless otherwise specified in the Project Specification, not more than a convenient raking distance of 2m. A suitable lightweight rake shall be provided with the hand rake screen.
3. The bar screen and framework support shall be designed to withstand forces at peak flow with the screen 100% blinded at the water elevations shown on the Tender drawings.
4. The bar rack screen shall be manufactured from the bar sections with the longer dimension parallel to the flow. Bars shall be offset from the supports by a length sufficient to allow for full penetration of the rake teeth. Bars welded or directly connected to the horizontal supports shall not be acceptable.
5. The screen shall be supplied with a perforated drip tray to which the screenings will deposited into when raked. The drip tray shall allow the conveyance of the screenings into the provided conveyor or skip bag as detailed in the project specification. The drip tray shall be wide enough to be able to accommodate the screening production from each screen.

### M01.5.2 Coarse Hand Rake Screen Material of Construction

Coarse Hand Rake Screen components shall be constructed of the material specified in the following Table 5-1:

**Table 5-1 Coarse Hand Rake Screen Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| Bar Screen | 304 L stainless steel |
| Support frame, walkways and handrails | 304 L stainless steel |
| Drip tray ( If Not Concrete Design) | 304 L stainless steel |
| Rake | Aluminium |

## M01.6 COARSE HAND RAKE SCREEN(S) IN EMERGENCY BYPASS CHANNELS

### M01.6.1 Design and Performance Requirements

1. Screenfield bars having a clear spacing between the bars of 100 mm minimum shall be installed at the head of works. with a minimum bar width of 10mm and a minimum depth of 40mm.
2. Manually hand raked screens shall be installed at an inclination of 60° from the horizontal unless otherwise specified in the Project Specification, not more than a convenient raking distance of 2m. A suitable lightweight rake shall be provided with the hand rake screen.
3. The bar screen and framework support shall be designed to withstand forces at peak flow with the screen 100% blinded at the water elevations shown on the Tender drawings.
4. The bar rack screen shall be manufactured from the bar sections with the longer dimension parallel to the flow. Bars shall be offset from the supports by a length

sufficient to allow for full penetration of the rake teeth. Bars welded or directly connected to the horizontal supports shall not be acceptable.

5. The screen shall be supplied with a perforated drip tray to which the screenings will deposited into when raked. The drip tray shall allow the conveyance of the screenings into the provided conveyor or skip bag as detailed in the project specification. The drip tray shall be wide enough to be able to accommodate the screening production from each screen.

### M01.6.2 Coarse Hand Rake Screen in Emergency Bypass Channel Material of Construction

Coarse Hand Rake Screen in the Emergency Bypass Channel components shall be constructed of the material specified in the following Table 6-1:

**Table 6-2 Coarse Hand Rake Screen in Emergency Bypass Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| Bar Screen | 304 L stainless steel |
| Support frame, walkways and handrails | 304 L stainless steel |
| Drip tray ( If Not Concrete Design) | 304 L stainless steel |
| Rake | Aluminium |

## M01.7 TRASH RAKE SCREEN(S)

### M01.7.1 Design and Performance Requirements

1. Screenfield bars having a clear spacing between the bars of minimum 100 mm shall be installed at the head of works.
2. The trash screens with a rake mechanism shall be installed at an inclination between 60° and 80° from the horizontal.
3. The screening installation shall comprise trash screens and with a corresponding number of overhead rake cleaning mechanisms typically on a duty and standby as a minimum. The cleaning mechanism will clean the trash screens and deposit the screenings into a skip positioned adjacent to the trash rake screening channels. The screen layout and design shall be subject to the approval of the Employer's Agent / Representative.
4. The raking mechanism shall not rake or collect wastewater together with the screenings into the skip bins. There shall be a drying area allowing the draining of screening before discharge into the skip bins. The drying area shall avoid the attraction of vectors by means of covering the screenings or odour control.
5. The trash screen field shall be removable for maintenance purposes under operating conditions and also under a blocked screen scenario.
6. Equipment shall be suitable for automatic and manual operation in raw sewage and shall be designed and arranged to remove trash, plastic bags, branches, tires and other debris from multiple bar screens, transport it to and discharge into the designated discharge area.
7. The Trash Rake System shall primarily consist of an overhead rail type track, a traversing carriage and a raking unit. The carriage shall travel along an overhead track until the desired section of the bar rack has been reached. The rake shall then be lowered to engage and penetrate the bar rack for debris removal to just above invert elevation. The rake shall then be closed, raised and debris transported to the designated discharge area.
8. The overhead track shall be fabricated as I-beam, which is the track for the traversing trolleys and the support the festoon system. The track shall be supported by steel

support columns located where shown on plan or as determined by the contractor to the approval of The Employer's Agent or Employer's Representative

9. The rake carriage unit shall contain the traversing trolleys with motor(s), hoisting gear motor(s) and a hydraulic power unit. Two trolleys mounted on top of the carriage shall traverse the carriage. The hoisting system shall consist of spirally grooved rope drums mounted on a common shaft within the carriage to raise and lower the rake. A geared motor unit shall drive the hoist shaft with brake. Electrical power to the carriage shall be supplied by a festooning system.
10. Gripper Trash Rake shall be designed to be operated both manually by an operator and automatically without an operator. The rake shall be lowered to engage and penetrate the bar rack for debris removal to just above invert elevation. The rake shall then be closed, raised and debris discharged to the appropriate discharge area. Trash rack cleaning must be possible up to the maximum clogged trash rack head differential at maximum flow.
11. The rake cleaner frame shall be rigid and dimensioned to carry the load of the hoist machinery and the maximum rake load.
12. The rake cleaning frame shall contain the electrically operated hoisting and lowering gear motor. The hoisting system shall consist of spirally grooved rope drums mounted on a common shaft within the carriage to raise and lower the rake. The hoist shaft shall be driven by a geared motor unit with brake.
13. The hoisting gear shall incorporate a power monitor to protect the motor if the rake becomes jammed by an obstruction on rising. A "slack rope" device shall be provided to operate a cut-out to stop the motor should the rake jam when lowering. Lowering the rake shall be accomplished by running the hoist motor in reverse, and limit switches shall be provided to limit upward and downward travel. An electromechanical brake shall be incorporated in the hoist gear to prevent movement of the rake immediately should the hoist motor stop or electricity supply fails.
14. The rake grab shall be supported by wire ropes and shall consist of a series of teeth designed to engage with the bar rack and shall be opened and closed by hydraulic cylinders. The rake head shall be prevented from excessive lateral swaying when traversing motion stops by a swing restrictor.
15. Each trash rake bar screen shall be front cleaned by one trash rake cleaning mechanism with stationary teeth/bars designed to penetrate the static bar field while descending from the overhead monorail mounted operating mechanism. A wire rope operated gripper assembly shall close over the collected debris for transportation back to surface and monorail to the designated discharge area into the screening skip.
16. Trash Rack screens shall be designed and constructed in accordance with the plant specific channel configuration requirements and the influent level in the channel.

### M01.7.2 Trash Rake Screen in Emergency Bypass Channel Material of Construction

Trash Rake Screen components shall be constructed of the material specified in the following Table 7-1:

**Table 7-3 Trash Rake Screen Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| All wetted parts | 304 L stainless steel |
| Trash Bar screen | 304 L stainless steel |
| Gripper or rake | 304 L stainless steel |
| Bar Rack | 304 L stainless steel |
| Drum | 304 L stainless steel |
| Trolleys | 304 L stainless steel |

| COMPONENT | MATERIAL TYPE |
|---|---|
| Monorail and Support columns | stainless steel |
| Wire or slack robe | 316 stainless steel |
| Guards or Covers | 304 L stainless steel |
| Un wetted Fasteners | 304 L stainless steel |

### M01.7.3 Equipment Design Features

M01.7.3.1. Screen Construction

- The bar screen is to be supplied by the same supplier as the gripper rake assembly. The bar screen and framework support shall be designed to withstand forces at peak flow with the screen 100% blinded at the water elevations shown on the Tender drawings.
- The bar rack screen shall be manufactured from the bar sections with the longer dimension parallel to the flow. Bars shall be offset from the supports by a length sufficient to allow for full penetration of the rake teeth. Bars welded or directly connected to the horizontal supports shall not be acceptable.

M01.7.3.2. Screen Rake and Gripper Assembly ( Where Applicable)

- The gripper shall be manufactured with teeth spaced to match the openings in the bar screens. The gripper shall operate by being traversed over the required section of the bar screen during a cleaning cycle. The gripper shall be in the open position when being lowered.
- The rake rear teeth shall normally engage with the bar screen above the maximum high-water elevation pushing the debris to the channel invert. Teeth shall automatically engage and self-centre between the bars during the descent.
- The rake and gripper assembly will ride on non-metallic, non-lubricated wheels and guide the rake along guide channels while ascending and descending.
- The rake rear teeth shall be capable of passing all the way through the bar screen without interference from the bar screen horizontal supports. The gripper shall continue to be lowered until it reaches the invert elevation (or an immobile object). The gripper mechanism shall close, trapping the collected debris for removal.
- The gripper shall be closed under hydraulic power by controls above deck level when the invert has been reached (or at any time under manual control). The hydraulic cylinders shall be suitable for submerged service.
- When closing, the upstream teeth of the gripper shall be rotated towards the rear teeth and close in conjunction with the rear teeth to remove and lift objects or debris build up wider than the bar screen opening and within the lifting capacity of the hoist.
- With the gripper in the closed position, the front teeth shall form an “overbite” past the rear teeth. During the hoist raising operation, the “overbite” shall penetrate the screen bars to prevent heavy build-up of debris. Designs employing pivoting rear or lower teeth shall not be allowed.

M01.7.3.3. Trolley Assembly ( Where Applicable)

- Trolley assembly shall contain all the necessary traversing and hoisting equipment to support and move the Rake and Gripper assembly. This includes the traversing drive and wheels, hydraulic power unit, hoisting drive, hoist drums, hoist cable, hydraulic hoses with spring tensioned hose reel, slack cable tension roller with limit switches, hoist raising and lowering limit sensors, over-travel limit switches and position sensors for automatic operation.
- Each trolley shall include four wheels. Two of the wheels shall be driven by rack-wheel, fitted to the gearbox on one side. Each shall be independently driven and shall have their own gearbox and brake motor. The trolley drives shall be controlled via VSD’s allowing the

speed to be adjusted with the increasing influent flows.

- The hydraulic power pack shall provide for the operation of the hydraulic cylinders which open/close the gripper. Designs which utilize mechanical closing rakes shall not be allowed. Fluid power shall be transferred to cylinders through high strength hoses which are to be wound on spring tensioned drum(s) operating in sequence with hoisting drums. The hoses shall be located downstream of the hoisting cables for protection. The hydraulic fluid shall be biodegradable for environmental concerns.
- Electrical power to the trolley unit shall be supplied by a trailing cable which power and control leads supported on cable wagons inside the track or other festooning method acceptable to the gripper.

M01.7.3.4. Support Structure

- The track (monorail) support columns shall be manufactured from carbon steel that is hot dipped galvanized. The columns shall be adequately sized to support the track, spaced as indicated on the drawings and sized to withstand the conditions that will be experienced during operation. The columns shall be “U” shaped or “L” shaped with heavy flanged feet for fixing to the deck level or other location. The feet shall be anchored via properly sized anchor bolts supplied by the grab rake supplier and grouted in place by the contractor.
- Steel supports columns and monorail shall be corrosion proteceted after fabrication and welding (no fabrication and / or welding shall be allowed post corrosion protection).

M01.7.3.5. Guards

The trolley movement area shall be protected in accordance with Occupational Health and Safety Act, 1993. .

## M01.8 MECHANICAL (COARSE INCLINED FRONT RAKE BAR) SCREEN(S)

### M01.8.1 Design and Performance Requirements

1. The screenfield bars shall be accurately set and secured to give the clear spacing between the bars of 12 mm. The screen bars shall be manufactured from bars that have a tapered cross section.
2. The maximum velocity through the screenfield openings shall be 1.2 m/s.
3. The minimum approach velocity shall be 0.6 m/s. The screen shall be set in the channel at between 60° and 85° from the horizontal. with a maximum allowable headloss of 150mm.
4. The individual bars (or screenfield) shall welded into position and shall extend from the sole plate and shall extend to at least 200 mm above the maximum flow depth within the channel as indicated on the drawings. The bars shall be fitted with laser cut spacer plates that shall allow for easy removal in the event of damage to the spacer plates.
5. The screen shall be front raked and the rake shall operate by means of a suitably designed lifting device, the entire driving device shall be installed above the channel coping level.
6. The screen frame, superstructure and operating components above channel coping level shall be completely clad in 304L stainless steel panels which shall be removable for maintenance and repair purposes. Screens discharge chute and conveyors shall be provided with sufficient wind deflection shielding to prevent light screening’s (e.g. paper and plastic) from being blown off the when transferred.
7. Approach velocities shall be not more than 0.9 m/s at peak hourly flow rate and not less than 0.6 m/s at average dry weather flow. Should grit removal chambers follow the bar screens then the minimum velocity shall be greater than 0.6 m/s. These requirements shall be met in the design and detailing of the civil structures.
8. The Tenderer shall submit full details regarding the plant offered by him and shall submit full details of the requirements for fitting the units into the civil structure including all necessary illustrations, drawings and pamphlets, etc. The Tenderer shall submit with his

tender complete references of clients who have installed screens identical to that offered by the Tenderer.

### M01.8.2 Equipment Design Features

M01.8.2.1. Housing

The screen housing shall be manufactured from 304 stainless steel, with a minimum thickness of 4.5 mm and shall be recessed to accommodate the scraping mechanism, chain guides and idler sprockets in order to maintain the screening of the full channel width and depth shall be provided. The screen housing shall be fitted with a rubber skirt and stainless-steel diversion plates, to accommodate the total channel width not covered by the screen field. The diversion plates shall keep away any screenings that might settle on this region. Furthermore, the screenfield shall be selected based on the channel size requirements to which it will be installed in order to minimize the space between the screenfield support and the channel wall. The covers shall be hinged on both end and lockable in the middle.

M01.8.2.2. Access

The screens shall be provided with suitably designed 304 stainless steel hand railings and deck gratings which shall provide access to the screens for repair and maintenance. The screening channel shall be provided with electrically actuated channel gates manufactured from 304 L stainless steel on either side of the screen to facilitate the maintenance and the repair thereof.

M01.8.2.3. Sole Plate

The screening field shall be provided with a sole plate designed such and profiled as to induce the accumulation of debris material at the lower portion of the screen for effective removal. The leading edge of the sole plate shall be installed at the invert level of the receiving channel.

M01.8.2.4. Rake System

The screen design shall be based on continuous operation. The screen shall be periodically raked by a mechanized rake system which shall be controlled by the differential water level and timing devices or by continuous operation. Thus, the level upstream of the screen and shall be monitored by level instrumentation which shall be selected with reference to the Johannesburg Water (SOC) LTD Control & Instrumentation Particular specification; Volume 6 & 9: Automation and Control Design Standards SCADA and Level Measurement.

A scraper cleaning mechanism at the top of the travelling rake shall remove the screenings collected by the rakes and discharge onto a discharge chute without any screenings remaining. The moving rakes shall be suspended between two side chains, which shall be driven through a head shaft and sprocket.

The rakes shall be bolted with counter sunk bolts to the main comb frame for ease of removal when necessary.

M01.8.2.5. Screen Scraper

The scraper cleaning mechanism shall be positioned at the discharge chute area and shall comprise of a single UHDPE blade positioned above the upper edge of the screening retention plate which is activated as the rakes rotate. The blade shall be positioned so that it efficiently cleans the full width of each screen rake.

Scraper arms shall be attached to the side frame and designed to pivot so as to allow efficient cleaning of each rake as it passes. The bearing for the scraper arm shall be self-lubricating polypropylene. The discharge height of the rake mechanism and the discharge chute shall be sufficient to allow free and unhindered discharge to the conveyor.

M01.8.2.6. Discharge Chute

Screenings shall be removed from the rakes and dropped onto the discharge chute.

The discharge chute shall be manufactured from 304 L SS, shall at least be the length of the screen and shall be positioned such that the screenings are deposited into the screenings conveyor without spillage of any of the screenings. The discharge chute shall be hinged for easy maintenance and operation.

The discharge chute of the screen shall be able to rotate at least 90degrees away from the conveyor centre in order to allow the screening operation to continue in cases, where the conveyor is out of service.

M01.8.2.7. Drive Units

Refer to Particular Specification M08: Mechanical Gearboxes for a detailed specification on gearboxes. Also refer to Particular Specification and E01 for a detailed specification for the Electric Motors.

A torque arm shall be attached to the drive unit to accommodate vertical adjustment. A facility shall be incorporated within the drive mechanism, to enable the drive chains to be correctly tensioned, and the combs to be accurately positioned across the screen field face. The design shall ensure that the chain drive is selected with due consideration to the class of work, length of the chain and the position of the drive, effective safety factor shall be provided for the working chain tension and the bearing pressure to ensure the useful life expectancy of 15 years is attainable.

This adjustment shall be possible without the dismantling of any part of the screen frame and without the necessity for any special tools. The comb teeth shall make an approximate angle of 5° to the plane of the screen field when engaged.

The geared motor and moving comb system shall be protected from damage caused by jamming, by means of an Intelligent Motor Protection Relay type device with built in phase angle protection. As a backup device a torque overload coupling with a proximity shall be provided. The limit switch must have at least one SPDT contact or one normally open and one normally closed contact capable of switching at least 500mA at 230 Volts AC. The limit switch protection shall be minimum of IP 67. The motor and gears shall be correctly sized to avoid over stressing of parts. A facility for reversing the rake drive back to a stationery park position must be provided.

M01.8.2.8. Bearings

All bearings shall be enclosed in a watertight assembly suitable for and shall be design to continuously exposed to moisture. The bearing shall have an L-10 rating life of 100 000 hours while operating at maximum load. Internal bearing parts shall be completely sealed from outside contamination. The bearing shall be accessible for maintenance without dismantling the entire screen mechanism.

M01.8.2.9. Screen Rake Control

The operation of the screen raking mechanism shall be automatically controlled by the upstream water level and shall be timer controlled incorporating; variable time between activation and variable operation duration. An override for continuous operation based on a maximum water level within the inlet structure shall be included. The automatic controls of the raking mechanism shall be supported by a manual override. The timing devices shall be supplied and installed by others.

M01.8.2.10. Channel Parameters

The channel preceding and immediately following the screen shall be shaped and sloped to eliminate the deposition of solids and permit draining of the channel. The channel shall be constructed by the Civil Contractor.

The Contractor shall be responsible for providing the Employer's Agent or Employer's Representative and the Civil Contractor with information regarding the civil requirements of their screening equipment on a timeous basis. This is to allow the Civil design to incorporate the necessary structures or changes to accommodate the installation of the equipment.

M01.8.2.11. Chains and Sprockets

The chain type shall be pin bush link type chain. The chain connecting the comb frames are to have vesconite rollers and 304L SS side plates and pins.

Preference will be given to a chain turn about track arrangement instead of bottom sprockets below water level. Chain links shall be straight line design and any oval shape design shall not be acceptable.

M01.8.2.12. Welds

All welds are to be in accordance with SANS 15614-1.

M01.8.2.13. Control Process

The screens shall be automatically controlled, based on:

- Timer controlled operation of the screen raking mechanism with a variable time between activation of the raking mechanism and variable duration of operation of the raking mechanism
- Override for continuous operation of the raking mechanism based on a water level in the inlet channel
- The activation of the raking mechanism shall be fitted with a manual override with "inching" facility in both the forward and reverse directions
- The screen control settings must be adjustable from the SCADA.

## M01.8.3 Materials of Construction

Coarse Inclined Front Rake Screen components shall be constructed of the material specified in the following Table 8-1:

**Table 8-4 Coarse Inclined Front Rake Screen Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| Screen frame or Housing | 304 L stainless steel |
| Discharge Chute | 304 L stainless steel |
| Access platforms and handrails | 304 L stainless steel |
| Screening Elements | 304 L stainless steel |
| Screen rake | 304 L stainless steel |
| Heavy-duty Drive Links and sprockets | 304 L stainless steel |
| Screen scrapper (wearing part or squeegees) | UHDPE |
| Chain Pins | 304 L stainless steel |
| rollers | Vesconite ( Material Detail) |
| Resting Pads | UHMW-PE |
| Monorail and Support columns | stainless steel |
| Screening element | 304 with UHMW-PE wear surface |
| Fasteners | 316 stainless steel |

| COMPONENT | MATERIAL TYPE |
|---|---|
| All other accessories shall be of manufacturer's standard coated material. | |

## M01.9 FINE PERFORATED SCREEN(S)

### M01.9.1 Design and Performance Requirements

- Fine screens of 6mm perforated type shall be installed downstream of the coarse screen.
- The minimum approach velocity shall be 0.6 m/s. Should grit removal chambers follow the bar screens then the minimum velocity shall be greater than 0.6 m/s. These requirements shall be met in the design and detailing of the civil structures.
- Solids will collect on a continuous belt of perforated filter panels perpendicular to the flow, elevating solids to the discharge point. The perforated filter panels shall be cleaned by means of an automatic adjusting rotating cleaner brush.
- The perforated filter panels shall be driven by drive sprockets secured to the main drive shaft.
- The Tenderer shall provide the spray water flow and pressure requirements for the screens offered as per the OEM recommendation and submit to the Employer Agent's or Representative for acceptance before procurement. Manual Isolation or control of the feed flow shall be allowed for and additionally consider a mechanical means of measurement.
- The minimum screening capture rate shall be 80% for the screens and must be confirmed by an independent testing authority. The documented report of the test which shows the result of screenings capture rate (SCR) must be provided with datasheets.
- The screen shall be designed to provide maximum solids filtration and thus maximize capture of debris and minimize rate of head loss increase through the screen. This shall be achieved by means of one piece perforated curved filter elements. The screen will be operated continuously by means of level measurement upstream of the screen by means of a timer.
- The screen shall be mounted by fastening to the top of the channel. The screen mounting system shall be constructed in 304L stainless steel complete as required to function in accordance with the specification. The mounting system should be designed to allow easy dismantling to facilitate installation and removal of the screen.
- Routine service, repair or replacement of damaged parts, shall be possible with the screen installed in the channel.
- The use of roller chain, filter shafts and rollers and/or two or more motors for screen band rotation is not acceptable.
- The screen shall be designed so that maintenance of the drive mechanism can be accomplished at operating floor level. Screen elements shall be capable of removal at the operating level without taking the screens out of the channel or effecting the continuous or intermittent rotation of the screen.
- The screen shall be factory assembled and tested prior to delivery and shall be delivered to the site fully assembled (other than the motor/reducer unit, discharge chute, and support legs). It shall be capable of being set in place and field erected by the contractor with minimal field assembly.
- The screen shall be fitted with a rotating deflector to prevent bypassing of solids into the downstream channel, driven from the screen drive via a drive chain.
- All components shall be amply proportioned for all stresses that may occur during manufacturing, transportation, erection, and operation.

### M01.9.2 Materials of Construction

All moving wetted parts, all wetted parts on which moving parts ride, all filter belt components under guiding, bearing, or driving loads shall be 316 stainless steel, wear resistant heat treated, high tensile, wear resistant steel, or UHMW-PE as detailed below:

Fine Inclined Perforated Screen components shall be constructed of the material specified in the following Table 9-1:

**Table 9-5 Fine Inclined Perforated Screen Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| Screen frame or Housing or covers | 304 L stainless steel |
| Discharge Chute | 304 L stainless steel |
| Access platforms and handrails | 304 L stainless steel |
| Screen and brush drive shafts | 304 L stainless steel |
| Screen rake | 304 L stainless steel |
| Screening elements | 304 L stainless steel |
| Heavy-duty Drive Links and sprockets | 304 stainless steel |
| Seals | UHMW-PE |
| Screening element support rails | 304 with UHMW-PE wear surface |
| Fasteners | 316 stainless steel |
| Spray bars | 304 stainless steel |
| All other accessories shall be of manufacturer's standard coated material. | |

### M01.9.3 Equipment Design Features

M01.9.3.1. Filter Screen Elements

- The one-piece curved screening elements shall be fixed by fasteners to the heavy-duty drive links. On every tenth screen panel a set of static, non-engaging 'finger' type lifters shall be attached to the lower edge of the panel, designed specifically to lift spherical and large size solids (stones, square lumber cans, bottles, rag clumps, etc…) from the bottom of the channel. Screens that use lifting ledge on top of the panel thereby preventing the removal of solids from the bottom of the channel floor will not be acceptable. To prevent metal to metal wear and bearing damage no submerged roller bearing wheels and spindles will be allowed as well as bearings that require lubrication. Screens which do not support the drive chains on the downstream side will not be acceptable.
- A submerged curved stainless-steel plate shall be provided at the base of the screen. The base of the screen shall be fitted with a rubber seal directly followed by a nylon brush along the full length of the filter panel to prevent ingress of stones and grit and to prevent solids bypass.
- To prevent deflection, the one-piece filter elements shall be made of curved stainless steel. This is required to ensure structural integrity and smooth operation. engaging tines, fingers or engaging elements, which can bind or jam, will not be acceptable.
- The screening elements are to be of the engineered curved shaped so that they can be cleaned with optimum efficiency with an automatic adjusting rotating cleaner brush. Minimum diameter of rotating cleaner brush is 450 mm. The rotation direction of the brush drive must be in the opposite direction of the belt drive.
- The screening elements must be sealed against the frame by means of special knuckle

joint side plates attached to each perforated plate filter element. Side plates must be made in Stainless steel type 304L. Simple brush systems are not acceptable. This is to ensure that small items are not floated past the sides of the screening elements.

M01.9.3.2. Filter Screen Panels

- The screen filtration belt shall be provided with one piece perforated curved elements, which limits the maximum opening in any direction to the perforated opening size. This restricted opening profile prevents long thin materials from passing through the openings. Filter panels that are not curved shall not be acceptable. Filter panels with a flat face inclined and a horizontal ledge shall not be acceptable.
- Cleaning device that causes screenings to be pushed or dropped into the interior of the filtration belt will not be acceptable.
- The individual screening elements must not exert stresses on one-another, and the load transmission must be exclusively via chains. Systems which involve connecting the screen elements together with other or additional attachments are therefore not acceptable because of stressing. Furthermore, the elements must not be able to overlap one another, which would create spaces in which material could collect.

M01.9.3.3. Screen Drive Mechanism

- Motor: 400 V, 3 Phase, 50 Hz. Overload protection shall be provided by a true power monitor electrical overload device that senses the motor power factor.
- Gear Reducer:
  - Helical Worm type.
  - Hollow, shaft mounting.
- Chain shall be heavy-duty block chain, which is supported outside the frame by UHMW-PE, a hardwearing, high lubricity synthetic material. Breaking load of the chain shall be a minimum 90 kN.
- Chain shall have no rollers.
- Chain shall have no metal to metal wear associated with running roller chain in the screen frame.
- All drive components shall be designed to operate the screen continuously under a calculated load resulting from the differential water level between the upstream and downstream sides of the screen.

M01.9.3.4. Brush Drive Mechanism

- Motor: 380 V, 3 Phase, 50 Hz
- Gear Reducer:
  - Helical Worm type.
  - Hollow, shaft mounting.
- Rotating Deflector Drive Mechanism:
  - The rotating deflector shall be driven from the screen drive via a drive chain.
  - Screens that require a third motor for the rotary deflector shall not be acceptable.
  - The brush mechanism shall automatically adjust with reference to wear to ensure constant brushing efficiency.

M01.9.3.5. Discharge Chute/Hood

- A discharge chute/hood shall be provided that fully encloses the discharge section of the screen. The upper section of the discharge chute/hood shall be hinged to allow complete access to the screen cleaner brush. The hinged hood shall be secured with quick closing clamps and supplied with two (2) gas cylinders to aid opening and closing.
- Discharge chute shall be manufactured from stainless steel type 304L
- Each screen discharge chute/hood shall direct screenings directly to the hydro-conveyor designed to match the screenings hydro-conveyor with no water leaking or screenings dropping to the floor.

M01.9.3.6. Frame Enclosures / Covers

- The screen shall be provided with hinged covers.
- Covers shall be provided on the upstream and downstream portion of the screen above the operating floor.

## M01.10 SCREENINGS CONVEYOR

Three Types of conveyors shall be covered under this particular specification namely:

- Covered screw type conveyor
- Covered Hydro type conveyor
- Belt conveyor type. Refer to M16: Particular Specification for Conveyor Equipment

### M01.10.1 General Specification

- The screenings from the screening equipment will be discharged onto a transfer conveyor as per the installation layout shown in the Tender drawings.
- Screenings that are conveyed will be deposited in the feed hoppers of the duty washer/compactor unit.
- Dewatered screenings will be deposited into a skip that will be mounted on a motorized dolly to facilitate positioning of the skips for loading/unloading.

### M01.10.2 Covered screw type conveyor:

M01.10.2.1. Design Parameters

- The design of the screw conveyor shall be of a spiral design enclosed in U-trough with the top closed with sectional hinged covers installed at an inclination that will allow the ease of flow of the screenings into the wash/screw compactor hopper unit or a collection skip. The diameter of the spiral screw shall be a minimum of 310mm. The U-trough shall be design and sized to facilitate the movement of the screw and conveyance of the screenings.
- The screening inlet or collection point shall have a hopper design along with the screens discharge chute to facilitate the ease of screenings deposit into the screw conveyor.
- The covers shall be manufactured from clear plastic which is UV resistance and hinged for easy inspection of the screw.
- A relatively low friction liner around the inside peripheral section of the U-trough shall be installed and secured. This shall be made from a minimum 10 mm UHDPE liner, alternative material offers can be provided but will be subject to the approval of the Employer's Agent or Employer's Representative.
- The screw unit shall be manufactured from carbon steel which is as the per corrosion specification G01.
- Any drainage, spillage and wash water from the conveyor must be returned to the influent sewer upstream of the screens.
- The geared motor and moving comb system shall be protected from damage caused by jamming, by means of an Intelligent Motor Protection Relay type device with built in phase angle protection. As a backup device a torque overload coupling with a limit switch shall be provided. The limit switch must have at least one SPDT contact or one normally open and one normally closed contact capable of switching at least 500mA at 230 Volts AC. The motor and gears shall be correctly sized to avoid over stressing of parts.
- Refer to Particular Specification M08: Mechanical Gearboxes for a detailed specification on gearboxes and to Particular Specification E01 Electrical Motors for a detailed specification for the Electric Motors.
- The size of the screw, gearbox and motor shall be selected based on the plant specific screens production rate.
- Lower bearings shall be enclosed in a watertight assembly suitable for submerged operation in grit service. The bearing shall have an L-10 rating life of 100 000 hours while

operating at maximum load. Internal bearing parts shall be completely sealed from outside contamination

- The spiral screw flights shall have easily replaceable bearing shoes on the leading edge which shall support the screw through the trough and keep drain holes clean.
- The bearings shall be designed to withstand the thrust forces imposed. The screw shall operate at a maximum speed of 10 rpm
- The bearing design shall make provision for self-alignment and allowance for axial movement of the shafts. Bearings for the lower stub shaft shall be designed to withstand bending, down pull, thermal expansion and radial loads imposed under 100% loading. The bearing can be provided as seal for life bearing or continuous lubricated bearing. Continuous lubricated bearing shall be preferable grease lubricated. Selection and design of screw bearing shall be subject to the approval of the Employer's Agent / Employer's Representative.
- The screw shaft shall be seamless and continuous. Where not practically possible to supply a continuous screw shaft. A multi-screw shaft(s) may be offered, the Contractor shall submit the full design of the screw shaft to the Employer's Agent or Representative for acceptance. The shaft shall not be jointed on maximum deflection. On sections where there is less deflection or bending.

M01.10.2.2. Covered screw type conveyor Material of Construction

Covered screw type conveyor components shall be constructed of the material specified in Table 10-1 below with a minimum thickness of 3mm.:

**Table 10-6 Covered screw type conveyor Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| U-trough frame | 304 L stainless steel |
| U-trough Liner | UHDPE |
| Covers | Clear Plastic (UV protected) |
| Screw unit | Epoxy coated Carbon steel |

### M01.10.3 Covered Hydro Conveyors

M01.10.3.1. Design Parameters

- The selection and use of the hydro-conveyor shall be selected based on the screening production in the specific plant of installation.
- The hydro conveyor shall be design for continuous operation.
- The hydro-conveyor shall only utilise plant wash water from the final effluent streams which can contain up to 30 mg/l solids and chlorinated. Therefore, it is expected as part of this contract to screen the washwater before being used in this system by means on strainers. A secondary alternative, the hydro-conveyor medium can be the degritter wastewater supplied by a submersible pump. The use of the secondary medium shall be by-pass on solid sensitive inline equipment. The plant washwater for the hydro-conveyor shall be temporarily stored in a suitably sized tank, acting as a retention tank. This storage facility shall ensure adequate supply of wash water based on the required flowrate is achieve for a reasonable time of at least 8 hours.
- The hydro-conveyor shall be of a U-trough design i.e. straight sides and a curved

bottom (flat bottom conveyor will not be acceptable) with a minimum radius of 200mm installed at an inclination that will allow the ease of flow of the screenings into the wash/screw compactor hopper unit.

- The top of the U-trough shall be covered ( if Specified by the Project Specification) with sectional hinged access covers and opening handles installed at least on 1 metre intervals and on bends. The bends of the hydro-conveyor shall be long radius bends in order to avoid blockages.
- The hydro-conveyor shall have collection hoppers that will allow the screenings from the discharge chute of the screen to be dropped at the centre of the hydro-conveyor. The hydro conveyor hopper and the washer compactor receiver shall overlap to ensure no spillage.
- The detailed design of the hydro conveyor will be prepared by the contractor including the support legs which shall be submitted to the Employer's Agent or Employer's Representative for approval prior to manufacture. A typical layout of the hydro conveyor indicated on the tender drawings with regards to the screening equipment and channel arrangement.
- The hydro conveyor shall be designed to handle the maximum loading screening and wash water loading selected base on the plant specific screen production rate and the no. of screening inlet/collection points
- The Wash water for the bar screens and washer/compactors will be supplied via the wash water pumps specified in the project specification. The wash water pressure shall have minimum pressure of 4 bar with a minimum injection flowrate that is be sized based on the screening feed requirements and any other variable required for effective operation of the conveyor. The injection flowrate shall be specified in the Project specification.
- The wash water supply shall have one main inlet at the beginning of the hydro-conveyor with a minimum diameter of 32mm. Higher diameters will be selected based on the loading conditions. There shall be an isolation ball valve on the wash water supply line prior to the inlet to the conveyor.
- At each screenings inlet or collection point there shall be spray nozzles directed such that they are able to wash away the screenings. Furthermore, there shall be additional spray nozzles on bends. Before each spray nozzles, there shall be a manual isolation valve.
- The hydro conveyor will incorporate an electric actuated "plug" for isolating the opening in the first (duty) washer compactor unit so that screenings can be transported onto the second (standby) washer compactor.
- The design of the water channel into the washer compactor shall be such that the flow of water is minimised by provision of screens and separation before the compactor i.e. perforated section before the washer compactor.
- There shall be an elevated platform along one side of the conveyor to allow access for operation and maintenance.
- The conveyor trough shall be sufficiently designed and supported to allow an operator to stand-on it.

M01.10.3.2. Covered Hydro conveyors Material of Construction

Covered Hydro conveyors components shall be constructed of the material specified in the following Table 10-2 below with a minimum thickness of 4.5mm.:

**Table 10-2 Covered Hydro type conveyor Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| Hydro-Conveyor Covers | Clear Plastic (UV Protected) |
| Collection Hoppers and Trough | 304 L Stainless Steel |
| Opening Handles | 304 L Stainless Steel |
| Support Structures | 304 L Stainless Steel |
| Wash Water & Drainage Pipework | 304 L Stainless Steel |

## M01.11 SCREW WASHER COMPACTOR

### M01.11.1 General

A screw washer compactor shall be included if specified in the Project Specification to wash organics out of the screenings and to remove excess liquid from the screenings collected. The screenings removed from the screens shall be transported by a conveyor system to the compactor. After being washed and dewatered the screenings shall be discharge into receiving bin for the disposal thereof. The wash water from the washer compactor shall be routed to the inlet channel upstream of the screens via a suitably sized drainpipe. The screw compactor and bin shall be located within a bunded area in which spillage from the equipment shall be collected and returned to the inlet channel upstream of the screens.

Where specified in the project specification, the contractor shall supply the trolley and the hand / or electrically operated winches for handling of the bin.

The compactor shall accommodate feed from a number of conveyed sources.

**Design Parameters**

The screw compactor shall consist of a washing zone, drainage zone, an inlet zone, a conveying zone and a compacting zone.

The design of the screw compactor shall be such that the extruded product shall have a moisture reduction of 70% minimum, a weight reduction of at least 65% and a volume reduction of no less than 70%. The screw compactor frame shall be manufactured from 304 L stainless steel.

The screenings shall enter the inlet hopper where it is washed and then transported and compressed by the screw and discharged. As the screenings are compressed, the liquid drains out of the holes in the bottom of the pan and discharges back into the inlet channel upstream of the screens.

Provision for bi-directional rotation of the screw compactor shall be made in order to remove any blockages that may occur. Access to the operation of this feature shall be by means of a key switch located locally in the field. A separate panel shall be provided to accommodate the relevant field control equipment. The materials used for the manufacturing of this field station shall conform to the requirements of the E03: Particular Specification for Isolator Push Button.

A high-pressure wash water spray system to wash the screenings shall be provided at the inlet Zone.

Inlet Zone

The inlet zone shall be designed to suit an inlet chute. The inlet chute shall have a minimum area of 0.4 $m^2$.

Drainage Zone

The drainage zone at the feed end of the compactor permits the drainage of free water. The drainage zone shall be a minimum length of 200 mm.

Conveying zone

As the screw rotates it conveys screenings along the length of the conveying zone up to the compacting zone. As the screw rotates the material, gravity and the surface friction react to force the water from the screenings. The conveying zone shall be a sized according to the specific plant layout and positioning of the collection skip.

Compacting Zone

The resulting compacted plug of screenings is forced out of the discharge. The compacting zone shall have a minimum length of 500 mm.

### M01.11.2 Helical Shaft Screws

The screw shall have a helical flight and shall have a minimum of 6 flights per linear meter. The shaft screws shall be designed to withstand the subjected torsional forces imposed during the operation thereof. Lower bearings shall be enclosed in a watertight assembly suitable for submerged operation in grit service. The bearing shall have an L-10 rating life of 100 000 hours while operating at maximum load. Internal bearing parts shall be completely sealed from outside contamination

The helical screw flights shall have easily replaceable bearing shoes on the leading edge which shall support the screw through the trough and keep drain holes clean. The bearings shall be designed to withstand the thrust forces imposed. The screw shall operate at a maximum of 10 rpm.

A relatively low friction liner around the inside peripheral section of the U-trough shall be installed and secured. This shall be made from a minimum 10 mm UHDPE liner, alternative material offers shall be accepted provided it is of similar of better properties to the specified, alternative offer shall be subject to the approval of the Employer's Agent or Employer's Representative.

### M01.11.3 Trough

The washing trough shall be totally enclosed to prevent spillage and contain odours. Hinged inspection covers (where applicable) shall however be provided for inspection and removal of objects if required.

#### Drive Unit

The compactor-drive unit shall be mounted at the bottom of the inclined screw trough and shall be enclosed. The compactor shall be directly driven by an electric motor coupled to a shaft mounted gearbox. Refer to particular specification M08: Mechanical Gearboxes and refer to particular specification E01: for a detailed specification for Electric Motors.

#### Screw Wash Compactor Material of Construction

Screw Wash Compactor components shall be constructed of the material specified in Table 11-1 below :

**Table 11-1 Covered Hydro type conveyor Material Specifications:**

| COMPONENT | MATERIAL TYPE |
|---|---|
| Screw compactor frame | 304 L stainless steel |
| Helical Shaft Screws | carbon steel |
| U-trough | 304 L stainless steel |
| U-trough liner, | UHDPE |
| Support Structures | 304 L stainless steel |
| Wash Water and Drainage Pipework | 304 L stainless steel |

## M01.12 FASTENERS

Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirement of the appropriate approved standard.

Bolts shall be of such standard length that a minimum of two to four complete threads shall protrude beyond the nut when in the fully tightened condition. The same shall applies to stud units. Mating surfaces shall be adequately protected against corrosion whilst awaiting assembly of the faces and bolting, all to the approval of the Employer's Agent or Employer's Representative.

All high tensile bolts and studs used in the Works shall bear the letter HTS stamped or engraved on the end. Washers shall be provided under all bolt heads and nuts. The threads of bolts and studs shall be lubricated before assembly with a lubricating substance subject to the approval of the Employer's Agent or Employer's Representative. Washers, locking devices and anti-vibration arrangements shall be provided where necessary and shall be subject to the approval of the Employer's Agent or Employer's Representative.

Stainless steel bolts, nuts and washers shall be in accordance with SANS 1700 A70 and the grade of stainless steel shall be subject to the approval of the Employer's Agent or Employer's Representative. Hot Dip Galvanised fasteners shall comply with the requirements of SANS 121. High strength friction grip (HSFG) bolts, nuts, load indicator washers and washers shall subject to the approval of the Employer's Agent or Employer's Representative and shall be hot dip galvanised. High strength friction grip bolts shall be tightened in accordance with the manufacturer's recommendations and the tension shall be re-checked not less than 3 hours after first tightening and then the bolts shall be retightened to the initial load all to the approval of the Employer's Agent or Employer's Representative.

All stainless-steel bolts, nuts and washers in contact with a dissimilar material shall be provided with isolating (non-metallic) washers and sleeves (insolating kit) where appropriate to prevent galvanic corrosion, unless otherwise specified in the project specification. The selection of the non-metallic washers shall consider the normal operating conditions of the installation. The bed plates and machinery shall be provided with means of adjustment for line and level to maintain the items of Plant in correct alignment during grouting. Packers used for adjustment shall be of non-corrosive material to the approval of the Employer's Agent or Employer's Representative. Holding down bolts which are to be tightened after grouting shall be provided with bond breakers where they pass through the grout.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt and nut does not exceed half of the yield stress of the bolt material under

all conditions. The shear value of high strength friction grip bolts shall be reduced in proportion to the reduced tensile stress compared with the normal design stress.

No tapped holes in mild steel shall be allowed. Where tapped holes are unavoidable, this shall be done into stainless steel. Where bolts and nuts are required to be removed and re-assembled on a regular basis, these shall be of stainless steel. Metal coatings and other treatments applied to fasteners shall be carried out in a manner which will not cause hydrogen embrittlement of the parent material

## M01.13 RECOMMENDED SPARES AND SPECIAL TOOLS

The Tenderer must submit on the appropriate schedule a priced list of spare parts which is recommended should be kept by the water treatment plant for maintenance of the equipment. Spares which the Client decides to order must be manufactured simultaneously with the rest of the equipment and be subject to the same tests for dimensions, tolerances, strength, etc. All spares must be packed separately, and the cases appropriately marked. All spares must be new and unused.

For special tools being used on offered equipment. Tenderers shall submit a provisional price (where applicable) for a complete set of special spanners, keys and tools required for the operation, adjustment and overhaul of the plant supplied. All spanners, keys and tools shall be new and unused.

## M01.14 GUARANTEE OF PERFORMANCE

The Defects Liability period shall be a period of at least 12 months calculated from the Completion as defined in the Contract Document.

However, should a portion or all of the plant and equipment fail / or require rectification during this period, the Employer's Agent or Representative reserves the right to extend the Defects Liability Period in respect of such portion or all of the plant and equipment for a further period of at least 12 months calculated from the date of Commissioning of such plant and equipment after rectification.

## M01.15 CORROSION PROTECTION

Refer to G02 - Particular Specification for Corrosion protection.

## M01.16 COLOUR CODES

The standard final colour codes for equipment supplied under this Contract shall be in accordance with Particular Specification G01: Colour Codes.

## M01.17 QUALITY MANAGEMENT (QM) AND QUALITY ASSURANCE

### M01.17.1 General

QM shall be categorised as 'critical and major' for this section of the Project. The Contractor's Quality Management System shall be in accordance with industry standard. The Contractor shall implement a comprehensive Quality Control programme and accept full responsibility for the quality of his workmanship and material used, irrespective of any quality surveillance that may be carried out by the Employer's Agent / Employer' Representative. In keeping with the basic principles Quality Management System, the Contractor and Subcontractor(s) shall:

- Be responsible for compliance with all the requirements of the Specification in every respect;
- Carry out all inspections and tests called for in the Specification in the presence of the Employer's Agent / Employer' Representative. The cost of these inspections and tests shall be carried out at the sole expense and under the responsibility of the Contractor;
- Draft a Quality Control Plan for manufacture for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during manufacturing process of all components indicating all the intended stages of testing during manufacture, cleaning and preparation for application as well as necessary hold points for independent quality surveillance;
- Draft a Quality Control Plan for corrosion protection for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during corrosion protection process of all components indicating all the intended stages of testing during corrosion protection as well as necessary hold points for independent quality surveillance;
- Draft a Quality Control Plan for installation for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during installation process of all components indicating all the intended stages of testing during installation as well as necessary hold points for independent quality surveillance; and
- Draft Quality Control Plans for any other construction process as may be required for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during the execution of the process indicating all the intended stages of testing as well as necessary hold points for independent quality surveillance.

The Quality Control Plans will not be compromised once approved and shall always be adhered to. The Contractor shall operate approved quality assurance and control programmes in the Supplier's and Manufacturer's premises and on Site in order to verify that the Works comply with this Section. Prior to the commencement of any work, the Contractor shall prepare and submit to the Employer's Agent / Employer' Representative for approval, quality plans describing the procedures, standards of acceptance, hold point inspections, routine and type tests to be carried out for each component both during manufacture and on Site.

Although it shall remain the responsibility of the Contractor to ensure that the Works conform to the Specification, the Employer's Agent / Employer' Representative shall be entitled to inspect, examine and test the materials, workmanship and performance of every item of Plant. The Employer's Agent / Employer' Representative will notify the Contractor which tests or inspections, detailed in the quality plan, they will attend.

Approval by the Employer's Agent / Employer' Representative of materials, workmanship, etc., during manufacture or at Site will not relieve the Contractor of his obligations to comply with all the requirements of the Contract.

All instruments and appliances necessary for the complete inspection and testing shall be provided by the Contractor. Calibration certificates for instruments shall be produced to the Employer's Agent or Employer's Representative for review prior to the commencement of any tests and, if required by the Employer's Agent / Employer' Representative, instruments shall be re-calibrated at the Contractor's own account before commencement of the tests.

In general, Quality Management System should be bench marked in accordance with the relevant ISO 9000 requirements.

### M01.17.2 Material Tests

The Manufacturer's material test data and the Contractor's quality records shall be subject to examination by the Employer's Agent / Employer' Representative. Reasonable samples of the cleaning and coating materials to be used may be taken for testing.

Rejection of the samples shall place a hold on the use of the materials of the same batch number and any components that have already been cleaned/coated with rejected material shall be re-cleaned and coated.

### M01.17.3 Type Tests

Where the Contractor offers Plant selected from the standard range of products from a specialist manufacturer, type tests in accordance with a recognised international standard are required on one unit of each type to prove satisfactory design and quality of manufacture of that Plant.

The Employer's Agent / Employer' Representative may waive the requirement for type tests if they are satisfied that tests have previously been performed on identical Plant. The Contractor shall submit the data and results with their Quality Plan in sufficient time to allow for repeat tests without delaying the Works should the Employer's Agent / Employer' Representative not approve the evidence submitted.

The above cost should be built into the supply of the equipment as per the project specification.

### M01.17.4 Manufacture

Tenderers shall submit with their tender a detailed Project Quality Plan, stating how they control the flow of paperwork from commencement of the Project through final handover to the Client, a sample of their Quality Control Plan, (QCP) and Project Quality Plan, (PQP) both during the course of the Project, manufacture and finally, installation.

The successful Tenderer shall submit a QCP covering all aspects of the manufacturing process, indicating held points to allow the Employer's Agent or Representative opportunities to evaluate the equipment for compliance to this specification.

All items of equipment shall be subject to inspections by the Employer's Agent or Representative during design and manufacture per these QCP's.

In general, it is anticipated that this Project shall be in accordance with the relevant ISO 9000 requirements.

### M01.17.5 Installation

The successful Tenderer shall submit a QCP covering all aspects of the installation of each item of equipment to be installed under this Project. The Employer's Agent or Representative shall be afforded every opportunity to certain stages of completion of the installation to ascertain compliance with the Specifications and to witness the Contractor's site activities at the Employer's Agent or Representative's discretion.

## M01.18 SYSTEM PERFORMANCE

### M01.18.1 Works Testing

All Equipment shall be subject to a Factory Acceptance Test (FAT) by the Manufacturer and witness by Employer's Agent / Employer' Representative at the Manufacturer's premises before despatch. All performance test results shall be made available to the Employer's Agent / Employer' Representative for verification or when the QCP's require intervention or hold points for inspection.

Equipment may only be despatch from factory once all relevant "hold points" on QCP's have been signed off by the Employer's Agent / Employer' Representative and/or the Approved

Inspection Authority (AIA) in accordance with approved quality control plan.

**M01.18.2 Before Commissioning**

- Check for correct lubrications levels in all rotating equipment including gearboxes and that motor bearings are greased properly.
- Ensure all HD bolts are torque down correctly.
- The alignment and levelling of each assembly shall be checked and witnessed by the Employer's Agent or Employer's representative.
- The electrical functions and control shall be checked by a responsible inspector prior to attempting to start any motor on this Project.

**M01.18.3 During Commissioning**

The commissioning stages, shall include but not limited to the following checks:

- Ensure all axillary components of the equipment and the peripheral instrumentation such as level, flow or pressure switches are functional
- Measure the screenings removed from by the screen
- Measure the volume of screenings in the raw sewage downstream of the screens. These shall correspond to the size of the Screenfield spacing.

**M01.18.4 Before expiry of the Defects Liability Period**

The Employer requires the Contractor to visit the site every quarter to inspect together with the Employer's Agent or Representative for the correct operation of the installed equipment. A report after each visit shall be submitted in writing within 14 days after the inspection to the Employer's Agent.

**M01.18.5 Substandard Quality Control**

All material, certification and records of the Contractor shall be subject to examination by the Employer's Agent / Employer' Representative.

This shall include the checking and testing of the Plant at the Works and on Site, installation and pre-acceptance testing. If any deviation is found, additional testing and quality surveillance shall be carried out at the Contractor's own costs until approved by the Employer's Agent / Employer' Representative.

If the additional testing confirms inaccurate quality control by the Contractor on an item of Plant, all work shall be stopped on that item of Plant and shall only proceed after remedial action in the quality control system has been implemented.

**M01.18.6 Access for Surveillance**

For the purpose of carrying out quality surveillance, the Employer's Agent / Employer' Representative shall be granted access to any part of the Contractor's premises relevant to the work being carried out, at any reasonable time.

**M01.19 EQUIPMENT TRAINING PROCEDURE**

Training shall be provided by the Contractor (or specialist equipment suppliers) based on the supplied and approved operation and maintenance (O&M) manuals for all supplied equipment. This training shall be provided to the Operations and Mechanical including other support discipline staff of the Employer along with the Employer's Agent and/or Representatives. The duration of the training period shall be advised by the Contractor and

agreed with the Employer's Agent and/or Representatives.

The training structure for the equipment and/or system should include both the theory and practical components of the equipment derived from the O&M manuals.

The preparation of the O&M manuals shall be based on the Johannesburg Water (SOC) Particular specification for Commissioning and Operation.

## M01.20 OPERATION AND MAINTENANCE MANUAL SUMMARY

The Contractor shall hand over to the Employer' Agent or Employer's Representative four sets of the Operation and Maintenance Manual compiled for each installation not later than at the time of commissioning of the installation. These manuals are a prerequisite for final takeover of the plant. A copy of the Operating and Maintenance Manual for each equipment type 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.

The Operation and Maintenance Manual will contain the following:

(a) Brief description of the plant and installation.

(b) Concise operating instructions including start-up, operating, shutdown and troubleshooting procedures.

(c) Routine maintenance instruction this shall include failure mode analysis and preventative strategies.

(d) Precautionary measures, elementary trouble location, rectifying measures and emergency actions.

(e) Detailed information on equipment.

(f) Lists of spare parts including names and addresses of suppliers.

(g) Schematic Diagram and Drawings

(h) Risk, Health and Safety Assessment with proposed control measures.

## M01.21 INTERCHANGEABILITY

Where two or more similar types of equipment are required, these units shall be identical in all respects.

All similar parts of items supplied shall be interchangeable without any additional machining or fitting.

## M01.22 DRAWINGS

The drawings included in the Tender Documents are the Employer's Agent or Employer's Representative. 's proposal for the plant layout. Should the Tenderer offer alternative layouts, he shall submit drawings with his Tender in order for it to be evaluated.

Before the Contractor carries out any work, they shall submit detailed working drawings to be approved by the Employer's Agent or Employer's Representative. . Approval of these drawings does not relieve the Contractor from their responsibility for the correctness of the drawings.

## M01.23 MEASUREMENT AND PAYMENT

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

Where separate payment is required for equipment and specified as such in the detail /project specifications, the following payment items shall be applicable:

### M01.23.1 General

The following items shall be included in the rates:

(a) Supply of all design and pre-manufacture documentation and obtaining approval thereof;
(b) Procurement/manufacture of required equipment with associated equipment items and delivery to Site;
(c) Installation of complete required equipment with associated equipment items and testing;
(d) Services required during period of initial use before handover to the Employer.
(e) Payment under scheduled items shall be made per complete installation as specified, electrical connections, etc and grouting, etc. Measurement and payment will distinguish between supply / delivery; installation and testing; and commissioning and trail operation of the equipment. A further training requirement shall be allowed for as specified in the scheduled items.

### M01.23.2 Supply and delivery to site with documentation

| Item | Unit |
|---|---|
| Supply and delivery to site with documentation | No |

The tendered rates shall include for full compensation of all costs incurred in design, drawings, manufacture, supply, testing at the manufacturers works, inspections, quality control, quality assurance, factory acceptance testing, corrosion protection, packing, delivery to site including transportation costs and offloading on site including any cranage requirements. 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.

### M01.23.3 Installation, Testing and Commissioning of the Equipment

| Item | Unit |
|---|---|
| Installation, Testing and Commissioning of the Equipment | No |

The tendered rates shall include for full compensation of all costs incurred in installation, site testing, setting into operation, the supply of O & M manuals, commissioning and maintenance during the warranty period of all equipment specified on Site including the provision of all labour, supervision, instruments, equipment, transport, on-site quality assurance and quality control, inspection and testing (including attendance at tests witnessed by the Employer's Agent / Employer' Representative), materials and Temporary Works necessary to completely install, test and commission and render fully operational equipment.

The rate shall also include the cost of the installation of all auxiliary equipment 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 until taken over by the Employer; the putting into service of the complete installation; remedial work and any other work as specified and necessary.

The rate shall also include for all preliminary testing and the provision of testing equipment therefore including all disruptions to installation caused by such testing.

Payment will only be effected after full compliance of the equipment items with this Section and associated documentation has been approved by the Employer's Agent / Employer' Representative.

**M01.23.4 Trial Operations**

| Item | Unit |
|---|---|
| Trial Operations | No |

This specification allows for a number of calendar days within which the system Trial Operation can be completed after completion of commissioning process. The Contractor shall programme and price for providing full technical and operational support during trail operation.

**M01.23.5 Employer's Operator Training**

| Item | Unit |
|---|---|
| Training | No |

Payment for Training of the Employer's Operational Staff will be made under this Section as set out in project specification or agreed with the Employer's Agent / Employer' Representative. The lump sum shall be inclusive of all costs associated with the training programme and on-site training of personnel.

**M01.23.6 Spares Equipment**

| Item | Unit |
|---|---|
| Spares | No |

The cost of spares, considered to be necessary by the Contractor other than spares required by the Employer, delivered to Site and handed over will be paid as a lump sum. A Spare Part Schedule subject to approval by the Employer's Agent/ Employer's representative shall be submited before procurement of spares.

The actual lump sum to be paid shall be based on the unit rates priced in the Bill of Quantity for the actual spares ordered and supplied and the Employer is entitled to purchase all, some or none of the items listed. A provisional sum will be allocated in the Bill of Quantity for the complete list of spare parts as listed by the Contractor.The rate tendered shall provide for the manufacture, supply, delivery to Site and handing over of the spares ordered and shall include permanent packing for long term storage. The spares shall be manufactured at the same time as the installed items.

# JOHANNESBURG WATER - MECHANICAL SPECIFICATIONS

## PARTICULAR SPECIFICATION: M08: MECHANICAL GEARBOXES

## M08.1 SCOPE

This specification covers the detailed design parameters, manufacture, supply, off-loading installation, test and commissioning of complete Gearboxes. The Specification shall be read in conjunction with the Project Specification and other relevant Particular Specifications.

## M08.2 INTERPRETATIONS

This specification shall be interpreted as follows:

- For the Employer design components, it shall be regarded as a specification.
- For the Contractor design components obligations, it shall be regarded as an Employer's requirements.

### M08.2.1 Definitions

For the purpose of this Specification the following definitions are used:

a) "**Manufacture**" includes, as applicable, the purchase of materials or goods, fabrication and assembly, any specified corrosion protection measures and any off-site inspection or testing of materials or parts.

b) "**Supply**" includes, as applicable, the purchase of materials or goods, manufacture and fabrication, any specified corrosion protection measures and all required off-site inspection or testing.

c) "**Installation**" includes, as applicable, all handling and transport from storage, erection and aligning of Works.

d) "**Factory Acceptance Test (FAT)**" shall refer to all tests done on Plant or Plant items at the factory to ensure its functionality

### M08.2.2 Abbreviations

In this Specification the following abbreviations will apply: -

| | |
|---|---|
| °C | : Temperature in degrees Celsius |
| A | : Current |
| AC | : Alternating Current |
| AGMA | : American Gear Manufactures Association |
| ANSI | : American National Standards Institute |
| API | : American Petroleum Institute |
| ASCE | : American Society of Civil Engineers |
| ASME | : American Society of Mechanical Engineers |
| ASTM | : American Society for Testing and Materials |
| BFP | : Belt Filter Press |
| BS | : British Standards Institution |
| BSPT | : British Standard pipe thread |
| CAD | : Computer Aided Drawing |
| CAM | : Computer Aided Manufacturing |
| CIP | : Cleaning in Place |
| COC | : Certificate of Conformance |
| D | : Diameter |
| DB | : Air Dry Bulb temperature |
| dB(A) | : Sound pressure level, "A" weighed in decibels |
| DCS | : Distributed Control System |

| | |
|---|---|
| DFT | : Dry Film Thickness |
| DIN | : Deutsch Industry Normen |
| DN | : Nominal diameter |
| DO | : Dissolved Oxygen |
| DP | : Differential Pressure |
| Eff. | : Filter efficiency in % |
| EPDM | : Ethylene Propylène Diène Monomer |
| ERW | : Electrical resistance weld |
| ETP | : Effluent Treatment Plant |
| FA | : Flange adaptor |
| FAT | : Factory Acceptance Tests |
| FBE | : Flanged both ends |
| FOE | : Flanged one end |
| FW | : Field weld |
| HDPE | : High Density Polyethylene |
| ID | : Inside diameter |
| ISO | : International Organisation for Standardization |
| JW | : Johannesburg Water |
| ℓ/s | : Flow in litres per second |
| LV | : Low Voltage |
| m | : Distance in metre |
| m.a.s.l | : Metres above (mean) sea level |
| m/s | : Air speed in metres per second |
| MCC | : Motor Control Centre |
| mm | : Dimension in millimetres |
| MPVC | : Modified Polyvinyl Chloride Pipes |
| MV | : Medium Voltage |
| N+1 | : N units in operation + 1 installed spare |
| Nm3/hr | : Normal cubic meters per hour |
| O&M | : Operation and Maintenance |
| OD | : Outside diameter |
| OHS | : Occupational Health and Safety |
| Pa | : Pressure in Pascals |
| PBE | : Plain both ends |
| PE | : Plain end |
| PN | : Nominal pressure (Rating) |
| PPE | : Personal Protective Equipment |
| PQP | : Project Quality Plan |
| PSV | : Pressure Safety Valve |
| QCP | : Quality Control Panel |
| RFA | : Restrained flange adaptor |
| rpm | : Rotational speed in revolutions per minute |
| SAECC | : South African Electrolytic Corrosion Committee |
| SANS | : South African National Standards |
| SAT | : Site Acceptance Tests |
| SAW | : Submerged arc weld |
| SCADA | : Supervisory Control and Data Acquisition |
| SIS | : Swedish Institute of Standards |

| | |
|---|---|
| SOC | : Slip-on coupling |
| SS | : Soft Starters |
| SS | : Soft Starters |
| SS | : Stainless Steel |
| SST | : Secondary Settling Tank |
| STP | : Standard Temperature and Pressure (i.e. T = 20°C, P = 101, 3 kPa). |
| t | : Wall thickness of pipes |
| TDS | : Total Dissolved Solids |
| uPVC | : Unplasticised Polyvinyl Chloride |
| VSD | : Variable Speed Drive |
| WB | : Air Wet Bulb temperature |
| WB | : Air Wet Bulb temperature |
| WP (B) | : Weld preparation (Butt)\ |

M08.2.3 Standards

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

| | | |
|---|---|---|
| PD 5304:2014 | : | Guidance on safe use of machinery |
| SANS9606-1: 1994 | : | Testing of welders, where applicable to the type of welding required |
| BS ISO1312-1:2018 | : | Rolling bearings. Accessories for sleeve type linear ball bearings. Boundary dimensions, geometrical product specifications (GPS) and tolerances for series 1 and 3 |
| SANS 10162-4 | : | Structural use of Steel Part 4: The design of cold-formed stainless steel structural |
| SANS 15614-1 | : | Specification and qualification of welding procedures for metallic materials - Welding procedure test Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys |
| SANS 10064 | : | The preparation of steel surfaces for coating |
| SANS 10111-2-1 | : | Engineering Drawing Part 1: General principles Engineering Drawing Part 2: Geometric Tolerancing Section 1 |
| SANS 10341 | : | Installation and maintenance of bearings – General guidelines |
| 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 |
| ISO 281 | : | Rolling bearings -- Dynamic load ratings and rating life |
| BS 4999-141 | : | General requirements for rotating electrical machines. Specification for standard dimensions |
| SIS 05 59 00 | : | Pictorial Surface Preparation Standards for Painting Steel Surface |

M08.2.4 Other Particular Specifications

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

G01: Particular Specification for Colour Codes

G02: Particular Specification for Corrosion Protection

M01: Particular Specification for Screening Equipment
M02: Particular Specification for Degritter Equipment
M03: Particular Specification for Primary Tanks
M05: Particular Specification for Sludge and Wastewater Mixing Equipment
M05: Particular Specification for Surface Aerator Equipment
M09: Particular Specification for Archimedean Screw Pumps
M10: Particular Specification for Secondary Clarifier Tanks
M15: Particular Specification for Filter Belt Press Equipment
M16: Particular Specification for Conveyor Equipment
M17: Particular Specification for Actuators
M20: Particular Specification for Valves
M34: Particular Specification for Sluice Gates, Adjustable Weirs
M36: Particular Specification for Diffused Aeration Equipment
Volume 1: Automation and Control Design Standards SCADA
Volume 6: Automation and Control Design Standards Cabling
Volume 8: Automation and Control Design Standards Flow Measurement
Volume 9: Automation and Control Design Standards Level Measurement
Volume 11: Automation and Control Design Standards Temperature Measurement
Volume 23: Automation and Control Design Standards Pressure Measurement

## M08.3 GENERAL DESIGN PARAMETERS

The gearbox or speed reducer equipment shall be designed such that the following requirements are met: -

- To ensure reasonable standards of engineering in design, materials selection and construction processes: -
- To facilitate manufacture, inspection, installation, maintenance, cleaning and repairs;
- To ensure safe and satisfactory operation for an acceptable life expectation of 15 years under the ambient conditions prevailing at the Site;
- The offered equipment shall be support in forms of spares by the original equipment manufacturer for at least 15 years in alignment with the specified life expectation of 15 years from project installation,
- To prevent undue stresses being produced by expansion due to temperature changes;
- To keep maintenance costs to a minimum that represent the value for money in both the initial purchase and subsequent running costs;
- To facilitate inter-changeability of units and/or sub-parts throughout the Contract works with regard to new equipment and equipment and/or sub-parts currently being used on the existing JW Wastewater Treatment Works;
- To operate without undue vibration and excessive noise. Maximum of 75dBA measured at 1 metre from operating equipment;
- To comply with the legal requirements in respect of safety such as the Occupational Health & Safety Act, 1993 and Regulations as well as the prevention of water and air pollution;
- To satisfy any specific requirement contained in the latest editions of the published statutory codes and legislation;
- To be suitable for operation 365 days per year, 24 hours per day under specified design

conditions; and

- The minimum availability of the equipment shall be 99 %.

## M08.4 SPECIFIC DESIGN PARAMETERS

The Tenderer shall submit with their Tender a catalogue of the make of gearbox offered and indicate how the selection of gearboxes was made.

Unless otherwise stated, the gearboxes shall be directly mounted to the motor. The gears shall be helical gears which are used in applications with high speeds, large power transmission and low noise levels.

Gear drives shall be sized to ensure that the running load peak does not exceed the endurance limits of the components.

Gearboxes shall have an efficiency of not less than 96% on two stage reduction and 95% on three stage reduction.

Simple cooling may be by convection from the gearbox casings but without assistance from cooling fins or fans. Adequate other cooling means shall be provided as applicable. The exterior of the gearbox shall be free from dust or moisture traps. Access for inspection purposes shall be allowed for in the design of the gearbox casing. Maintenance free oil lock seals on the high speed shafts shall be a standard design feature.

The tenderer shall provide with his tender all information on oil circulation for gearboxes that incorporate the use of oil circulating pump.

A stainless-steel ball valve and extension drainpipe and plug shall be provided to facilitate oil changes by the maintenance staff. The termination of this drain shall be accessible from the operating platform. The drain provision shall be a rigid design with due consideration to handling, installation and maintenance activities. The baseplate shall be design such that the driving shaft is accessible for inspection, while at the same time allow access to the drainage pipe, without decommissioning and dismantling the gearbox from the transmission assembly.

Where the lubrication system requires the use of an oil pump then the circulation system will be fitted with an oil flow detection system/ device such as an oil flow switch in order to ensure gear protection when operational by detecting any no flow or low flow conditions which shall further be monitored on the works SCADA system. The oil flow detection system shall be capable of switching off the drive unit in the least time as recommended by the original gearbox Manufacturer.

The bearing span shall be suitably selected for vertical gearbox application and shall promote shaft support for the intended application. Rigid lateral load distribution shall be by means of a standardized pinioned arrangement reducing noise and vibration.

A rigid half coupling shall be shrunk onto the output shaft of the gearbox and shall be secured by an additional keep plate and bolted connection in a recognised manner.

Substantial eye bolts shall be provided for all reasonable lifting purposes.

The gearboxes shall carry the manufacturer's identification details together with the rated shaft speeds, rated shaft torque, output power and maximum ambient operating temperature.

The gearboxes shall conform to the relevant British Standards and AGMA ratings with respect to the following requirements:

(a) The design ambient temperature shall be 45°C unless otherwise specified in the project specification.

(b) The noise at 100% of the full output power and 45°C ambient shall not exceed 75 dBA as

measured 1 m in distance from the equipment.

(c) The gearing shall give double the life of the bearings when subjected to similar loadings.

The design of the gearbox shall be such that the following calculation shall be adhered to: -

$$\frac{\text{Actual Radial Load}}{\text{Permissible Actual Radial}} + \frac{\text{Actual Axial Load}}{\text{Permissible Axial Load}} \text{ shall be} \leq 1{,}0$$

Calculations shall be submitted. Failure to do so may render the Tender invalid.

M08.4.1 Gears

The gears shall be high efficiency case hardened helical gears and rated in accordance with the AGMA Code of Practice 420.04 for continuous operation.

Semi-hardened and subsequently machined gears will not be accepted.

M08.4.2 Service Factor

The minimum service factors indicated in the table below shall be based upon the installed power unless otherwise specified in the project specification: -

| Process Units | Service Factor |
|---|---|
| Rotating Bridges: Sedimentation & Clarifier Tanks | 1.5 |
| Rotating Scraper System: WAS Thickeners, Primary Sedimentation & Fermentation Tanks | 1.75 |
| Aerators | 2.25 |
| Mixers | 2 |
| Screw & Plunger Pumps | 2.25 |
| Centrifugal and Positive displacement Pumps | 2 |
| Turbo Centrifugal Blowers | 2.25 |
| Dosing Pumps | 2 |
| Mechanical Screens | 2 |
| General speed reducing applications | 2 |

M08.4.3 Bearings

Roller bearings shall be used throughout. Taper roller bearings shall be used to sustain radial and thrust loads. Bearings shall be designed for a design life in excess of the indicated hours in the table below, in accordance with ISO.281. Bearings for the output shaft shall be designed to withstand bending, up thrust, down pull and radial loads imposed by the equipment being driven. Tenderers shall indicate what these forces are and how these shall be accommodated.

The Contractor shall ensure the lubricant used for the initial filling and specified in the maintenance manual, is adequate for prolonged operation in ambient temperatures of up to 45°C without overheating.

| Process Units | Design Life | Operation |
|---|---|---|
| Rotating Bridges: Sedimentation & Clarifier Tanks | L10 for 100 000 | Continuous |
| Rotating Scraper System: WAS Thickeners, Primary Sedimentation & Fermentation Tanks | L10 for 100 000 | Continuous |
| Aerators | L10for 100 000 | Continuous |
| Mixers | L10 for 100 000 | Continuous |
| Screw & Plunger Pumps | L10 for 100 000 | Continuous |
| Centrifugal and Positive displacement Pumps | L10 for 100 000 | Continuous |
| Dosing Pumps | L10 for 100 000 | Continuous |
| Mechanical Screens | L10 for 100 000 | Continuous |

M08.4.4 Lubrication

The gearboxes shall be constructed with a dry well for the low speed shaft bearing to avoid complete drainage of oil in the event of an oil seal failure. Provision to monitor the oil level must be provided. The bearing shall be grease lubricated with the greasing point easily accessible, where greasing point are not accessible due to gear orientation / auxiliaries attached to the gearbox, stainless steel extension pipes shall be used to ensure that points are accessible, the position of the extended grease lubrication points shall be subject to approval by the Employer's Agent / Employer's Representative. A stainless-steel ball valve and extension drainpipe and plug shall be provided to facilitate oil changes by the maintenance staff. The termination of this drain shall be accessible from the operating platform.

M08.4.5 Gearbox / Motor Coupling

The coupling shall be fully rated to transmit the motor full load power and tested to prove static and dynamic balance. The coupling shall accommodate small axial, lateral and angular misalignments without imposing undue stresses on the shaft and bearings. All coupling shall be suitable for standard motor IEC dimensioning (universal gearbox connection). The coupling shall be enclosed in a stationery solid-plate guard to the Employer's Agent / Employer's Representative satisfaction.

M08.4.6 V-belt

V-belts shall be designed to withstand the high tension and high-power drives, shall be long wearing, tough and trouble free. The V-belt cover shall be oil, heat and ozone resistant in order to protect the inner components. The compression section shall provide excellent gripping action and a high coefficient of friction but shall also allow an initial start-up clutching action in order to eliminate power spikes and excessive bearing loading. The moulded cogs shall provide optimum flexibility with minimal build-up of heat.

M08.4.7 Flexible Couplings

Flexible couplings consist of two types: gear type and multiple disc/diaphragm type. The gear type uses gear teeth to make them flexible and is either grease lubricated, or oil lubricated depending upon their size. Diaphragm couplings do not require any form of lubrication and the flexibility is created by a series of multiple discs or a diaphragm made of spring steel and flexes as the shaft rotate.

Misalignment of the coupling is to be prevented by proper alignment of the coupling by means of a taper gauge or set of feeler gauges and a straight edge or dial indicator. Two types of misalignments are encountered by flexible couplings: Angular misalignment and parallel misalignment. Any adjustment to correct the misalignment in one direction may affect the other direction and both the angular and parallel alignment shall be checked after each adjustment.

A periodic check of the coupling alignment shall be performed as recommended by the Original Equipment Manufacturer during commissioning, testing and trail operation as specified in the project specification.

M08.4.8 Housing

The gearbox shall be manufactured of high strength cast iron which enables the gearbox to be used in harsh environments. The gearbox housing design shall incorporate a breathing plug and means of checking oil level.

All gearbox with a mass more than 25kg shall have lifting hooks or eyes integrally cast on the housing. All gearbox with a mass greater than 100 kg shall either have two removable eye bolts of the required strength securely attached to the valve body or lifting eyes forming an integral part of the valve body to facilitate easy handling during transport and installation

The breather plug shall be designed to effectively prevent pressure build-up inside the gearbox and also prevent dust and moisture ingress. Breather unit allowing continued oil spillage due to the overfilling of the gearbox shall not be accepted.

Oil level sight glasses (fully protected and UV resistant) shall be provided with levels marked for running and filling minimum and maximum positions respectively. These shall be arranged for easy viewing and shall take into account the angle of the gearbox mounting to ensure that the correct oil level in the gearbox is always visible. The filler cap and drain plug must be easily accessible without the need to remove any other part of the gearbox or connected equipment such as motor and belt drive covers & pulleys to get access to it. All gearboxes with motor of 110kW and above shall be provided with oil level protection. The design and installation configuration of the level protection shall be submitted to the Employer's Agent or Representative for review and acceptance.

M08.4.9 Shaft

The Input and output shafts shall be of sufficient dimension in order to avoid excessive torsional or bending stresses and deflection. The driven equipment (e.g. impeller) shall be secured to the shaft in such a way that it can be readily removed without any damage to the equipment or the shaft.

The shafts shall be protected by replaceable sleeves manufactured from non-corrosive material. The shaft shall be manufactured from stainless steel.

## M08.5 FASTENERS

Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirement of the appropriate approved standard.

Bolts shall be of such standard length that a minimum of two to four complete threads shall protrude beyond the nut when in the fully tightened condition. The same shall applies to stud units. Mating surfaces shall be adequately protected against corrosion whilst awaiting assembly of the faces and bolting, all to the approval of the Employer's Agent or Employer's Representative.

All high tensile bolts and studs used in the Works shall bear the letter HTS stamped or engraved on the end.

Washers shall be provided under all bolt heads and nuts. The threads of bolts and studs shall be lubricated before assembly with a lubricating substance subject to the approval of the Employer's Agent or Employer's Representative. Washers, locking devices and anti-vibration arrangements shall be provided where necessary and shall be subject to the approval of the Employer's Agent or Employer's Representative.

Stainless steel bolts, nuts and washers shall be in accordance with SANS 1700 A70, and the grade of stainless steel shall be subject to the approval of the Employer's Agent or Employer's Representative. Hot Dip Galvanised fasteners shall comply with the requirements of SANS 121.High strength friction grip (HSFG) bolts, nuts, load indicator washers and washers shall subject to the approval of the Employer's Agent or Employer's Representative and shall be hot dip galvanised. High strength friction grip bolts shall be tightened in accordance with the manufacturer's recommendations and the tension shall be re-checked not less than 3 hours after first tightening and then the bolts shall be retightened to the initial load all to the approval of the Employer's Agent or Employer's Representative.

All stainless steel holding down bolts, nuts and washers in contact with a dissimilar material shall be of stainless steel and provided with isolating washers and sleeves (insolating kit) where appropriate to prevent galvanic corrosion, unless otherwise specified in the project specification. The bed plates and machinery shall be provided with means of adjustment for line and level to maintain the items of Plant in correct alignment during grouting. Packers used for adjustment shall be of non-corrosive material to the approval of the Employer's Agent or Employer's Representative. Holding down bolts which are to be tightened after grouting shall be provided with bond breakers where they pass through the grout.

Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt and nut does not exceed half of the yield stress of the bolt material under all conditions. The shear value of high strength friction grip bolts shall be reduced in proportion to the reduced tensile stress compared with the normal design stress.

No tapped holes in mild steel shall be allowed. Where tapped holes are unavoidable, this shall be done into stainless steel.

Where bolts and nuts are required to be removed and re-assembled on a regular basis, these shall be of stainless steel.

Metal coatings and other treatments applied to fasteners shall be carried out in a manner which will not cause hydrogen embrittlement of the parent material.

## M08.6 MATERIAL OF CONSTRUCTION

The equipment unit components shall be constructed using the critical material specified in the table below:

| COMPONENT | MATERIAL |
|---|---|
| Gears | High cast iron to BS 1542 Class 220 or an equivalent standard. |
| Pinions | AGMA 390.02 class 12. |
| Housing | Epoxy coated high strength cast iron |
| Input and output shaft | Stainless steel or similar approved |
| Oil drainpipe (external to the housing) | 304L stainless steel |
| Oil level sight glass | UV and chemical resistant glass |
| Base Plate | Hot dip galvanized mild steel |
| Fasteners | 316 stainless steel |

All other accessories shall be of the manufacturer's standard, industry approved, and corrosion protected.

## M08.7 RECOMMENDED SPARES AND SPECIAL TOOLS

The Tenderer must submit on the appropriate schedule a priced list of spare parts which it is recommended should be kept by Johannesburg Water for maintenance of the plant. Spares which the Management decides to order must be manufactured simultaneously with the rest of the equipment and be subject to the same tests for dimensions, tolerances, strength, etc. All spares must be packed separately, and the cases appropriately marked. All spares must be new and unused.

Tenderers must submit a provisional price (if requested in the Bill of Quantities) for a complete set of special spanners, keys and tools required for the operation, adjustment and overhaul of the plant supplied. All spanners, keys and tools shall be new and unused.

## M08.8 GUARANTEE OF PERFORMANCE

The Contractor shall guarantee the output and efficiency of all equipment, which guarantees shall be binding under the Contract. Where guaranteed performance is specified, certified test curves shall be drawn from the test data obtained from the purchased equipment and shall include efficiency (%), power consumption (kW), speed in rpm and speed/torque (rpm/kNm).

The Defects liability period shall extend over a period of 12 months calculated from the Completion as defined in the Contract Document. However, should a portion or all of the plant and equipment fail / or require rectification during this period, the Employer's Agent / Employer's Representative reserves the right to extend the Defects Liability Period in respect of such portion or all of the plant and equipment for a further period of not more than 12 months calculated from the date of Commissioning of such plant and equipment after rectification.

## M08.9 CORROSION PROTECTION

Refer to Particular Specification G02: Corrosion Protection

## M08.10 COLOUR CODES

The standard final colour codes for equipment supplied under this Contract shall be in accordance with Particular Specification G01: Colour Codes.

## M08.11 QUALITY MANAGEMENT (QM) AND QUALITY ASSURANCE

M08.11.1 General

QM shall be categorised as 'critical and major' for this section of the Project.

The Contractor's Quality Management System shall be in accordance with industry standard.

The Contractor shall implement a comprehensive Quality Control programme and accept full responsibility for the quality of his workmanship and material used, irrespective of any quality surveillance that may be carried out by the Employer's Agent / Employer' Representative.

In keeping with the basic principles Quality Management System, the Contractor and Subcontractor(s) shall:

- Be responsible for compliance with all the requirements of the Specification in every respect;
- Carry out all inspections and tests called for in the Specification in the presence of the

Employer's Agent / Employer' Representative. The cost of these inspections and tests shall be carried out at the sole expense and under the responsibility of the Contractor;

- Draft a Quality Control Plan for manufacture for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during manufacturing process of all components indicating all the intended stages of testing during manufacture, cleaning and preparation for application as well as necessary hold points for independent quality surveillance;
- Draft a Quality Control Plan for corrosion protection for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during corrosion protection process of all components indicating all the intended stages of testing during corrosion protection as well as necessary hold points for independent quality surveillance;
- Draft a Quality Control Plan for installation for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during installation process of all components indicating all the intended stages of testing during installation as well as necessary hold points for independent quality surveillance; and
- Draft Quality Control Plans for any other construction process as may be required for approval by the Employer's Agent / Employer' Representative and comply with the approved Quality Plan during the execution of the process indicating all the intended stages of testing as well as necessary hold points for independent quality surveillance.

The Quality Control Plans will not be compromised once approved and shall be adhered to at all times. The Contractor shall operate approved quality assurance and control programmes in the Supplier's and Manufacturer's premises and on Site in order to verify that the Works comply with this Section. Prior to the commencement of any work, the Contractor shall prepare and submit to the Employer's Agent / Employer' Representative for approval, quality plans describing the procedures, standards of acceptance, hold point inspections, routine and type tests to be carried out for each component both during manufacture and on Site.

Although it shall remain the responsibility of the Contractor to ensure that the Works conform to the Specification, the Employer's Agent / Employer' Representative shall be entitled to inspect, examine and test the materials, workmanship and performance of every item of Plant. The Employer's Agent / Employer' Representative will notify the Contractor which tests or inspections, detailed in the quality plan, he will attend.

Approval by the Employer's Agent / Employer' Representative of materials, workmanship, etc., during manufacture or at Site will not relieve the Contractor of his obligations to comply with all the requirements of the Contract.

All instruments and appliances necessary for the complete inspection and testing shall be provided by the Contractor. Calibration certificates for instruments shall be produced to the Engineer for review prior to the commencement of any tests and, if required by the Employer's Agent / Employer' Representative, instruments shall be re-calibrated at the Contractor's own account before commencement of the tests.

In general, Quality Management System should be bench marked in accordance with the relevant ISO 9000 requirements.

M08.11.2 Material Tests

The Manufacturer's material test data and the Contractor's quality records shall be subject to examination by the Employer's Agent / Employer' Representative. Reasonable samples of the cleaning and coating materials to be used may be taken for testing.

Rejection of the samples shall place a hold on the use of the materials of the same batch

number and any components that have already been cleaned/coated with rejected material shall be re-cleaned and coated.

M08.11.3 Type of Tests

Where the Contractor offers Plant selected from the standard range of products from a specialist manufacturer, type tests in accordance with a recognised international standard are required on one unit of each type to prove satisfactory design and quality of manufacture of that Plant.

The Employer's Agent / Employer' Representative may waive the requirement for type tests if he is satisfied that tests have previously been performed on identical Plant. The Contractor shall submit the data and results with his Quality Plan in sufficient time to allow for repeat tests without delaying the Works should the Employer's Agent / Employer' Representative not approve the evidence submitted.

M08.11.4 Quality Control Records

Accurate and detailed quality control records shall be kept by the Contractor for all stages of the work.

All the quality control records shall be available for inspection by the Employer's Agent / Employer' Representative.

The collection of record documents for each item of Plant shall be collated and bound in a logical manner and retained by the Contractor as proof of quality achieved. These shall be available on demand for quality control and part payment releases.

The records shall be neatly filed and handed over to the Employer's Agent / Employer' Representative. on completion of the work in the form of a Data Pack together with all relevant material and test certificates. Only after the Data Pack has been approved and signed off by the Employer's Agent / Employer' Representative. shall Plant be dispatched to Site.

M08.11.5 Substandard Quality Control

All material, certification and records of the Contractor shall be subject to examination by the Employer's Agent / Employer' Representative.

This shall include the checking and testing of the Plant at the Works and on Site, installation and pre-acceptance testing. If any deviation is found, additional testing and quality surveillance shall be carried out at the Contractor's own costs until approved by the Employer's Agent / Employer' Representative.

If the additional testing confirms inaccurate quality control by the Contractor on an item of Plant, all work shall be stopped on that item of Plant and shall only proceed after remedial action in the quality control system has been implemented.

M08.11.6 Access for Surveillance

For the purpose of carrying out quality surveillance, the Employer's Agent / Employer' Representative shall be granted access to any part of the Contractor's premises relevant to the work being carried out, at any reasonable time.

M08.11.7 Manufacture

Tenderers shall submit with their tender a detailed Project Quality Plan, stating how they control the flow of paperwork from commencement of the Project through final handover to the Client, a sample of their Quality Control Plan, (QCP) and Project Quality Plan, (PQP) both

during the course of the Project, manufacture and finally, installation.

The successful Tenderer shall submit a QCP covering all aspects of the manufacturing process, indicating held points to allow the Employer's Agent or Representative opportunities to evaluate the equipment for compliance to this specification.

All items of equipment shall be subject to inspections by the Employer's Agent or Representative during design and manufacture per these QCP's.

In general, it is anticipated that this Project shall be in accordance with the relevant ISO 9000 requirements.

M08.11.8 Installation

The successful Tenderer shall submit a QCP covering all aspects of the installation of each item of equipment to be installed under this Project. The Employer's Agent or Representative shall be afforded every opportunity to certain stages of completion of the installation to ascertain compliance with the Specifications and to witness the Contractor's site activities at the Employer's Agent or Representative's discretion.

## M08.12 SYSTEM PERFORMANCE

M08.12.1 Works testing:

All Equipment shall be subject to a Factory Acceptance Test (FAT) by the Manufacturer and witness by Employer's Agent / Employer' Representative at the Manufacturer's premises before despatch. All performance test results shall be made available to the Employer's Agent/ Employer's Representative for verification or when the QCP's require intervention or hold points for inspection.

Gearboxes shall be subject to testing using the selected project motors for at least 12 hours before dispatch to site. All results shall be available for inspection.

Equipment may only be despatch from factory once all relevant "hold points" on QCP's have been signed off by the Employer's Agent / Employer' Representative and/or the Approved Inspection Authority (AIA) in accordance with approved quality control plan.

M08.12.2 Before commissioning

- Check for correct oil level in gearboxes
- Ensure all HD bolts are torqued down correctly.
- Ensure the output shaft is rotating in the correct direction.
- The alignment and levelling of each assembly shall be checked, and the results shall be available for inspection by the Employer's Agent / Employer' Representative.
- The electrical functions and control shall be checked by a responsible inspector prior to attempting to start any motor on this Project.

M08.12.3 During Commissioning

- Ensure all oil pumps. Temperature, level, flow or pressure switches are functional
- Vibration testing and benchmarking.
- Ensure that there no oil leaks or visible damages to the gearbox housing.

## M08.13 BEFORE EXPIRY OF THE DEFECTS LIABILITY PERIOD

The Contractor has an obligation to visit the site every quarter to inspect for the correct operation of the installed equipment. A report after each visit shall be submitted in writing within 14 days.

Should the first oil change (based on the original equipment manufacturers recommendation) occurs before the issuing of the certificate of completion of the gearbox equipment to the Employer. The Contractor must carry out the first oil change in each gearbox. The drained oil shall be sieved and inspected for any contamination in the oil. In the event of any unusual contamination, (metal deposits etc) the Contractor, will take the necessary steps, to investigate the cause, and where required to replace and or repair the gearbox (s) at no cost to the employer.

## M08.14 EQUIPMENT TRAINING PROCEDURE

Training shall be provided by the Contractor (or specialist equipment suppliers) based on the supplied and approved operation and maintenance (O&M) manuals for all supplied equipment. This training shall be provided to the Operations and Mechanical including other support discipline staff of the Employer along with the Employer's Agent and/or Representatives. The duration of the training period shall be advised by the Contractor and agreed with the Employer's Agent and/or Representatives.

The training structure for the equipment and/or system should include both the theory and practical components of the equipment derived from the O&M manuals.

The preparation of the O&M manuals shall be based on the Johannesburg Water (SOC) Particular specification for Commissioning and Operation.

## M08.15 OPERATION AND MAINTENANCE MANUAL SUMMARY

The Contractor shall hand over to the Employer' Agent or Employer's Representative four sets (x2 hard copies and x2 electronic copies on non-locked USB) of the Operation and Maintenance Manual compiled for each installation not later than at the time of commissioning of the installation. These manuals are a prerequisite for final takeover of the plant. A copy of the Operating and Maintenance Manual for each equipment type 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.

The Operation and Maintenance Manual will contain the following:

- Brief description of the plant and installation.
- Concise operating instructions including start-up, operating, shutdown and troubleshooting procedures.
- Routine maintenance instruction this shall include failure mode analysis and preventative strategies.
- Precautionary measures, elementary trouble location, rectifying measures and emergency actions.
- Detailed information on equipment.
- Lists of spare parts including names and addresses of suppliers.
- Schematic Diagram and Drawings
- Risk, Health and Safety Assessment with proposed control measures.

## M08.16 DRAWINGS

The drawings included in the Tender Documents are the Employer's Agent or Employer's Representative. 's proposal for the plant layout. Should the Tenderer offer alternative layouts, they shall submit drawings with his Tender in order for it to be evaluated.

Before the Contractor carries out any work, he will submit detailed working drawings to be approved by the Employer's Agent or Employer's Representative. . Approval of these drawings does not relieve the Contractor from his responsibility for the correctness of the drawings.

## M08.17 INTERCHANGEABILITY

Where two or more similar types of equipment are required, these units will be identical in all respects.

All similar parts of items supplied will be interchangeable without any additional machining or fitting.

## M08.18 MEASUREMENT AND PAYMENT

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

Where separate payment is required for gearboxes and specified as such in the detail specifications, the following payment items shall be applicable:

M08.18.1 General

The following items shall, inter alia, be included in the rates:

- Supply of all design and pre-manufacture documentation and obtaining approval thereof;
- Procurement/manufacture of gearbox equipment with associated items and delivery to Site;
- Installation of gearbox equipment with associated items and testing;
- Services required during period of initial use before handover to the Employer.

Payment under scheduled items shall be made per complete installation as specified, electrical connections, etc and grouting, etc. Measurement and payment will distinguish between supply / delivery; installation and testing; and commissioning and trail operation of the equipment.

M08.18.2 Supply and Delivery to site with Documentation

| Item | Unit |
|---|---|
| Supply and delivery to site with documentation | No |

The tendered rates shall include for full compensation of all costs incurred in design, drawings, manufacture, supply, testing at the manufacturers works, inspections, quality control, quality assurance, factory acceptance testing, corrosion protection, packing, delivery to site including transportation costs and offloading on site including any cranage requirements. 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. Tender rate shall include any external oil filters, flow and pressure in their offer.

M08.18.3 Installation, Testing and Commissioning of the Gearbox Equipment

| Item | Unit |
|---|---|
| Installation, Testing and Commissioning of the Gearbox Equipment | No |

The tendered rates shall include for full compensation of all costs incurred in installation, site testing, setting into operation, the supply of O & M manuals, commissioning and maintenance during the warranty period of all equipment specified on Site including the provision of all labour, supervision, instruments, equipment, transport, on-site quality assurance and quality control, inspection and testing (including attendance at tests witnessed by the Employer's Agent / Employer' Representative), materials and Temporary Works necessary to completely install, test and commission and render fully operational gearbox equipment.

The rate shall also include the cost of the installation of all auxiliary equipment 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 until taken over by the Employer; the putting into service of the complete installation; remedial work and any other work as specified and necessary.

The rate shall also include for all preliminary testing and the provision of testing equipment therefore including all disruptions to installation caused by such testing.

Payment will only be effected after full compliance of the equipment items with this Section and associated documentation has been approved by the Employer's Agent / Employer' Representative

The Contractor shall include in the Tendered rate for straining of the gearbox oil after 600 hours of initial operation. The Contractor shall furnish the Employer's Agent / Employer' Representative with a report recording any irregularities when cleaning the sieves after straining.

M08.18.4 Trial Operations

| Item | Unit |
|---|---|
| Trial Operations | No |

This specification allows for a number of calendar days within which the system Trial Operation can be completed after completion of commissioning process. The Contractor shall programme and price for providing full technical and operational support during trail operation.

M08.18.5 Employer's Operator Training

| Item | Unit |
|---|---|
| Training | No |

Payment for Training of the Employer's Operational Staff will be made under this Section as set out in project specification or agreed with the Employer's Agent / Employer' Representative. The lump sum shall be inclusive of all costs associated with the training programme and on-site training of personnel.

M08.18.6 Spares

| Item | Unit |
|---|---|
| Spares | No |

The cost of spares, considered to be necessary by the Contractor other than spares required

by the Employer, delivered to Site and handed over will be paid as a lump sum. A Spare Part Schedule subject to approval by the Employer's Agent/ Employer's representative shall be submited before procurement of spares.

The actual lump sum to be paid shall be based on the unit rates priced in the Bill of Quantity for the actual spares ordered and supplied and the Employer is entitled to purchase all, some or none of the items listed. A provisional sum will be allocated in the Bill of Quantity for the complete list of spare parts as listed by the Contractor.

The rate tendered shall provide for the manufacture, supply, delivery to Site and handing over of the spares ordered and shall include permanent packing for long term storage. The spares shall be manufactured at the same time as the installed items.

# JOHANNESBURG WATER - MECHANICAL SPECIFICATIONS

## M16 MECHANICAL CONVEYOR EQUIPMENT

### CONTENTS

## M16.1 SCOPE

This specification covers the detailed design criteria, manufacture, supply, installation, test and commissioning of mechanical belt conveyor systems for the conveyance processed sludge at a wastewater treatment works.

## M16.2 INTERPRETATIONS

### M16.2.1 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 Bureau of 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 |

### M16.2.2 Standards

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

| | | |
|---|---|---|
| SANS 1168, 1313 and 1173 | : | Conveyor equipment |
| ISO 5048 | : | Design of Conveyors |
| ISO 5048 | : | Continuous mechanical handling equipment, Belt Conveyors with carrying idlers, Calculations of operating power and tensile forces |
| SABS 400: 1990 | : | National Building Regulations |
| BS 5304: 1988 | : | Code of practice for safeguarding of machinery |
| SABS 044 Part lll to lv: 1993 | : | Testing of welders, where applicable to the type of welding required |
| BS 292 Part 1: 1987 | : | Dimensions of ball bearings, cylindrical and spherical roller bearings |
| SIS 05 59 00 | : | Pictorial Surface Preparation Standards for Painting Steel Surface |

### M16.2.3 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

## M16.3 DESIGN OF CONVEYOR EQUIPMENT

### M16.3.1 General Design Parameters

Equipment shall be designed:

- To facilitate manufacture, inspection, installation, maintenance, cleaning and repairs.
- To ensure safe and satisfactory operation for an acceptable life expectation of 12 yearsunder the conditions prevailing at the site.
- To prevent undue stresses being produced by expansion due to temperature changes.
- To keep maintenance costs to a minimum.
- To facilitate inter-changeability of units and/or sub-parts throughout the contract works with regards to new equipment and equipment and/or sub-parts currently being used on the existing Johannesburg Water Sites.
- To operate without undue vibration and excessive noise. Maximum of 84dBA measured at 1metre from operating equipment.
- To comply with the legal requirements in respect of safety as well as the prevention of waterand air pollution.
- To satisfy any specific requirement contained in the statutory codes and legislation.
- To be suitable for operation 365 days per year, 24 hours per day under specified designconditions.
- As a minimum, components shall be selected with a service factor of 1.5 applied to the maximum operating power to be transmitted or otherwise as per the manufacturer's recommendations.

### M16.3.2 Belt Conveyors Design of Parameters

All plant and equipment shall be designed to operate satisfactory under atmospheric, ambient and other conditions specified in the Project Specifications.

All conveyors shall be designed for a surcharge angle of 0º and a troughing angle of 35º.

Design tonnage and maximum tonnage for belt conveyors shall be for a digested sludge cake of 18 – 22 % dewatered from a belt press process. No additional percentage shall be applied to the maximum feed tonnage to obtain a maximum design tonnage.

The maximum belt speed for a conveyor system shall be 0.75 m/s. Conveyors shall be capable of starting up under full load.

Inclination of conveyors shall be such that no runback of material occurs when the belt is loaded. The maximum inclination of any conveyor will be 14º.

Where transfer points are located outside a building then the transfer point is to be covered with a steel structure with roof sheeting and side sheeting to the top 50% of the side height to facilitate maintenance.

Gearboxes shall be standardised as far as is possible. Integral holdbacks shall be provided for conveyors where required. Speed reducers shall be of the helical geared, shaft-mounted types. Gear unit ratios shall be based on 4 pole, 50Hz motors with the minimum gear unit service factors being 2.0 based on installed motor power. Thermal and mechanical service factors shall be selected such that the gearbox shall be able to operate effectively without the risk of excessive heat build-up under all operating and ambient conditions specified.

A spare gearbox for each size of gearbox used in the conveyor system installation shall be supplied for storage in the client's stores.

All conveyor equipment will comply with SANS 1173. In the design of the equipment, special consideration shall be given to the standardisation of such parts as pulleys, gearboxes, hold- backs, couplings, shafts, bearings, electric motors, etc. reducing spare equipment to a minimum.

Belt widths, belt speeds and transfer points shall be designed with particular attention to the prevention of spillage. The maximum belt loading capacity shall be 85% of theoretical loading capacity.

M16.3.3 Starting Equipment

Accelerating and braking forces shall be taken into account in the calculations of belt tensions and counterweights. Starting equipment shall be designed that the belt is not over-stressed when started under a full load.

M16.3.4 Pulleys

The diameter of driving, tail and tripper pulleys as well as pulley shafts shall be as specified in SANS 1169 and shall be calculated for belt tensions between 100 - 150% of the maximum operating working tensions.

Pulley bearings shall be of the spherical roller bearing type with a L10h life rating of 100,000 hours. Pulleys shall be of the fabricated type, bearings and pulleys shall be standardised.

The driving and tail pulley shall be rubber lined after manufacture

M16.3.5 Idlers

Outer surfaces shall be smooth and corners chamfered. Each assembly of roll, shaft, bearings, seals, etc. shall be concentric. Rolls shall be no less than 125 mm outside diameter.

Bearings shall be high-grade anti-friction type and shall have a minimum L10h life rating of 100,000 hours. Idler bearings shall be of the life lubricated type. The bearings shall be protected by an effective sealing arrangement.

Troughing idler assemblies shall be of the three-roll type, in accordance with SANS 1313.

Parts exposed to dirt accumulation shall be designed and constructed for self-cleaning. Idler spacing shall comply with the spacing specified in SANS 1173. Return idlers shall be subject to the same basic design principles as the toughing idlers shall also apply to impact idlers.

At the loading points, closely spaced troughing idlers shall be used. The same provisions regarding bearings, etc. applicable to troughing idlers shall apply to impact idlers.

M16.3.6 Loading and Transfer Points

Loading and transfer points shall be designed with the primary objective of reducing belt wear to a minimum and to eliminate spillage. Feed presentation from belts to equipment in parallel via trouser leg chutes will be central to the chute to avoid preferential feed to the equipment.

Feed presentation to the belt shall be central to avoid training problems. Chutes shall be designed to utilise the most suitable and economical wear resistant materials available and shall be made large enough to facilitate access for maintenance purposes.

Chute valley angles shall be a minimum of 60º from vertical.

New chutes and hoppers shall be provided with replaceable liners. All surfaces to be lined shall be covered over the full surface area that may be subject to wear.

Sideliners shall be made of not less than 4.5 mm thick VRN 500 plate. Impact liners shall be made of no less than 4.5 mm thick VRN 500 plate.

The liners shall be sized to facilitate ease of replacement and inter-changeability.

Chutes shall be provided with inspection hatches to allow for ease of inspection and block chute detection if required.

M16.3.7 Take-ups

Gravity type take-ups shall be provided on all conveyors exceeding 40m between centers of the drive and tail pulley. Take-ups for conveyors shorter than 40m shall be screw type.

M16.3.8 Walkways and Gantries

Walkways shall be open grid flooring suitably corrosion protected and shall be 750mm wide. All inclined walkways on conveyor gantries shall be of sloped construction and not stepped. All conveyors are to be supplied with only one walkway.

Where weight meters are to be installed on conveyors, a straight section of at least 6m will be allowed for the installation.

Where conveyors interface with buildings at ground level, external access to the gantry shall be allowed for without having to enter the gantry through the building.

M16.3.9 Belting

Belting shall conform to SANS 1173. All splices shall be hot vulcanised.

M16.3.10 Belt Cleaning

Scorpio type (or similar approved by the Engineer) primary and secondary scrapers shall be used for belt cleaning of all conveyors.

M16.3.11 Return Belt Ploughs

All conveyors shall be fitted with Scorpio type (or similar approved by the Engineer) belt ploughs on return belts situated at the tail end.

M16.3.12 Skirts

Skirts shall be provided at all feed points.

M16.3.13 Deck Plates

Deck plates shall be provided at head, take-up and tail terminal points, including areas where conveyors cross access roads or buildings. All deck plates shall be of mild steel construction and painted to the paint specification requirements.

M16.3.14 Protection

Suitable protection shall be provided for slippage and in the event of an obstruction causing the conveyor operation to be interrupted. The protection provided shall interrupt the operation of the conveyor.

The protection device shall be of an Intelligent Motor Protection Relay type with built in phase angle protection. As a backup device a torque overload coupling with a limit switch shall be provided. The limit switch must have at least one SPDT contact or one normally open and one normally closed contact capable of switching at least 500mA at 230 Volts AC. The contractor shall provide details of the proposed system at the time of tendering.

All conveyor equipment shall have a trip switch operated by a switch wire on both sides of the conveyor for emergency tripping. The trip wire must be operational along the full length of the conveyor.

Suitable protection shall be provided for belt tracking/alignment. The contractor shall provide details of the proposed system at the time of tendering.

It is a requirement of this specification that the above malfunction in operation be reflected on the works SCADA system.

## M16.4 DESIGN SERVICE FACTORS

M16.4.1 Service Factors Specified

Where special requirements exist, these shall be stated in the individual equipment specifications/data sheets and design service factors shall exceed these values.

M16.4.2 Service Factors Unspecified

For continuous duty and heavy shock loads, service factors shall be individually considered and shall be approved. For medium duty and light shock loads, the following service factors shall apply. Consideration must also be given to the individual starting conditions in the selection of these components.

In selecting the capacity of electric motors, gears, gearboxes, power transmissions, couplings, pulleys, shafts, belts, etc., the design theoretical kilowatt ratings shall be increased by 20%.

In selecting the capacity of electric motors, couplings, shafts, vee-belts, and vee-belt drives, etc. for pumps, the designed theoretical kilowatt rating shall be increased by 25% to 50%, and for agitators (not stirrers) by 50%, to allow for possible overloading produced by pumps delivering larger quantities or at specific gravities higher than specified by the process requirement.

The factors of 25% to 50% and 50% shall be additional to the design factors used to obtain the theoretical kilowatt rating.

M16.4.3 Overload Capacities

Machinery and equipment, excluding motors, shall be designed to withstand a starting overload based on a minimum of 100% momentary overload, 50% overload allowance for 15 minutes and 25% overload allowance for periods not exceeding 2 hours. Refer to individual equipment specifications for variations.

M16.4.4 Transmission

Chain drives shall be in accordance with BS 228: 1984 – Transmission Roller Chains, Chain Wheels and Cutters.

Sufficient take-up allowance shall be provided on the motor mounting to take up two full chain pitches. Where take-up allowance is not possible due to fixed shaft centres, an adjustable chain wheel idler shall be incorporated.

All chain drives shall be adequately guarded and lubricated.

Unless otherwise specified, V-belt drives shall be standard sections and of the Space-Saver type. Belts shall be furnished in matched sets. Sheaves shall be accurately balanced and fitted with keyed ‘Taper-Lock’ bushings.

Drive motors shall be mounted on slide or pivoted bases allowing sufficient adjustment for correct belt tensioning according to the manufacturer’s requirements. Bases shall incorporate jack screws with lock nuts. All V-belt drives shall be adequately guarded.

***Gearboxes***

Gearing shall be in accordance with the appropriate AGMA standards as revised. All gearing shall be machine cut to high commercial grade and shall be suitably heat treated before final machining.

Gearing not enclosed in an oil bath shall be adequately guarded and provision shall be made for safe lubrication.

Speed reduction units shall be of approved design and manufacture. Allowance for efficiency, cooling and lubrication shall conform to the manufacturer's recommendations.

Gearboxes shall be of rigid construction manufactured either from cast steel or fabricated from mild steel plate.

Gearboxes shall be dustproof and equipped with inspection covers, drain and filler plugs, breathers with suitable filters, oil level indicators or dip sticks and lifting lugs as required.

Fabricated gearboxes shall be guaranteed against distortion when in service.

Foot mounted gearboxes shall be assembled together with the prime mover on a common baseplate and accurately doweled in position. Shaft mounted gearboxes shall be mounted according to the manufacturer's recommendations.

**NOTE: A spare gearbox for each size of gearbox used in the conveyor system installation shall be supplied for storage in the client's stores.**

All rotating equipment shall be clearly marked with an arrow showing the direction of rotation.

***Bearings***

Where required by design considerations, well lubricated non-ferrous bushings and bearings may be used.

Where phosphor bronze bearings are used the quality shall be to SAE 64 or equivalent. The supplier shall be required to provide details of specification number and analysis of metals used. This requirement shall also apply to the use of white metal.

Self-lubricating graphite or compound bearings shall not be used unless specifically requested.

For heavy duty and continuous service, Plummer blocks shall be anti-friction spherical roller type with split housing rated to suite the application. All Plummer blocks shall be fully self- aligning with one fixed and one floating type for each shaft assembly. With parallel shafts, inner ring adapter sleeves may be used.

For lighter duty, 80mm diameter and less, ball bearing Plummer blocks may be used.

Unless otherwise specified, the basic rated life for all anti-friction bearings shall be 75,000 hours

(L10h as defined by SKF).

Plummer blocks shall be mounted on accurately machined sole plates equipped with lugs and jack screws with lock nuts for proper horizontal alignment.

All Plummer blocks shall be installed such that the loads pass through the base and not the cap. Deviations from this arrangement for practical reasons shall be subject to approval and accompanied by design calculations.

Bearing housings shall be of cast steel, good quality cast iron or fabricated to specification and accurately machined where necessary. Housings shall be mounted on machined surfaces and located and fixed by permanent devices.

Design allowance shall be made for keyways and combined bending and torsion stress. Suitable fillet radii shall be provided at changes in diameter and shaft ends shall be chamfered. Changes in diameter and keyways shall not coincide.

Light duty shafting shall be hot rolled polished mild steel or cold rolled mild steel. Cold rolled shafting shall be subject to approval.

All shafts shall be metric and shall be supplied with key seats and keys or feathers in accordance with BS 4235 Part 1: 1986 unless a fastening method other than by key is used. Any such proposed fastenings shall be submitted to the responsible Engineer together with design calculations for approval.

All couplings shall be fitted with a removable guard unless the machine is already guarded in such a manner as to make a separate guard unnecessary.

Brakes shall be adequately sized for the load characteristics and heat dissipation.

## M16.5 LUBRICATION

Lubricants and lubrication fittings shall be in accordance with the following standards:-

- SANS 053:1972 : Viscosity Classification of Industrial Lubricating Oils
- SANS 344:1974 : Calcium Base Lubricating Grease
- SANS 351:1974 : Sodium Base Lubricating Grease
- SANS 406:1974 : Lithium Base Lubricating Grease
- SANS 1014:1974 : Multi-Purpose Lubricating Grease
- BS 1486:1982 : Lubricating Nipples Parts 1 & 2
- BS 1399 Parts 1 to 3:1970 : Rotary Shaft Oil Seal Units

All equipment supplies shall submit a specification of the lubrication requirements for their equipment, which shall include the following:-

(i) Approximate quantities required for the initial fill.

(ii) The expected rate of consumption of the lubricant and the recommended intervals for acomplete change of lubricant.

(iii) A lubrication chart indicating all lubricating points, periods for lubrication, oil and filterchanges.

(iv) A list of South African based suppliers of the recommended lubricants.

All Plummer blocks shall be sealed against the ingress of moisture or dirt by means of a double.

lip seal or a Labyrinth seal.

Where wet or extremely dirty conditions occur, a flinger shall be used in addition to seals.

For vertical shafts, a flinger shall be installed above the upper bearing seal. Lubrication of equipment, such as gearboxes, compressors, etc. shall conform to the recommendation of the equipment manufacturer.

All equipment, which normally contains lubricant and is dispatched without such lubricant, shall be sprayed internally with a suitable moisture inhibitor to prevent

deterioration during transport and storage. All machinery and equipment shall be checked for cleanliness and lubrication prior to testing or start-up.

Any special requirements for flushing and cleaning shall be stated by the manufacturer.

Such equipment shall carry clear legible tags indicating that there is no lubricant contained therein.

Gearing and chain drives shall have fully enclosed oil bath lubrication except where a low peripheral velocity requires grease lubrication. Where the peripheral velocity of gearing exceeds 750 m/min, forced feed lubrication shall be provided.

All lubrication points shall be easily accessible from the normal maintenance/operating zones of the equipment. If necessary, lubrication points shall be extended by means of pipes or tubing to a location that is both convenient and safe for access during normal equipment operation.

## M16.6 BASEPLATES

Baseplates shall be designed to prevent undue deflection or failure under any conditions of loading likely to be encountered.

Baseplates shall be rigidly constructed, generally of cast steel or fabricated steel. For light duty, cast iron bases may be used.

Where practical, the prime mover and the gears, bearings, or other equipment shall be mounted on a common base plate.

Mounting pads and base plate feet shall be machined true and parallel. Allowance shall be made on the prime mover mounting pad for 5 mm maximum and 1 mm minimum shimming.

Where baseplates are fabricated they must be stress relieved before machining.

Baseplates shall incorporate jack screws with lock nuts to assist with aligning of the prime mover in relation to the gearbox, bearings or other equipment.

## M16.7 PLATEWORK

Where bins, chutes, liners and skirts are supplied as an integral part of mechanical equipment they shall be designed such that:-

(a) They allow for the fast, smooth flow of material and avoid abrupt changes of directionwhich invite material build-up and subsequent plugging.

(b) They have a minimum of throat constrictions.

(c) They are firmly supported, manufactured from a minimum of 6 mm plate to SANS 1431Gr. 300 WA and are suitably stiffened and supported to deal with loads and forces imposed on them.

(d) Their valley angles are conservative and suitable for the materials handled.

(e) Falling material does not impact directly on sensitive receiving equipment but rather on the sloping bottom of chutes.

(f) Chutes and hoppers shall be provided with bolted flange connections in order to

simplify installation and maintenance.

(g) All nozzles to be fabricated from scheduled piping, wall thickness to match plate work thickness. Flanges will be specified on the relative data sheets.

(h) All plate work and chutes to be trial assembled and match marked by the fabricator before delivery to site.

(i) Bins, chutes, etc. and support structure (where required) shall be designed for a maximum static load when all full of mineral sand or slurry at a design bulk density as specified. Subassemblies or components shall be fitted with lifting lugs designed with adequate safety factors to lift the subassembly or components. Travelling members to befitted (where required) to avoid distortion. Fabricator to supply spreader bars for components requiring such.

(j) Where equipment such as scrapers, rappers and squeezers, spray units, etc. are housed within the chutes, they must be able to be removed without disturbing the main assembly.

(k) Where material is in contact with the chutes, suitable liner plates shall be installed which shall be fastened by means of nib head countersunk bolts and waterproofed where necessary. Such liner plates shall be designed to allow for interchange ability and not to exceed 30 kg in mass.

(l) Equipment subject to abrasive slurry particle contact shall be protected against such abrasive materials by a minimum 6 mm thick natural rubber lining. All lining is to be returned around flange faces for sealing. Rubber lining shall be done in accordance with BS 6375-5: 1985 and SANS 1198: 1978.

(m) The maximum deflection of any plate shall be less than 1 mm in 300 mm.

*UNLESS OTHERWISE STATED ON THE DRAWING, LINER PLATES SHALL BE ARRANGEDIN A BRICK PATTERN WITH A GAP OF NOT MORE THAN ONE LINERPLATE THICKNESS OR 10 mm (WHICHEVER IS THE LEAST) BETWEEN ADJACENT LINERS.*

## M16.8 DUCTING AND SHEET METALWORK (DUST COLLECTION AND VENTILATION)

Ducting, flanges, gates, etc. shall conform to details shown by the Industrial Ventilation Manual of Recommended Practice issued by the American Conference of Governmental Industrial Hygienists.

Ducting shall be checked after fabrication to ensure that:-

- No pin-holes or slag inclusions which would cause leaks during service are present in anywelds.
- Inside diameters are to drawing, and ducts are concentric within 5 mm on diameter.
- Supports shall be designed and spaced so that sagging does not occur, allowing for anormal dust load, and shall be structurally adequate allowing for a dust filled plugged duct.
- After erection of ducting and the installation of dust extraction units, the complete system shall be tested, balanced and blast gates locked or tack-welded in place.
- All ducting and bends shall be manufactured from mild steel with a minimum

thickness of3 mm.

- All ducting shall have flanges welded to each end of each piece; such flanges shall be of asuitable thickness for the diameter but shall not be less than 3 mm.
- All flanged connections shall be complete with matching gaskets made from material suitablefor the needs of the process.

## M16.9 WIRE ROPE, CHAINS AND FITTINGS

All ropes, whether fixed suspension or for general use, shall comply with all relevant Acts and Statutory Regulations.

Hoist ropes and fittings shall comply with the regulations of the Mines and Works Act and the Machinery and Occupational Safety Act of the Republic of South Africa.

Rope fittings shall be securely attached to the ropes, preferably with terminal splicing standard spelter fittings or approved swaged fittings. All rope slings shall be tested to twice the required working strength. Spelter fittings shall not be used for high temperature applications. Where rope clips are specified, a minimum of three rope clips and a thimble shall be correctly fitted to make the connection.

All lifting tackle shall be supplied with test certificates.

Rope slings for general use shall be fitted with a metal tag indicating the safe working load.

Sockets, thimbles, rigging screws, stretching screws, eyebolts, etc., shall have a safe working load of no less than that for the attached rope or chain. Wire rope and fittings that are a stationary part of a machine, and fixed guys shall be galvanized.

Chains shall comply with all relevant Acts and Statutory Regulations and shall be stamped indicating the safe working load.

## M16.10 FASTENERS

When bolting onto parallel surfaces, all nuts shall be fitted with plain parallel washers except where the machinery is subject to vibration or movement. Then, springs washers, nylon insert locknuts or tack welding shall be used as indicated by the design. Adjustable nuts (e.g. bearing take-up), castellated nuts with split cotter pins shall be used. For thread diameters of 10 mm and under, the use of tab washers is permitted.

High strength friction grip bolts shall be installed in accordance with:-

- SANS 094:1982 Bolted Friction-Grip Joints
- BS 3294 Part 1:1960 Structural Steelwork (Metric Units)

Precision bolts and nuts shall be supplied in accordance with:-

- SANS 136:1985 and Nuts (MetricUnits) ISO Metric Precision Hexagon-Head Bolts, Screws
- SANS 646:1962 Precision Bolts, Screws and Nuts

Black bolts and nuts shall be supplied in accordance with:-

- SANS 135:1985 ISO Metric Black Bolts, Screws and Nuts Hexagon and Square (Metric Units)
- SANS 1143:1977 Mushroom and Countersunk Head Bolts and Nuts

Washers shall be supplied in accordance with SANS 1149 – Flat and Tapered Steel Washers. Black bolts shall be installed in accordance with the following assembly requirements:-

(a) All bolt heads and nuts shall make contact, bearing on parallel plan surfaces perpendicular to the bolt axis.

(b) A tapered washer shall be correctly positioned under the bolt head or the nut whenever the surfaces contacted are not parallel and perpendicular to the bolt axis. It shall be usedagainst the sloping surface.

(c) A flat washer or a tapered washer shall be used under the bolt head or nut, whichever is to be rotated during tightening operations. Washers shall be of adequate size and thickness to prevent their distortion, for any reason, during tightening.

(d) After assembly and proper tightening, bolts shall project through nuts for a minimum distance of three (3) full threads.

When assembled, all HSFG bolted joint surfaces shall be free of dirt, loose scale, burrs and other defects that would prevent solid seating of the parts. All contact surfaces shall be free of oil, paint and lacquer or galvanising.

All HSFG bolts shall be torqued using load-indicating washers of an approved type to ensure correct tension is achieved.

Plate liners, unless otherwise specified, shall be fitted with nib-headed countersunk bolts, and spring washers shall be used under the nuts.

## M16.11 OPERATION AND MAINTENANCE

Operation and maintenance of mechanical equipment shall be carried out strictly in accordance with the Equipment Manufacturer's recommendations.

The Equipment Manufacturer shall supply Operation and Maintenance instructions which shall include full details and recommended frequencies of periodic maintenance checks, adjustments, running clearances and lubrication requirements.

## M16.12 PLANT LAYOUT

The following criteria shall apply for plant layouts:-

Buildings and conveyor transfer towers shall be positioned to make use of the natural slope of the contours at the site where possible, i.e. to minimise building heights and conveyor lifts.

Major mechanical equipment shall be positioned to facilitate removal with overhead cranes in the event of breakdown or maintenance. For smaller equipment, or where

equipment cannot be reached by cranes, due to the nature of the plant layout, hoists and crawl beams will be used for maintenance purposes.

All sump pumps shall be suitably guarded for personal safety, as well as protection against the ingress of large objects.

The layout of the plant shall allow sufficient access for personnel engaged in operational and maintenance duties.

M16.12.1 Platforms and walkways

Platforms and walkways shall be provided wherever access is required for regular inspection, lubrication or operation of machinery or equipment.

Walkways shall be clear 600 mm wide as a minimum.

Access to all valves, instruments and equipment lubrication points will be provided either from the ground floor or from a platform.

A minimum clearance of 2100mm shall be provided under equipment and steelwork.

Stairways shall be provided rather than ladders except in extreme cases where space is not available or usage will be very infrequent.

Stairway slope shall be between 38º and 42º, maximum slope.

A walkway will be provided along one side of each belt conveyor. Access ladders shall be provided to all crane bridges.

Vendors to specify maintenance clearance requirements for equipment supplied, these clearances to be incorporated into layouts.

## M16.13 ROTATING EQUIPMENT

The direction of rotation of all rotating non-reversing equipment will be clearly and indelibly marked on the casing or nameplate.

## M16.14 STAIRWAYS AND PLATFORMS

Stairways, platforms, access ladders and landings shall be provided as necessary and shall conform to relevant Building Regulations, or International Design Standard. Stairway slope shall be between 38º and 42º maximum.

## M16.15 HANDRAILS

Handrails shall be provided around all permanent openings, the edges of elevated platformsand access ways abutting edges to all internal side wall sheeting and walls, and to each stairway stringer and where required for safety.

## M16.16 EQUIPMENT ERECTION

All equipment shall be erected in accordance with the requirements of the Mechanical Erection Specification, and in accordance with Equipment Manufacturer's Installation Instructions.

## M16.17 EQUIPMENT NAME PLATES

All equipment shall have permanent nameplates of material suitable for corrosive conditions on which the equipment number and description shall be clearly marked. This will facilitate equipment identification during construction and commissioning.

## M16.18 OVERHEAD CRANES, LIFTING BEAMS AND HOISTS

Overhead cranes shall be sized for maintenance duties as opposed to installation duties. The overhead cranes will be sized for the heaviest regular maintenance lift required.

Lifting beams, hoists and cranes shall be provided for ease of servicing and removal of equipment. Adequate space shall be provided for rigging, removal and set down. Lifting beams and crane rails shall be designed to the relevant standards and test certificates shall be provided. Beams shall be stamped with the appropriate SWL. Lifting beams shall be equipped with a trolley from which to attach the hoists.

## M16.19 SAFETY

### M16.19.1 General

All mechanical designs shall ensure that the relevant regulatory and statuary requirements aremet.

### M16.19.2 Guards

All rotating parts that are accessible shall be guarded. Shield guards or guard railing shall be provided at all belts, pulleys, gears, or moving parts.

Handrails, toe boards, and nonslip surfaces shall be provided on all elevated platforms, walkways, stairways and ramps.

All nip points shall be adequately guarded to prevent injuries

### M16.19.3 Signs

Signs shall be provided to alert all personnel of the need for protective clothing such as steel caped boots, hard hats, and safety glasses.

Signs shall be provided where a specific exists, such as live conductors, high noise levels, low head clearance, trip hazards, hot surface prevails.

### M16.19.4 Clothing

Special footwear, masks and clothing for areas with high dust levels or surface area contamination shall be used.

Non-slip footwear, gloves, helmets, face protection, leggings and other protective equipment, as necessary, for work near high temperature materials shall be used.

Where there is a risk of flying chips or sparks, or where intense light is generated, eye protection shall be used.

Protective clothing and goggles shall be used in areas where highly corrosive materials are handled.

Emergency eyewash stations and safety showers shall be installed as required.

The mechanical design shall ensure that priority is given to all project safety and ergonomic aspects, including plant layout, constructability, maintainability and operability.

## M16.20 SPARES AND TOOLS

The Tenderer must submit on the appropriate schedule a priced list of spare parts which nit is recommended should be kept by the water treatment plant for maintenance of the plant. Spares which the Management decides to order must be manufactured simultaneously with the rest of the equipment and be subject to the same tests for dimensions, tolerances, strength, etc. All spares must be packed separately and the cases appropriately marked. All spares must be new and unused.

A full range of spares must be kept available for not less than 15 years.

Tenderers must submit a provisional price (where applicable) for a complete set of spanners, keys and tools required for the operation, adjustment and overhaul of the plant supplied. All spanners, keys and tools shall be new and unused.

## M16.21 PROOF OF MAINTENANCE

The period of maintenance will extend over a period of 12 months calculated from the Completion as defined in the Appendix. However, should a portion or all of the plant and equipment fail / or require rectification during this period, the Engineer reserves the right to extend the Period of Maintenance in respect of such portion or all of the plant and equipment for a further period of not more than 12 months calculated from the date of Commissioning of such plant and equipment after rectification

## M16.22 METAL PREPARATION AND CORROSION PROTECTION

Refer to Particular Specification G02: Corrosion Protection

## M16.23 COLOUR CODES

The standard final colour codes for equipment supplied under this Contract shall be in accordance with Particular Specification G01: Colour Codes.

## M16.24 QUALITY MANAGEMENT (QM) AND QUALITY ASSURANCE

QM shall be categorised as ‘critical and major’ for this section of the Project.

### M16.24.1 Manufacture

Tenderers shall submit with their tender a detailed Project Quality Plan, stating how they control the flow of paperwork from commencement of the Project through final handover

to the Client, a sample of their Quality Control Plan, (QCP) and Project Quality Plan, (PQP) both during the course of the Project, manufacture and finally, installation.

The successful Tenderer shall submit a QCP covering all aspects of the manufacturing process, indicating held points to allow the Engineer opportunities to evaluate the equipment for compliance to this specification.

All items of equipment shall be subject to inspections by the Engineer during design and manufacture per these QCP's.

In general, it is anticipated that this Project shall be in accordance with the relevant ISO 9000 requirements.

M16.24.2 Installation

The successful Tenderer shall submit a QCP covering all aspects of the installation of each item of equipment to be installed under this Project. The Engineer shall be afforded every opportunity to certain stages of completion of the installation to ascertain compliance with the Specifications and to witness the Contractor's site activities at the Engineer's discretion.

## M16.25 SYSTEM PERFORMANCE

M16.25.1 Works testing

Each item of equipment shall be subject to inspection and testing prior to despatch from the works. All performance test results shall be made available to the Engineer for verification or when the QCP's require intervention or hold points for inspection.

In the case of gearboxes, they shall be subject to testing under operating conditions for at least 12 hours on the test bed. All results shall be available for inspection

M16.25.2 Before commissioning

- Check for correct oil level in gearboxes and that motors are greased properly.
- Ensure all HD bolts are torqued down correctly.
- The alignment and levelling of each assembly shall be checked and the results shall be available for inspection by the Engineer.
- The electrical functions and control shall be checked by a responsible inspector prior to attempting to start any motor on this Project.

M16.25.3 After Initial Commissioning

- Ensure all oil pumps and flow or pressure switches are functional
- Ensure that all transfer points are operating satisfactory with no spillage.

M16.25.4 Before Expiry of the Defects Liability Period

The Engineer requires the Contractor to visit the site every quarter to inspect for the correct operation of the installed equipment. A report after each visit shall be submitted in writing.

## M16.26 MEASUREMENT AND PAYMENT

Payment under scheduled items shall be made per complete installation as specified, electrical connections, civil preparation, coring and grouting, etc. Measurement and payment will distinguish between supply / delivery and installation / commissioning of the conveyor equipment required.

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.

# JOHANNESBURG WATER

# PARTICULAR MECHANICAL SPECIFICATIONS

## M18 MECHANICAL CENTRIFUGAL PUMPS

CONTENTS

# M18 MECHANICAL CENTRIFUGAL PUMPS

## M18.1 SCOPE

This specification covers the detailed design parameters, manufacture, supply, installation, test and commissioning of Centrifugal Pumps. The Specification shall be read in conjunction with that of the Project Specification.

## M18.2 INTERPRETATIONS

M18.2.1 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 |
| AGMA | : | American Gear Manufactures Association |

M18.2.2 Standards

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

| | | |
|---|---|---|
| SANS 10400 | : | National Building Regulations |
| BS 5304 | : | Code of practice for safeguarding of machinery |
| SANS 9096-1: 1994 | : | Testing of welders, where applicable to the type of welding required |
| BS 292 Part 1: 1987 | : | Dimensions of ball bearings, cylindrical and spherical roller bearings |
| SANS 10162-4 | : | Structural use of Steel Part 4: The design of cold-formed stainless steel structural |
| SANS 1044-3 | : | Welding Part 3: The fusion of steel (including stainless steel): Tests for the approval of welding procedures |
| SANS 10044-4 | : | 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 10064 | : | The preparation of steel surfaces for coating |
| SANS 10102-4 | : | Selection of pipes for buried pipelines Part 1: General Provisions |

| | | |
|---|---|---|
| SANS 10104 | : | Hand railing and balustrading (safety aspects) |
| SANS 10111-2-1 | : | Engineering Drawing Part 1: General principles Engineering Drawing Part 2: Geometric Tolerancing Section 1 |
| SANS 10341 | : | Installation and maintenance of bearings – General guidelines |
| 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 |
| BS EN ISO 14847:1999 | : | Rotary positive displacement pumps. Technical requirements |
| BS EN 734:1995 | : | Pumps and pump units for liquids. Common safety requirements |
| BS EN 12162:2001 | : | Liquid pumps. Safety requirements. Procedure for hydrostatic testing |
| BS EN 60041:1995 | : | Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines. |
| BS EN 60994:1993 | : | Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines) |
| BS EN 22858:1993 | : | End-suction centrifugal pumps (rating 16 bar). Designation, nominal duty point and dimensions |
| BS EN 23661:1993 | : | End-suction centrifugal pumps. Baseplate and installation dimensions |
| BS EN 733:1995 | : | End-suction centrifugal pumps, rating with 10 bar with bearing bracket. Nominal duty point, main dimensions, designation system |
| SANS 1123 | : | Pipe Flanges |
| ISO 281 | : | Rolling bearings -- Dynamic load ratings and rating life |
| BS 4999 | : | General requirements for rotating electrical machines. Specification for standard dimensions |
| SIS 05 59 00 | : | Pictorial Surface Preparation Standards for Painting Steel Surface |
| BS 5316 Part 2 | : | Pump test codes |

M18.2.3 General Requirements

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

M08: Particular Specification for Gearboxes

M21: Particular Specification for Pressure Pipework

E01: Particular Specification for Electric Motors

G01: Particular Specification for Colour Codes

G02: Particular Specification for Corrosion Protection

Automation and Control Design Standards Volume 8: Flow Measurement

Automation and Control Design Standards Volume 11: Temperature Measurement

## M18.3 PUMPS

M18.3.1 Design Parameters

Centrifugal pumps shall have stable non-overloading characteristics and the shaft speed shall not exceed 1500 rpm.

The pumps shall be of the highest quality and shall be suitable for continuous operation over long periods with a minimum amount of maintenance at high-sustained efficiency.

In all applications, with exception of clear water pumps, non-clogging impellers must be used. Pumps shall be designed as to remove the impeller cover without moving the pump, pipe work or motor. Each pump shall have a drip tray with a 20 mm diameter galvanised drain pipe to the nearest drainage point.

The pump design shall make adequate provision for the balancing of residual axial thrust. Pumps shall be supplied complete with suction and delivery pressure gauges complete with air-bleed and isolating cocks, shaft couplings and guards, gland leakage piping, base plates, foundation bolts and other necessary equipment.

Detailed performance curves for the pump type shall be provided at the time of tendering.

The curves shall indicate the following:

- Head (metres) vs. flow (litres/second) - 0% to 120% duty flow
- Power absorbed in kW - 50% to 120% of duty flow
- Pump efficiency – 0% to 120% duty flow
- Net positive suction head curves required by the pumps at the specified flow rate.

The efficiency curve shall be flat over a wide range in order to provide efficient working at various pump operating conditions.

Pumps shall be able to operate without cavitation over a full range as specified without throttling. Pumps are required to operate continuously at an ambient temperature of 40°C.

The following quantities shall be guaranteed by the Contractor:

- Minimum flow rate of the pump at the specified total head.
- Maximum power demand at the specified total head.
- Minimum efficiency at the specified total head.
- Maximum net positive suction head required by the pump at the specified flow rate.

*Multiple Units*

Unless specified arrangements incorporating multiple units coupled in series in order to achieve the duty specified for each complete pump set shall only be offered as an alternative.

The mechanical equipment to be supplied under this Contract shall be installed, tested and commissioned on concrete structures, constructed by others, to the dimensions indicated on the construction detail drawings.

M18.3.2 Pump Casing

The pump casings shall be manufactured from cast iron or cast steel depending on the stresses corresponding to the required test pressures. Unless otherwise stated the dimensions and drilling of the suction and discharge flanges shall be SANS 1123 to the design pressures as specified but with a minimum of 10 Bar.

The pressure rating of the flanges shall at least be equal to the maximum static pressure plus the pump shut-off pressure.

Casings shall be designed for not less than the following working pressures or 1.5 times the actual working total discharge pressure, whichever is the greater.

| | | |
|---|---|---|
| Horizontal Split casing | : | 1000 kPa |
| End Suction type | : | 1000 kPa |
| Vertical Split Casing | : | 600 kPa |
| Multistage | : | 1.5 times working pressure. |

*End suction pumps*

End suction pumps are arranged with a central suction connection and a tangential discharge connection. Both these connections shall be suitably flanged.

The casings shall be split at right angles to the shaft to enable the easy withdrawal of the impeller assembly. The volute casing shall be preferably a separate casing from the pump bearing and base assembly, but bolted and spigoted thereto.

For end suction pumps of more than 5.5l/s and not more than 70 l/s capacity, the casing shall be arranged to have a removable casing cover on the motor side so that the pump may be dismantled without disturbing the suction or delivery piping.

*Horizontally split casings*

These shall be double entry type casings, which are split on the axial centreline. The suction and delivery branches must be cast integral with the part of the pump incorporating the pump base.

The other half of the casing must be easily removable for an internal examination of the pump without the necessity of disturbing either the suction or delivery pipe work or rotating assembly.

The casing shall be fitted with suitable renewable corrosion resisting wearing rings and bushes in all positions where fine clearances require to be maintained. Wearing rings shall be made of high quality bronze or stainless steel.

All casings must be fitted with ceramic or stainless steel neck rings where fine clearances must be maintained between stationary and moving parts, to suit the fluid pumped.

*Semi-concentric back pull-out design casings*

The pump casing shall be semi-concentric back pull-out design, with the first half of the circumference after the pump outlet being cylindrical. The remaining circumference shall spiral outwards towards the flanged centreline discharge. The casing shall be manufactured from cast iron.

All casings shall be provided with the following tapping's as a minimum requirement:-

- One suction pressure gauge tapping
- One discharge pressure gauge tapping
- One bleeder cock tapping
- One filling point tapping
- Suitable tapping or, where possible, internal drilling to provide water for the glands.

All casings shall be heavily ribbed and strengthened as necessary to resist hydraulic forces, and internal passages shall be smoothly finished to minimize hydraulic forces.

M18.3.3 Pump Impeller

Each impeller after machining and dressing shall be independently statically balanced and the complete rotating assembly with coupling shall be dynamically balanced.

All impellers shall be of a non over loading design.

Impellers shall be securely keyed and fixed to the shaft by means of suitable shaft nuts and locking sleeves.

All bolting devices must be securely locked so that they cannot accidentally come loose. Bolting devices shall be made of corrosion resistant materials.

M18.3.4 Pump Shaft

The pump shafts shall be of sufficient dimension in order to avoid excessive torsional or bending stresses and deflection.

The pump shaft shall be designed so that the critical speed of the rotating assembly is well above the maximum pump operating speed.

The impeller shall be secured to the shaft in such a way that it can be readily removed without any damage to the impeller and the shaft.

The shafts shall be protected by replaceable sleeves manufactured from non-corrosive material. The shaft shall be manufactured from stainless steel.

M18.3.5 Shaft Coupling

The pump and motor shall be connected by a flexible coupling in such a way as to prevent them from uncoupling regardless of which way the impeller may be rotating.

The coupling shall accommodate small axial, lateral and angular misalignments without imposing undue stresses on the shaft and bearings. The coupling shall be enclosed in a stationery solid-plate guard to the Engineers satisfaction.

## M18.4 BEARINGS

All bearings shall be suitable for shaft rotation in both directions. All bearings shall be designed for a life of at least 100 000 hours at an (L10) rating. Bearings for the output shaft shall be designed to withstand bending, up thrust, down pull, thermal expansion and radial loads imposed by the impeller.

The rotating assembly shall be positively located in the axial direction and thrust bearings will therefore be required.

For ease of lubrication all bearing grease pipes must be piped to grease nipples on the outer cover of the pump support frame.

### M18.4.1 Bearing Housing

The bearing housing shall be manufactured from cast iron and shall be oil bath lubricated. Oil level sight glasses shall be provided with level markers for running and filling minimum and maximum positions respectively. These shall be arranged for easy viewing and shall take into account the angle of mounting.

The bearing housing and motor stool design shall provide accurate, self-aligning mounting for the flanged electric motor.

### M18.4.2 Lubrication

In the case where oil lubrication is required, adequate provision shall be made for the cooling of the oil. The bearings shall be required to operate at temperatures no higher than 60°C.

Oil reservoirs of sufficient capacity shall be fitted with easily accessible oil level indicators, which are to be clearly marked in order to indicate the oil standing and running levels.

## M18.5 GLANDS AND SEALS

Low pressure glands of the stuffing box pattern shall allow repacking without having to dismantle the pump.

If mechanical seals are offered they shall be manufactured from 316 SS to prevent the pump from leaking and shall be cartridge-type seals with O-rings and silicon carbide or tungsten carbide faces.

The cartridge seal shall be pre-assembled and pre-tested, requiring no adjustments and settings from the installer. Any springs required to push the seal faces together shall be shielded from the fluid that is to be pumped. The cartridge shall include a heat treated sleeve and an iron seal gland.

Full details of the seals and glands indicating the materials, finishes, clearances etc. shall be submitted with the Tender.

A spare mechanical seal for each size and type shall be supplied.

## M18.6 VENT COCKS

Vent cocks shall be fitted at all high points to the pump casing. These cocks shall be adequately sized in order to allow the trapped air to be released freely.

An automatic air vent shall be fitted to each pump casing if specified. This device shall be suitable for the remote operation of an indicator to show the open and closed positions of the air vent.

## M18.7 BASE PLATE

The base plate of the pump and motor shall be rigid. The pump and motor shall be situated on the upper face of each base plate, which shall be machined flat and smooth to ensure that the pump and motor are bedded properly without the use of spacers.

The pump/motor base plate shall be completely aligned prior to grouting and provision shall be made to grout within the base plate itself to facilitate vibration-free operation.

Base plates which have a mass greater than 200 kg shall have two jacking bolts at right angles with a lock nut at every corner of the unit.

## M18.8 DRIVE UNIT

The pump shall be driven by a fixed electric speed motor and a speed reducer. Refer to Particular Specification E01: Electric Motors for a detailed specification for Electric motors.

### M18.8.1 Gearbox / Motor Coupling

The coupling shall be fully rated to transmit the motor full load power and tested to prove the above features together with static and dynamic balance. The motor shall be coupled to the gearbox input shaft with either a V-belt or a flexible coupling. V-belts and couplings are to be provided with protective cover guards.

## M18.9 GEARBOX

Refer to M08: Volume M08: Mechanical Specification for Gearboxes.

## M18.10 MONITORING DEVICES

Full detail of all monitoring devices offered must be submitted with the Tender.

## M18.11 PRESSURE GAUGES

Pressure gauges shall be fitted with an isolating cock, shall be vibration and shock resistant and shall be calibrated to read with an accuracy of ±1% of the indicated pressure. Three 20mm minimum diameter ball valves shall be employed to zero the gauge, to isolate it and to vent to atmosphere. A chemical seal shall be used to insulate the gauge from the media being measured.

The faceplate diameters of the pressure gauges shall be at least 100 mm. The gauges shall indicate the water pressure in kilopascal and shall have a range of a maximum of

50% higher than the normal maximum working pressure. All gauge glass must conform to internationally recognized standards. These standards include DIN 7081, BS 3463 and JIS B 8211.

A calibration certificate is to be provided with each pressure gauge.

## M18.12 TEMPERATURE DETECTORS

If required oil lubricated bearings and glands offered shall be fitted with temperature detectors. The temperature detectors shall be PT100 – RTD's

If grease lubricated bearings are offered, the Tenderer will indicate in his Tender if temperature detectors can in fact be used. If temperature detectors are not feasible, an alternative means of monitoring bearings must be offered.

## M18.13 NO-FLOW PROTECTION

(a) Each pump shall be protected against no flow by a flow meter installed in the discharge line from the pump.

## M18.14 INDICATOR ON AUTOMATIC AIR VENT

If an automatic air vent is required for the pump casing, it shall be fitted with an indicator to indicate the open and closed positions of the air vent. The air vent shall be suitable for remote operation and air vent control shall be mounted on the control panel inside the pump station.

## M18.15 GLAND LEAKAGE

If a gland leakage device is required in order to monitor the gland leakage it shall be supplied and fitted with adjustable alarm contacts designed to close when gland leakage rises to a pre-set value.

## M18.16 PIPEWORK

All suction and delivery pipes shall be connected to the pump casing by means of flexible connections. All flexible connections shall be installed as close to the pump's casings as possible, and in any event, shall be between the suction valve and the pump casing and delivery non-return valve and the pump casing. In all cases the flexible connection shall be in the section of piping of smallest diameter.

Double Victaulic joint are generally preferred for flexible connections, but approved re-enforced rubber bellow units are acceptable for low-pressure services.

All valves and pipework external to the pump casing and separated there from by means of flexible connections shall be securely anchored to prevent movement.

Refer to Particular Specification M21: Volume M21 Pressure Pipework for a detailed specification on pipework.

## M18.17 HOLDING DOWN BOLTS

The contractor shall be responsible for the supply of all necessary holding down bolts for the machines supplied by him/her. The holding down bolts shall be manufactured from 316 SS.

All bolts necessary for assembling all equipment shall be supplied by the contractor.

## M18.18 VIBRATION AND NOISE

The pumps as well as the motors will comply with the requirements of BS 4999. The Contractor may be requested by the Engineer to carry out vibration tests. The noise level shall not exceed 85 dBA at 1m.

## M18.19 CORROSION PROTECTION

Refer to Particular Specification G02: Corrosion Protection

## M18.20 DESIGNATION AND INFORMATION PLATES

Each pump shall be supplied with an information plate secured to the pump casing in a visible position indelibly marked with the following details:-

- Maker's name, pump type and serial number
- Year of manufacture
- Rated duty of pump in litres per second
- Head in metres at rated duty
- Pump speed in r/min
- Mass of completely assembled pump in kilogram

## M18.21 INTERCHANGEABILITY

Where two or more similar pump units are required, these units will be identical in all respects.

All similar parts of items supplied will be interchangeable without any additional machining or fitting.

## M18.22 RECOMMENDED SPARE PARTS

The Tenderer must submit details of spare parts recommended to be kept in store by the Employer with his Tender.

The detail will include a full description of the parts, part identification, number required, guaranteed delivery time and total price delivered to Site.

## M18.23 OPERATION AND MAINTENANCE MANUAL

The Contractor shall hand over to the Employer's Agent four sets of the Operation and Maintenance Manual compiled for each installation not later than at the time of commissioning of the installation. These manuals are a prerequisite for final take-over of the plant.

The Operation and Maintenance Manual will contain the following:

(i) Brief description of the plant and installation.

(j) Concise operating instructions.

(k) Routine maintenance instruction.

(l) Precautionary measures, elementary trouble location, rectifying measures and emergency actions.

(m) Detailed information on equipment.

(n) Lists of spare parts including names and addresses of suppliers.

## M18.24 DRAWINGS

The drawings included in the Tender Documents are the Engineer's proposal for the plant layout. Should the Tenderer offer alternative layouts, he shall submit drawings with his Tender in order for it to be evaluated.

Before the Contractor carries out any work, he will submit detailed working drawings to be approved by the Employer's Agent. Approval of these drawings does not relieve the Contractor from his responsibility for the correctness of the drawings.

## M18.25 INSTALLATION

The pump and motor shall be aligned to within ± 0.025 mm full indicator movement on dial gauge, regardless of the coupling type. After the pump and motor feet are tightened down, ad pipework erected and tightened, both angular and parallel alignment shall be checked and recorded at each quarter revolution. These readings shall be submitted to the Employer's Agent and is a prerequisite for handover.

Upon completion, dowel pins shall be fitted to facilitate relocation at any future time.

## M18.26 INSPECTION, TESTING AND COMMISSIONING

M18.26.1 Testing by Manufacturer

The Manufacturer will carry out all tests on materials, quality control tests, dimensional checking and routine tests on parts to ensure that the pumps and materials conform to the requirements of the relevant SANS or BS specifications and to this Specification. The Employer's Agent will not necessarily attend these tests but records must be kept and all test results will be made available to the Employer's Agent.

M18.26.2 Witnessed Testing

In addition to the above, a number of performance tests will also be carried out in the testing facility of the supplier before equipment is transported to Site. These tests can be carried out in the workshop of the manufacturer/supplier if it is suitably equipped or another approved test facility.

The Employer's Agent may witness these tests and the Contractor will notify the Employer's Agent two weeks in advance of the date and place at which the equipment

may be inspected and tested. When tests and inspections have met the satisfaction of the Employer's Agent a certificate of workshop acceptance will be issued. These certificates are a prerequisite before payment for "Materials on Site" can be passed. The Employer's Agent's acceptance will in no way relief the Manufacturer of any of his obligations to design, manufacture and supply pumps strictly in accordance with the Specification.

Performance tests shall include:-

(a) Hydraulic tests on the pump casing. The test pressure will be equal to 1½ times the maximum working pressure at the delivery end of the pump. The testing will be done with blank flanges bolted onto the flanges. The pressure will be maintained for at least 15 minutes. No sign of sweating, leaking, undue deformation and stressing or defect of any kind will be evident during the test period.

(b) Tests to prove that the rotating parts are dynamically balanced.

(c) Performance tests on pump and driving unit.

(d) NPSH requirements if called for in the Project Specifications.

A performance test shall be carried out in accordance with BS 5316 Part 2 - Class B tests if specified. Unless otherwise stated, the Contractor will be required to conduct the performance test on the combined pump/motor unit.

If a performance test of the pump and its driving unit is not possible at the manufacturer's works, this shall be stated in the Tender with reasons to allow the Engineer opportunity to make alternative proposals.

M18.26.3 Testing by an Independent Facility

The Employer may require that an independent testing facility or institution such as the South African Bureau of Standards carry out performance tests. A separate item for performance testing will be provided in the Schedule of Quantities to allow for this.

M18.26.4 Failure to Pass Performance Test

Should the pump unit fail the performance test, whether performed at the manufacturer's works or at an independent institution, the Engineer shall authorise any amendments to the plant which may be considered necessary to meet the guaranteed quantities within the permissible tolerances laid down in BS 5316 Part 2 - Class B tests and prove with further test that the equipment conform to the Specification.

All costs involved in the re-testing of pump units will be borne by the Contractor.

Should the pump unit fail to pass the test with more than 5% variation on the actual guaranteed figures; the engineer will reject the pump unit and request the Contractor to replace the unit so rejected.

Should the pump until still fail to pass the test, but the actual figures do not vary by more than 5% from the actual guaranteed figures, the Employer's Agent may :-

(a) Request the Contractor to carry out amendments to ensure the compliance of the unit with the Specification; or

(b) Accept the equipment but impose a penalty for non-compliance on the Contractor. A sum will be calculated based on the additional energy used over the life expectancy of the equipment and this will be deducted from the Contract price for each pump set for every kilowatt by which the gross demand exceeds the guaranteed figure with permissible tolerances.

M18.26.5 Commissioning

On completion of the installation the Contractor will check all items for satisfactory functioning. He will then inform the Engineer of his intension to commission the plant. The Engineer may request control measurements on pump alignment at this stage.

A detailed programme of his proposed commissioning procedures will be submitted not later than two weeks prior to the commissioning date.

After a successful running period of 4 hours (to be witnessed by the Employer's Agent) the Contractor will hand over the installation to the Employer as well as the Operation and Maintenance Manuals. The Completion Certificate will only be issued after the units have been in successful operation for 14 consecutive days and the acceptance tests successfully completed.

During the first 14 days of operation, the Contractor will rectify any problems with the units on Site within 24 hours of being telephonically notified. During the remainder of the maintenance period, the Contractor will, within 14 days of being notified, commence rectifying any possible problems that the Employer may encounter with the equipment supplied under this Contract.

Should the Contractor fail to meet the above requirements, the Employer may appoint others to undertake the necessary repair work at the Contractor's cost.

M18.26.6 Tests at the Site of the Works

The Engineer may require that site tests are performed to verify performance figures guarantee by the Contractor. Flow rate, total head and power input to the pump/motor units shall be determined, as accurate as Site conditions permit, for one or more points on the pump curves close to the specified duty point. The Contractor shall provide suitable instruments with recent calibration certificates.

Should these measured and calculated quantities differ from those guaranteed by more than the tolerances allowed by BS 5316 Part 1 - re-testing of the unit at any testing facility, or the recalibration of the measuring instruments.

Should the subsequent test results still fall outside the allowable tolerances, Clause M18.28.4 shall apply, and call costs shall be borne by the Contractor. In the event of the subsequent test being successful, costs shall be borne by the Employer.

## M18.27 COLOUR CODES

The standard final colour codes for equipment supplied under this Contract shall be in accordance with Particular Specification G01.

## M18.28 MEASUREMENT AND PAYMENT

Payment under scheduled items shall be made per complete installation as specified, electrical connections, etc and grouting, etc. 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.

# JOHANNESBURG WATER

# PARTICULAR MECHANICAL SPECIFICATIONS

## M20 MECHANICAL VALVES: MANUFACTURE AND SUPPLY

### CONTENTS

## 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 Employer's Agent 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.

M20.3.5 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

M20.3.6 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.

M20.3.7 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 Employer's Agent 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.

M20.7.2 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.

M20.7.3 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.

M20.7.4 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 Employer's Agent. 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 Employer's Agent. 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 Employer's Agent.

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 Employer's Agent. 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 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.

M20.17.2 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 Employer's Agent shall not necessarily attend these tests but records must be kept and all test results and tests certificates must be provided to the Employer's Agent.

M20.20.2 Testing by Independent Body

The Employer's Agent 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 Employer's Agent 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 Employer's Agent 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.

# JOHANNESBURG WATER

# PARTICULAR MECHANICAL SPECIFICATIONS

## M21 MECHANICAL PRESSURE PIPEWORK

CONTENTS

## 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 Employer's Agent'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 Engin Employer's Agent. All electrodes must be supplied by the Contractor and the

consignment number submitted to the Employer's Agent. Should a different consignment be used on the works, the Employer's Agent 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 Employer’s Agent 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 Employer's Agent 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 Employer's Agent 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.

M21.13.3 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 Employer's Agent.

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 Employer's Agent '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 Employer's Agent 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 Employer's Agent 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 Employer's Agent. 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 Employer's Agent.

The Employer's Agent 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 Employer's Agent, 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 Employer's Agent 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 Employer's Agent 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 Employer's Agent. 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 Employer's Agent.

The Contractor shall supply the necessary equipment and labour to make the openings according to the dimensions and/or requirements directed by the Employer's Agent 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 Employer's Agent.

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 Employer's Agent 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 Employer's Agent 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 Employer's Agent 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 |

| Nominal Pipe Diameter (mm) | Working Pressure KPa | Bends | | | | End Caps and T-pieces |
|---|---|---|---|---|---|---|
| | | 11.25º | 22.50º | 45.00º | 90.00º | |
| | 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 |
| | 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 Employer's Agent'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

M21.26.2 Testing and Inspection at Manufacturer's Works

Where factory inspection and supervision of tests are required by the Employer's Agent, 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 Employer's Agent. Fees payable to such an inspector, however, will not be to the account of the Contractor.

M21.26.3 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.

M21.26.4 Destructive Tests

Destructive tests on steel pipes and specials shall be carried out in accordance with SANS 719 and SANS 1178.

M21.26.5 Testing and Inspection on Site

*M21.26.5.1* *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 to the Employer's Agent at no cost.

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 to the Employer's Agent at no cost.

All joints, which fail the prescribed test of API Std 1104, must be repaired in accordance with chapter 7 of above specification.

*M21.26.5.2* *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 Employer's Agent'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.

*M21.26.5.3* *Hydrostatic Testing of Pipe Line*

Pipe joints shall in general be left exposed until the pipeline has been successfully tested and passed by the Employer's Agent. 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 Employer's Agent.

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 Employer's Agent.

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 Employer's Agent.

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) <u>For pipeline with flexible joints</u>

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) <u>For pipeline with welded joints</u>

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.

M21.26.6 <u>Other Pipe Materials</u>

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.

# JOHANNESBURG WATER

# PARTICULAR MECHANICAL SPECIFICATIONS

## M34 MECHANICAL SLUICE/CHANNEL GATES, ADJUSTABLE WEIRS, HAND STOPS AND STOP LOGS

### CONTENTS

## M34.1 SCOPE

This Specification covers the manufacture, testing and supply of sluice / channel gates, adjustable weirs, hand stops and stop logs for use in waste water and potable water treatment plants at ambient temperatures.

## M34.2 INTERPRETATIONS

M34.2.1 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 |

M34.2.2 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 freefit series) |
| SANS 136 | : | Isometric Precision Hexagon Head Bolts and Screws and Hexagon Nuts (coarse thread medium fit series) |
| SANS 1431 | : | Steel |
| BS 3100 | : | Cast Steel |
| BS 4504 | : | Flange Drilling |
| SIS 05 59 00 | : | Pictorial Surface Preparation Standards for Painting Steel Surfaces |
| ISO 244 | : | Pipeline Flanges for General use - Shapes and Dimensions of Pressure Tight Surfaces |
| SANS 1123 | : | Steel Pipe Flanges |

M34.2.3 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

## M34.3 GENERAL REQUIREMENTS

Sluice / channel gates, adjustable weirs, hand stops and stop logs shall be so transported, stored and handled as to prevent damage. Equipment damaged in any way shall be removed from the site repaired or replaced to the satisfaction of the engineer.

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 equipment is strictly in accordance with this Specification.

### M34.3.1 Pressure Rating

The design pressure for the sluice / channel gates, adjustable weirs, hand stops and stop logsis specified in the Tender Document in the Project Specification, Drawings and Schedule of Quantities.

### M34.3.2 Wastewater Liquids and chemicals

Sluice / channel gates, adjustable weirs, hand stops and stop logs which encounter raw wastewater, treated wastewater and sludge shall be manufactured from corrosive resistant material.

### M34.3.3 Guarantee

All sluice / channel gates, adjustable weirs, hand stops and stop logs shall be guaranteed against faulty design, materials and workmanship until the end of the maintenance period on theMain 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.

### M34.3.4 Operating and Maintenance Manuals

A copy of the Operating and Maintenance Manual for each equipment type 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.

### M34.3.5 Contents

A copy of the signed factory test certificate shall be bound in with the manual, while the originalshall be handed to the Engineer.
Operating instructions
Maintenance instructions
Lubrication instructions
Spare parts list
Drawings
Brochures

M34.3.6 Jointing Material

Jointing material shall comply with SANS 1700. sluice / channel gates, adjustable weirs, hand stops and stop logs shall be supplied complete with bolts, nuts, washers (2 per bolt) andgaskets for joining up to adjacent mating flanges and or concrete mounting.

Bolts shall be of stainless steel and 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.

M34.3.7 Contact between Dissimilar Metals

When flanges of dissimilar metals are bolted together, the internal epoxy coating shall cover thecontact 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 potential coating specified shall overlap onto the latter by at least 5 mm.

## M34.4 MATERIALS

The thickness of materials shall be suitable for the duty required.

## M34.5 DESIGN

All parts shall be designed for the duty required, but the minimum factor of safety against structural failure shall not be less than 3, based on the working stress of the material. In the design, due consideration shall be given to the thickness of materials with regard to corrosionand operating conditions. The force required at a hand wheel or crank to raise a gate or open avalve shall be in the order of 100 Newton, and the design parameters must be submitted in theTechnical Schedule.

The design shall be such as to give a 100% leak free seal when under the full operating head.

## M34.6 SLUICE AND CHANNEL GATES

The sliding frames, floor seats and gates of wall mounted as well as channel type gates with head frame shall be made of grade 304L stainless steel or as specified. All gates shall be well guided withno possibility of jamming. The gates shall be held uniformly against the side facings of the framesby the action of adjustable wedges and shall provide drop-tight closure under the operating conditions. Sluice gates shall be of the standard or flush invert type fitted with renewable seals of anon-biodegradable material on the invert.

Channel gates shall be dimensioned such that their installation in the channels and openingsshown on the drawings is facilitated. The channel gates shall be standard items and shall be installed so that head frames shall be flush with vertical channel walls and do not project horizontally into the channel. Vertical sliding frames and floor seat to be cast into concrete so as to leave an unobstructed waterway to dimensions indicated in the schedule. Pre-formed recess details forcasting in of frames to be submitted by the supplier. Head frame bridge for a channel gate toallow indicated water level to pass

under the gate when in UP-position.

All nuts, bolts, washers and other components shall be manufactured from same grade stainless steel specified for gate.

Gates shall be robustly designed and constructed, having vertical and horizontal ribs to withstandpressures from both directions. The matching head frame for channel gates shall be adequatelydesigned to resist distortion, and both the gate and the frame shall have machined seating faces toensure perfect sealing. The head frame shall extend above the concrete channel, to support thegate in the fully open position.

Seating pressure as well as unseating pressure may act on any channel or circular sluice gate and the sluice gate shall be able to resist these pressures.

Holding down bolts of penstocks fixed against concrete walls shall be made of Grade 304 Stainless Steel.

Channel gates shall be provided with rising spindles as well as approved transparent position indicators as requested.

## M34.7 ADJUSTABLE OVERFLOW TILTING WEIRS

The adjustable overflow tilting weirs shall comply with the following requirements:

(i) 304L stainless steel manufacture or as specified.

(ii) Stainless steel indicators showing the degree of adjustment of the weirs in mm enclosed inan approved transparent tube.

(iii) Be horizontal after installation with a maximum allowable variation from the horizontalnot exceeding 1 mm.

(iv) Be equipped with rounded side plates and be watertight underneath and at the sides ofthe frame.

(v) Holding-down bolts, washers, etc. shall be of same grade stainless steel as specifiedfor weir.

## M34.8 HAND STOPS

The following requirements shall be applicable to hand stops:

Supplied with an aluminum frame extending to the top of the concrete or masonry. The frame shall be grouted into a recess in the concrete or masonry. Details of suchrecess to be submitted by supplier. Hand stop shall be capable of sliding in and out ofthe frame.

Hand stop shall seal 100% watertight under all circumstances. This may be achievedwith the use of neoprene sealing material.

Hand stops and frames shall be manufactured from 6 mm aluminum plate and shall be robust and provided with reinforcing elements designed by the supplier to the approval of the Engineer. The reinforcing elements shall effectively prevent buckling under full static head conditions.

## M34.9 OPERATING GEAR

M34.9.1. Spindles to be extended as required and secured to structure to Engineer's approval.

M34.9.1.1. Arrows shall be cast on all hand wheels together with the wording "OPEN" or "CLOSE".

The closing direction shall be clockwise unless otherwise specified.

M34.9.1.2. Gates shall be fitted with position indicators. Fully closed, fully open and intermediate positions shall be indicated in corrosive proof and robust design indicators.

M34.9.2. Channel gate - Head frame bridge across with hand wheel or actuator on rising spindle.

M34.9.3. Gates and Tilting Weirs

Hand wheels or actuators installed in the following manner.Platform-mounted hand wheel pedestal (PMP)

Hand wheel pedestal on wall support bracket (HPWB)

Stub hand wheel pedestal on wall support bracket (SHWB)

Tee-key on support bracket (TKSB)

Grid-mounted hand wheel pedestal (GMP)

## M34.10 STOPLOGS

A stop log set shall comply with the following requirements:

Stop log sets shall be supplied with stainless steel frames extending to the top of the concrete or masonry. The frames shall be grouted into the recess in the concrete or masonry in such a way that the stop logs are capable of sliding in and out of the frame. The stop logs sets shall be watertight under all normal operational circumstances.

(i) Stop logs and frames shall be manufactured from stainless steel plate. Each stop log shall be provided with reinforcing elements designed by the supplier to the approval of the Engineer. The reinforcing shall effectively prevent buckling under full differential static head conditions.

(ii) The maximum vertical dimension of any individual stop log shall not exceed 150 mm.

(iii) Each individual stop log in any one set shall have the same vertical and horizontal dimensions.

(iv) Each individual stop log shall be provided with two lifting lugs.

(v) A neat stainless-steel stand or pair of stainless-steel hooks shall be installed in close proximity to each installed set of stop logs for the storing of stop logs when removed from the frame.

(vi) Each set of stop logs shall be provided with two portable stainless steel lifting hooks, each fastened with a 200 kg capacity stainless steel anti-loss chain or UV-

stabilized 200 kg capacity nylon rope to a suitable bracket on the hand railing or walkway structure. The chain or rope shall be long enough to facilitate easy operation of the lifting hooks. The lifting hooks shall be used to manipulate individual stop logs in to lifting lugs

(vii) Enough individual stop logs shall be supplied in each set to effectively span a minimum distance

## M34.11 RECOMMENDED SPARE PARTS

The Tenderer must submit details of spare parts recommended to be kept in store by theEmployer with his Tender.

The detail will include a full description of the parts, part identification, number required, guaranteed delivery time and total price delivered to Site.

## M34.12 OPERATION AND MAINTENANCE MANUAL

The Contractor shall hand over to the Engineer four sets of the Operation and Maintenance Manual compiled for each installation not later than at the time of commissioning of the installation. These manuals are a prerequisite for final takeover of the plant.

The Operation and Maintenance Manual will contain the following:

(a) Brief description of the plant and installation.

(b) Concise operating instructions.

(c) Routine maintenance instruction.

(d) Precautionary measures, elementary trouble location, rectifying measures, and emergency actions.

(e) Detailed information on equipment.

(f) Lists of spare parts including names and addresses of suppliers.

## M34.13 DRAWINGS

The drawings included in the Tender Documents are the Engineer's proposal for the plant layout. Should the Tenderer offer alternative layouts, he shall submit drawings with his Tender in order for it to be evaluated.

Before the Contractor carries out any work, he will submit detailed working drawings to be approved by the Engineer. Approval of these drawings does not relieve the Contractor from his responsibility for the correctness of the drawings.

## M34.14 INSTALLATION

The equipment shall be installed, aligned and grouted in to position without distortion of the frame and or gate/weir which may cause damage to the sealing arrangement of the equipment.

## M34.15 INSPECTION, TESTING AND COMMISSIONING

M34.15.1 Testing by Manufacturer

The Manufacturer will carry out all tests on materials, quality control tests, dimensional checking and routine tests on parts to ensure that the equipment and materials conform to the requirements of the relevant SANS or BS specifications and to this Specification. The Engineer will not necessarily attend these tests but records must be kept and all test results will be made available to the Engineer.

Test shall include but not be limited to hydraulic testing to ensure 100% leak free. If the equipment offered is not 100% leak free then the percentage should be specified in the data sheets.

M34.15.2 Witnessed Testing

In addition to the above, a number of performance tests will also be carried out in the testing facility of the supplier before equipment is transported to Site. These tests can be carried out in the workshop of the manufacturer/supplier if it is suitably equipped or another approved test facility.

The Engineer may witness these tests and the Contractor will notify the Engineer two weeks in advance of the date and place at which the equipment may be inspected and tested. When tests and inspections have met the satisfaction of the Engineer a certificate of workshop acceptance will be issued. These certificates are a prerequisite before payment for "Materials on Site" can be passed. The Engineer's acceptance will in no way relief the Manufacturer of any of his obligations to design, manufacture and supply pumps strictly in accordance with the Specification.

M34.15.3 Testing by an Independent Facility

The Employer may require that an independent testing facility or institution such as the South African Bureau of Standards carry out performance tests. A separate item for performance testing will be provided in the Schedule of Quantities to allow for this.

M34.15.4 Failure to Pass Performance Test

Should the equipment fail any test, whether performed at the manufacturer's works or at an independent institution, the Engineer shall authorise any amendments to the equipment which may be considered necessary to meet the specifications and prove with further test that the equipment conform to the specification.

All costs involved in the re-testing of equipment will be borne by the Contractor.

M34.15.5 Commissioning

On completion of the installation the Contractor will check all items for satisfactory functioning. He will then inform the Engineer of his intension to commission the plant.

A detailed programme of his proposed commissioning procedures will be submitted not later than two weeks prior to the commissioning date.

The Completion Certificate will only be issued after the equipment has been in successful operation for 14 consecutive days.

During the first 14 days of operation, the Contractor will rectify any problems with the equipment on Site within 24 hours of being telephonically notified. During the remainder of the maintenance period, the Contractor will, within 14 days of being notified, commence rectifying any possible problems that the Employer may encounter with the equipment supplied under this Contract.

Should the Contractor fail to meet the above requirements, the Employer may appoint others to undertake the necessary repair work at the Contractor's cost.

## M34.16 COLOUR CODES

The standard final colour codes for equipment supplied under this Contract shall be in accordance with Particular Specification G01.

## M34.17 MEASUREMENT AND PAYMENT

Payment under scheduled items shall be made per complete installation as specified, electrical connections, etc and grouting, etc. 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

# PORTION 7: PARTICULARS SPECIFICATIONS FOR ELECTRICAL WORK

| Volume | Description |
|---|---|
| E12 | ELECTRICAL MEDIUM VOLTAGE CABLES |
| E13 | ELECTRICAL MEDIUM VOLTAGE SWITCHGEAR |
| E14 | ELECTRICAL SUPPLY AND INSTALLATION OF A STANDBY GENERATOR |
| E15 | ELECTRICAL TRANSFORMERS |
| E19 | ELECTRICAL 11KV RING MAIN UNIT |
| E20 | ELECTRICAL OVERHEAD LINES UP TO 22KV |
| E21 | ELECTRICAL LIGHTING AND ILLUMINATION |
| E24 | ELECTRICAL BATTERY TRIPPING UNIT |
| E26 | ELECTRICAL COLOUR CODING OF EQUIPMENT |

# ELECTRICAL PARTICULAR SPECIFICATION:

# VOLUME E01 : ELECTRICAL MOTORS

## CONTENTS

## 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.

# ELECTRICAL PARTICULAR SPECIFICATION:
# VOLUME E02 : ELECTRICAL CABLE RACKS

## CONTENTS

## 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

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 |

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

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.

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 metre 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 metre 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 metre 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 metre 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 PARTICULAR SPECIFICATION :

## VOLUME E03 : ELECTRICAL ISOLATOR PUSHBUTTON STATION (LOCAL START/STOP) EQUIPMENT

## CONTENTS

## E03.1 SCOPE

This section covers the requirements for local isolator/start/stop pushbutton stations. Local isolator/start/stop pushbutton stations shall be supplied, delivered, installed and commissioned for each mechanical equipment driven by a motor.

## E03.2 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 62262 : Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)

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

(c) SANS 10142-1 : The wiring of premises Part 1 Low-voltage installations

(d) SANS 60439-1 : Low-voltage Switchgear and Control gear Assemblies Part 1 Type-tested and partially type-tested assemblies

(e) SANS 60439-2 : Low-voltage Switchgear and Control gear Assemblies Part 2 Particular requirements for busbar trunking systems (busways)

(f) SANS 60439-3 : Low-voltage Switchgear and Control gear Assemblies Part 3 Particular requirements for low-voltage switchgear and control gear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards

(g) SANS 60947-1 : Low-voltage Switchgear and Control gear Part 1 General rules

(h) SANS 60947-2 : Low-voltage Switchgear and Control gear Part 2 Circuit breakers

(i) SANS 60947-3 : Low-voltage Switchgear and Control gear Part 3 Switches, disconnectors, switch-disconnectors and fuse-combination units

(j) BSI-BS 3858 : Specification for Binding and identification sleeves for use on electric cables and wires

(k) SANS 1091 : National colour standard

## E03.3 GENERAL REQUIREMENTS

### E03.3.1 PARTICULAR SPECIFICATIONS TO BE READ IN CONJUNCTION WITH THIS SPECIFICATION

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

E26: ELECTRICAL SPECIFICATION FOR COLOUR CODES

G02: PARTICULAR SPECIFICATION FOR CORROSION PROTECTION
E08: WIRING

E03.3.2 **GENERAL REQUIREMENTS**

(a) The enclosure will be manufactured from 3CR12 stainless steel.

(b) The enclosure will be rated IP65 to SANS 60529 and shall be fitted with a canopy.

(c) The enclosure shall be painted electric orange (B26).

(d) The Isolator Pushbutton Station will be equipped with

- A green flush START pushbutton with spring return. In case of a bidirectional drive a START FORWARD and START REVERSE pushbutton will be installed;
- A red flush STOP pushbutton with spring return;
- A red mushroom head EMERGENCY STOP button with mechanical latching, turn to release. The emergency stop pushbutton will be lockable (key reset) and not a padlockable unit. This will not be a lockout point, but will be used for Process use only.
- A three-pole non-fusible disconnect switch complete with a shaft extension and a door interlocked red and yellow padlockable rotary handle mounted on the door. The current rating of the disconnect switch must match the motor rating as specified in the motor equipment schedule (rated for on-load conditions).
- All equipment must be installed in one box (power and control).

(e) The Isolator Pushbutton Station will be clearly labelled with an identity label, engraved with 30mm high black on white characters, and shall be mounted on top of the enclosure. The name of the associated drive will be shown.

(e) All pushbuttons shall be labelled with an identity label, engraved with 10mm high black on white characters and shall be mounted above the pushbutton.

(f) The Isolator Pushbutton Station shall be mounted within a radius of 1000mm maximum from o the associated drive. If this is not possible, the Engineer will indicate the position of the Pushbutton Station.

(g) The station shall be pedestal mounted at least 1100mm above floor level. The pedestal design shall be approved by the Engineer.

(h) The pedestal base plate shall be installed on 10mm of epoxy grout to prevent crack corrosion.

(i) The pedestal material shall be Stainless steel (3CR12) and have minimum thickness of 6mm. The pedestal shall be painted electric orange (B26).

(j) The station enclosure shall be designed to provide adequate space for the following:

- The required pushbuttons, the disconnect switch and the respective labels.
- A single multi-core control cable (including glanding) shall be installed from the MCC to the station, from where the required signals shall be individually wired, as per the cable schedule.
- Power cable/s (including glanding) shall be installed from the MCC to the station, providing power to the associated motor, as per the cable schedule.

**E03.4 DIMENSION FOR ISOLATOR STATION**

The dimensions of the start/stop isolator pushbutton stations shall allow ample space to

accommodate all the equipment, taking into account the bending radius of all cables and minimum clearances. The contractor must supply design drawings of the Isolator Pushbutton Station to Johannesburg Water or their representative for approval prior to manufacturing.

## E03.5 FASTENERS

All fasteners in concrete shall be 316 stainless steel. Pedestal bases shall be sealed against the ingress of any crevice corrosion by means of a suitable non-shrink cementitious grout and approved by the Engineer.

## E03.6 MEASUREMENT AND PAYMENT

| Item | Unit |
|---|---|
| Supply and delivery of local start/stop isolator pushbutton stations ..... | No |

The unit of measure shall be the number of stations supplied and delivered.

The tendered rate shall include all costs related to the manufacture, supply and delivery of the local start/stop isolator pushbutton or control stations (as detailed in the schedule of quantities), including support pedestal in accordance with this specification and the additional requirements detailed in the detail specification complete with all mounting brackets.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the kW rating of the driven equipment, of pushbutton / control stations.

| Item | Unit |
|---|---|
| Install local start/stop isolator pushbutton stations ..... | No |

The unit of measure shall be the number of stations installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the local start/stop isolator or control stations as specified. The rate shall further include for pedestal support securing and sealing preventing crevice corrosion.

Separate items will be scheduled in the schedule of quantities for different types of pushbutton / control stations.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the kW rating of the driven equipment, of pushbutton / control stations.

## JOHANNESBURG WATER PARTICULAR SPECIFICATION :

## VOLUME E04 : ELECTRICAL LOW VOLTAGE SWITCHBOARDS AND MOTOR CONTROL CENTRES

## CONTENTS

## 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

E04.1.5.1 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.

E04.1.5.2 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.

E04.1.5.3 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;

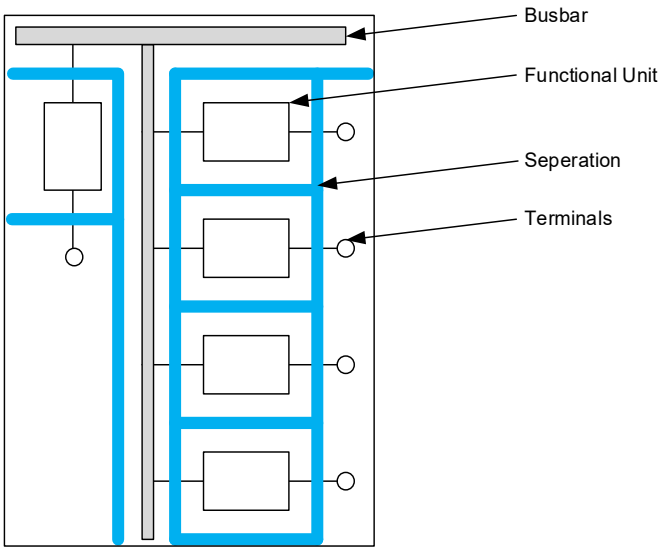



Figure 1: Form 3B

E04.1.5.4 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.

E04.1.5.5 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.

E04.1.5.6 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.

E04.1.5.7 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.

E04.1.5.8 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.

E04.1.5.9 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.

E04.1.5.10 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

E04.2.5.1 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.

E04.2.5.2 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.

E04.2.5.3 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.

E04.2.5.4 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.

E04.2.5.5 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.

E04.2.5.6 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.

E04.2.5.7 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.

E04.2.5.8 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.

E04.2.5.9 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.

E04.2.5.10 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.

E04.2.5.11 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;

E04.2.5.12 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.

E04.2.5.13 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.

E04.2.5.14 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

E04.3.5.1 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.

E04.3.5.2 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".

E04.3.5.3 Mounting of Contactors

(a) Contactors shall only protrude through the panel in special cases. Plastic covers or other coverings will not be required.

E04.3.5.4 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.

E04.3.5.5 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.

E04.3.5.6 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.

E04.3.5.7 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 | WHEN REQUIRED |

| | | (YES OR NO ) | |
|---|---|---|---|
| DRAWINGS & DESIGN<br><br>(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<br><br>(2 SETS OF EACH) | QUALITY CONTROL PLAN | YES | ORDER + 3 WEEKS |
| | MANUFACTURING PROGRAM | YES | ORDER + 3 WEEKS |
| | | | |
| | | | |
| 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.)** | |
| **Busbars** | | |
| ☐ | **Correct cross-section** | |
| ☐ | **Correct phasing with incomer/feeders** | |

| | | Comments |
|---|---|---|
| ☐ | 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 | |

| | | Comments |
|---|---|---|
| ☐ | **Correct operation of all interlocks** | |
| ☐ | **Correct operation of indicator lights** | |
| ☐ | **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 Site Acceptance Test and Commissioning

(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 PARTICULAR SPECIFICATION :**

**VOLUME E05 : ELECTRICAL LOW VOLTAGE POWER AND CONTROL CABLES**

**CONTENTS**

## E05.1 SCOPE

This specification covers the requirements with regards to the manufacture, supply, delivery, installation, testing and commissioning of power and control cables rated up to 600/1000V. The term cable shall indicate electrical conductors or carriers manufactured for supplying power for the control and supervision of multipurpose loads.

### E05.1.1 Statutory Documents and Standards

Cables shall be strictly manufactured in accordance with the requirements of the latest editions of the following standards:

| | | |
|---|---|---|
| (a) SANS 1507 | : | Electrical cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) |
| (b) SANS 1411 | : | Materials of insulated electric cables and flexible cords |
| (c) SANS 1339 | | Electric cables - Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV |
| (d) SANS 1520 | : | Flexible electrical cables for use in mines |
| (e) SANS 10198 | | The selection, handling and installation of electric power cables of rating not exceeding 33 kV |
| (f) SANS 10142-1 | : | The Wiring of Premises Part 1 – Low Voltage Installations |
| (g) IEC 60245 | : | Rubber insulated cables |
| (h) IEC 60287 | : | Electric cables - Calculation of the current rating |
| (i) IEC 60811 | : | Electric and optical fibre cables - Test methods for non-metallic materials |
| (j) DIN VDE 0250-816 | : | Cables – Wires and flexible cords for power installation – Heat-resistant silicone rubber insulated flexible cable |

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

### E05.1.2 Definitions and Terminology

In general, the following definitions and terminology shall apply:

| | |
|---|---|
| Armouring | A layer or layers of galvanized steel wires applied to the cable to provide mechanical protection or earth continuity, or both. |
| Bedding | A layer of extruded compound applied to the cable beneath the armouring. |
| Cable | A length of core or more cores assembled, that may or may not be provided with an overall mechanical covering. |
| Core | A single insulated conductor without protective covering. |
| Direction of lay | The lateral direction of inclination to the axis (either left or right) of the receding helix formed by wire or core in a cable or flexible cord. |
| PVC | Polyvinyl chloride |
| Sheath | A solid extruded protective covering applied as the exterior of a cable or a |

flexible cord.

E05.1.3 Particular Specifications to read in Conjunction with this Specification

This specification shall be read in conjunction with the following specifications:-
E06: ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION

## E05.2 GENERAL SCOPE

E05.2.1 Design and Supply

(a) Conductor sizes

The minimum conductor size for control cables shall be 2.5mm$^2$.

The minimum conductor size for power cables on plant equipment (excluding small power and lighting) shall be 16mm$^2$.

(b) Conductor material

In the case of plants with a high risk of cable theft, cables with aluminium conductors must be used where the nominal core diameter exceeding 25mm$^2$. This must be agreed upon in writing by the Engineer.

## E05.3 CONSTRUCTION

The cable shall be constructed as follows:

E05.3.1 Conductor Material

The copper conductors shall be of plain annealed or hard draw wire in accordance with the requirements of the latest edition of SANS 1411.

The aluminium conductors shall be of plain hard drawn aluminium wire in accordance with the requirements of the latest edition of SANS 1411.

E05.3.2 Insulation

The insulation material shall comprise of PVC in accordance with the requirements of the latest edition of SANS 1411.

E05.3.3 Core Colour Identification

The cable cores colour shall be in accordance with the requirements of the latest edition of SANS 1507-3.

E05.3.4 Bedding

The bedding shall consist of a continuous PVC extruded sheath.

E05.3.5 Armour

The armouring shall consist of one layer of round galvanised steel wire in accordance with the requirements of the latest edition of SANS 1411.

E05.3.6 Sheath

The outer sheathing shall be an impermeable, halogen free, reduced smoke emission, flame retardant PVC in accordance with the latest edition of SANS 1411.

## E05.4 CABLE MARKINGS

The cables shall be legibly marked in accordance with the requirements of the latest edition of SANS 1507, and shall include the following:

(a) Conductor size in square millimetres
(b) Number of cores
(c) Conductor material (copper)
(d) The specification number (SANS 1507) to which the cable has been manufactured.
(e) The year of manufacture.
(f) Nominal voltage.

## E05.5 STORAGE

Cables shall be packed on reeled drums. The moisture content of wooden cable drums shall not exceed 20%.

Each end of the cable shall before being secured to the reeled drum, be sealed by an acceptable method approved by the Engineer. The outer end shall be secured to the reel drum and the inner end shall be protected in a manner against mechanical damage.

The cable reeled drums shall be capable of taking a round spindle and be lagged with strong, closely fitted battens, at the inner and outer circumference to prevent damage to the cables. The spindle bearing plates shall be steel. The dimensions of the drum shall not exceed 1 100 mm width, 2 000 mm diameter and the spindle bearing plate shall not be less than 9 mm thick. Each drum shall be clearly marked on both sides in accordance with the latest edition of SANS 1507.

The ends of the PVC sheathed cable shall be sealed to avoid penetration of moisture. Each cable drum shall be numbered.

## E05.6 CABLE SIZING AND DE-RATING

The cables shall be sized and de-rated in accordance with the requirements of the latest edition of SANS 10142-1.

## E05.7 TESTING OF CABLES

E05.7.1 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) SANS 1507 (Electric cables with extruded solid dielectric insulation for fixed installations

(300/500 V to 1 900/3 300 V));

| SANS 1507 Test Wave | Duration (min) | Commissioning test voltage between conductors (V) | | | Commissioning test voltage between conductors / earth (V) | | |
|---|---|---|---|---|---|---|---|
| | | 300/ 500 | 600/ 1000 | 1900/ 3300 | 300/ 500 | 600/ 1000 | 1900/ 3300 |
| AC (rms) | 15 | 1000 | 2000 | 6000 | 1000 | 2000 | 3500 |
| DC | 15 | 1500 | 3000 | 9000 | 1500 | 3000 | 5000 |

This test will be conducted to the Engineers judgement. The constructer must obtain written approval from the Engineer before conducting any tests.

(a) The requirements of the Local and Supply Authorities.

## E05.8 QUALITY ASSURANCE

All the cables supplied under the Scope of Works of this project shall be designed and manufactured under a quality control system, typically to ISO 9000 series. The contractor must supply current compliance certificates on the manufacturers ISO classification.

## E05.9 MEASUREMENT AND PAYMENT

Measurement and payment will distinguish between supply/delivery and installation/commissioning of the cabling lengths required.

**Item** **Unit**

Supply and delivery of low-voltage cable..... metre

The unit of measurement shall be the length of low-voltage cable supplied. It is the responsibility of the Contractor to verify the lengths of cables required on site. The Contractor shall only supply the required length of cables required. The final quantity of installed cable lengths shall determine the final quantity to be paid of the supplied cable lengths.

The tendered rate shall include for the design, manufacture, supply and delivery of the specified cable to the site.

Separate items shall be scheduled under this payment item for each size and type of cable.

# PARTICULAR SPECIFICATION : VOLUME E06 : ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION

## CONTENTS

## E06.1 SCOPE

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

E06.1.1 Statutory Documents and Standards

The installation will be conducted in accordance with the requirements of the following standards. Where any document or standard is referenced, it shall be deemed the latest version of that document.

| | | |
|---|---|---|
| (a) SANS 10198 | : | The selection, handling and installation of electric power cables of rating not exceeding 33 kV |
| (b) SANS 1507 | : | Electrical cables with extruded solid dielectric insulation for fixed installations |
| (c) SANS 10142-1 | : | The wiring of premises Part 1 – Low Voltage installations |
| (d) SANS 1213 | : | Mechanical Cable Glands |
| (e) DIN EN 50655-2 VDE 0278-655-2 | : | Fingerprinting for heat shrinkable components for low and medium voltage applications up to 20,8/36 (42) kV |

E06.1.2 Particular Specifications to be read in conjunction with this specifications

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

| | | |
|---|---|---|
| (a) E02 | : | ELECTRICAL CABLE RACKS |
| (b) E03 | : | ISOLATOR PUSHBUTTON STATIONS |
| (c) E04 | : | MOTOR CONTROL CENTRES |
| (d) E05 | : | ELECTRICAL LOW VOLTAGE POWER AND CONTROL CABLES |
| (e) E07 | : | ELECTRICAL INDUSTRIAL WELDING PLUGS, COUPLERS AND SOCKET OUTLETS |
| (f) E08 | : | WIRING |
| (g) E12 | : | ELECTRICAL MEDIUM VOLTAGE CABLES |

## E06.2 GENERAL

E06.2.1 Cable theft prevention

Consideration must be given at design stage for the risk posed by cable theft. The routing of cables on site must be so that there is minimum risk of cable theft. This can be effected by avoiding use of bare earth copper cables, burying cables where possible, covering with secured covers, using a concrete paving over a cable route and any other approaches that will reduce probability of cable theft. As each site has different exposure to the risk of cable thefts, the user plant personnel must be involved in a risk assessment exercise to determine measures that may be applied on a site-by-site basis.

Cable runs outside of buildings must be buried. Where cables need to cross, rise onto structures, enter buildings or link structures, cable ladders may be used. In such cases, cable racks must be covered to prevent access. The cover may be bolted, welded in such a way that it is secure and may not be easily removed by simple tools.

E06.2.2 Competence of Personnel

Contractor supervisors overseeing work on or the installation of MV equipment and cables on site will be authorised under the Operating Regulations for High Voltage Systems (ORHVS). A valid authorisation certificate will be submitted with each tender. All contractor personnel working on medium voltage equipment shall work under the direct supervision of the authorised supervisor.

Cables, cable joints, cable terminations and cable accessories shall be installed in accordance with the manufacturer's installation instructions by competent personnel. The Contractor shall only employ personnel fully conversant with the cable manufacturer's recommendations to lay, joint and terminate cables.

## E06.3 CABLE INSTALLATION ON CABLE RACKS AND STRUCTURES

E06.3.1 Installation of Cables

Cables may be installed in one of the following ways:

(a) On horizontal or vertical cable ladders;
(b) Against horizontal or vertical metal supports or brackets;
(c) Fixed to structures.

E06.3.2 Installation of Cable Ladders

Cable ladders shall be installed:

(a) Within Motor Control Centre stations,
(b) On access platforms to the mechanical equipment;
(c) In accessible cable duct.

Cable ladders shall be supported with struts, channels, brackets, clamps, cantilever arms ext. The corrosion protection of the support elements shall be of the same system as that of the cable ladder. Nuts/bolts/washers shall be used as fasteners. 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.

On access platforms, the cable ladder will 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.

In accessible cable duct, cable ladder shall be supported by a 50mm high strut section securely fixed to the wall. The corrosion protection of the strut shall be of the same system as that of the cable ladder

To minimise cable theft, long cable runs on cable ladders should be avoided. For high risk areas where cable racking is used or, 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. If any additional methods to prevent cable theft are required, such requirements will be made clear to the contractor at the time of tender. This will also apply to all areas where cables are exposed or where cables are visible to by passers.

Before any cables are laid, the Engineer or his representative will inspect all cable racks.

E06.3.3 Installation of Cable Supports

Cable supports must be 3CR12-grade stainless steel, 304-grade stainless steel or 316-grade stainless steel and electric orange powder coated as for the cable racks. The size of angle

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

E06.3.4 Grouping and Spacing of Cables

Wherever possible cable racks must be mounted in the vertical plane to avoid accumulation of dirt and debris. Only single layers of cable will be allowed on a rack, to reduce de-rating and for ease of replacement and/or repairs. No more than two cables may be run on a single angle profile (3CR12) support.

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

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

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

Cables for telephone, communication and alarm systems and all other low voltage systems (less than 50 V), shall be separated from power cables. In building ducts, a physical barrier shall be provided between power cables and cables for other services. Where armoured cables are used for such other services, they shall be at least 500mm away from power cables or shall be installed on separate cable trays. In the case where unarmoured cables are used for these other services, they shall be installed in separate metal channels or conduits.

E06.3.5 Fixing of Cables on Cable Racks and Supports

UV stabilised PVC straps may be used for cables up to 4core x 25mm2. For cables of larger diameter than this (i.e. 30mm diameter and larger), stainless steel strapping must be used. All cables must be individually strapped.

E06.3.6 Spacing of Cable Supports

The most generally known method of supporting cables is the restrained installation where the distance between supports is small enough to prevent any noticeable sag in the cable.

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

**Table 1: Maximum Spacing of Supports (Cleats) (mm)**

| FOR RESTRAINED CABLE | | | | |
|---|---|---|---|---|
| Cross-sectional area of Cable conductors (mm²) | Wire Armoured Cables | | Other than Wire Armoured Cables and Unarmoured Cables | |
| | Horizontal Cable Routes | Vertical Cable Routes | Horizontal Cable Routes | Vertical Cable Routes |
| 1,5 | 500 | 750 | 300 | 400 |
| 2,5 | 500 | 750 | 300 | 400 |

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

## E06.4 CABLE INSTALLATION IN CABLE TRENCHES

### E06.4.1 General

The Contractor shall preserve the site as far as possible. Only the minimum of trees, shrubs, rocks, etc. shall be removed and cleared for the cable route.

The cable trench will be arranged as shown in figure 2 below:

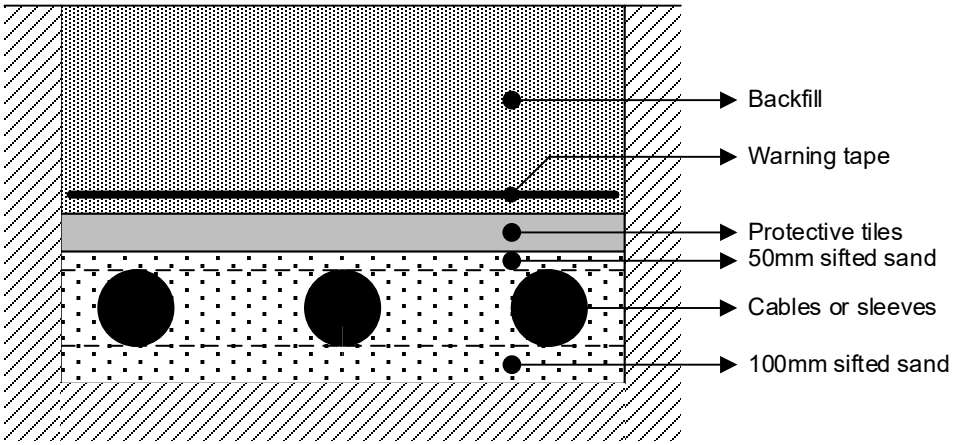



**Figure 2:** Cable trench arrangement

### E06.4.2 Trench Routes

The cable trench shall be excavated along the route indicated on the relevant drawing. The routing should preferably traverse through the lowest theft risk areas as much as is possible.

The trench shall be as straight as possible and shall comply with all requirements. The Engineer shall determine the length of the trench to be excavated, which shall not exceed 300 m, before the cable is installed and the trench backfilled.

If any obstacle or interference should be encountered, which may require alterations to the

trench or routes, such alterations shall receive prior written approval from the Engineer.

E06.4.3 Excavation of Cable Trenches

The exact positioning of trenches shall be approved on site by the Engineer and excavations shall not commence until approval has been received.

The trench shall be excavated to a depth indicated on the drawings for the different cables. Where depths are not indicated on the drawings, the following shall apply:

Cable trenches shall be excavated deep enough so that the top layer of the cables is buried a minimum of 600 mm below final ground levels for LV cables and 1000mm for MV cables.

The Contractor shall excavate by hand where he cannot excavate by means of machines due to limited access and the proximity of other services.

The bottom of the trench shall be level and shall follow the contours of the final ground level. Where the excavation is in excess of the required depth, the excavation shall be backfilled and compacted with suitable material to the required depth.

The Contractor shall remove all sharp projections, which could damage the cable where the trench is excavated through rocky formations, and shall remove all loose rocks, material, etc. from the bottom of the trench.

The Contractor shall trim the trenches and clean up the bottom of the trenches after he has completed the required excavation.

E06.4.4 Excavation of Jointing Chambers

Jointing pits shall be excavated to a depth of 1,2 m and shall be rectangular in shape and large enough for the cable jointers to work comfortably and in an efficient manner. Where more than one joint is to be made in the same position the joint pit shall be large and long enough to allow staggered joints to be made. The minimum size of a joint pit shall be as follows:

(a) One joint : 2,5 m long x 1,25 m wide

(b) Two joints : 3,0 m long x 1,5 m wide

E06.4.5 Excavated Material

No excavated material shall be left closer than 300 mm from the side of the excavation. The excavated material shall take up as small an area as possible with the safety of the workers and Works taken into consideration. The excavated material suitable for bedding material shall be placed separately on one side of the trench so that it is available when required.

Where surplus material or material unsuitable for backfilling has to be disposed of, the Contractor shall load and transport the material in the area provided to him, where it will be dumped.

E06.4.6 Inspection of Excavations

All cable excavations will be inspected by the Engineer prior to cable laying and backfilling commences.

The Contractor shall give the Engineer 24 hours' notice to do the inspections. No inspections shall be undertaken on Saturdays, Sundays and public holidays.

E06.4.7 Measurement of Excavations

Full detail of the cable trench dimensions and classification of the type of excavation shall be recorded by the contractor. The report will be presented to the Engineer as the final quantities for such excavations. The Contractor shall be responsible to keep all records as proof of progress and as basis for claims for payment. Inspections and measurements shall be

completed before the installation of any bedding or backfilling.

The Contractor shall give the Engineer 24 hours' notice to be present when excavation are measured. No measurements shall be undertaken on Saturdays, Sundays and public holidays.

E06.4.8 Maintenance of Excavations

The Contractor shall maintain the excavation in a good condition, free of water, mud, loose ground, rocks, stones, gravel and other strange material until the cables are installed and the excavation is backfilled and compacted.

E06.4.9 Bedding Sand

A 100mm layer of sifted bedding sand free from sharp objects and rocks shall be laid and levelled at the bottom of each trench after the trench has been approved by the engineer, and prior to cable laying.

If the soil for the sand bed and sand cover has to be sifted, a sieve with holes 6 mm or smaller shall be used. Where this material is not available, the contractor shall import suitable material for such purposes. Where bedding has already been laid, the Engineer may instruct the Contractor to demonstrate that the minimum thickness of bedding has been provided for before authorising cable laying to proceed.

E06.4.10 Cable Laying

After approval of the trench, the cable shall be laid with the minimum of delay so that the trench can be backfilled. The Contractor shall, however, not backfill the trench until each length of cable has been inspected and approved by the engineer.

Only one cable shall be laid at a time and the Contractor shall take precautions that installed cables are not damaged. Cables should be laid with sufficient slack to relieve stresses.

The method to be used for laying cables shall be approved by the Engineer prior to the commencement of the laying of the cables.

Cable rollers shall be used when cables are drawn into trenches. The cable rollers shall be placed so that the cable does not touch the bottom or the sides of the trench. The rollers shall be of an approved construction without any sharp metal parts, which could damage the cables.

If the Contractor intends using a winch to draw the cable into the trench, a cable stocking shall be used or the draw wires shall be soldered to the cable so that the tension is exerted on all the cores, lead sheath and/or steel wire armouring at the same time.

The maximum tension on a cable during laying operations shall not exceed the value specified by the manufacturer.

Should the Engineer not be satisfied with the manner or method employed to lay the cable he shall have the authority to instruct the Contractor to lay the cable by hand or in accordance with approved standards.

Medium-voltage cables shall overlap by at least 1m, but not more than 1,5m at joints.

Sufficient lengths of cable shall be left at the beginning and end of the cable routes to allow for the termination of the cables. Where necessary the Engineer shall decide on what length of cable is to be left. The Contractor shall take the necessary precautions to protect the cable ends until they are terminated. The cable ends shall be sealed by means of lead or heat-shrink sealing caps to ensure that the cable is waterproof.

Where cables are drawn through sleeves, care shall be taken that they are not kinked or excessively bent. No bend in a cable shall have a radius less than the minimum-bending radius specified by the cable manufacturer.

The Contractor shall keep accurate records of each length of cable laid. The following information shall be recorded:-

(d) Cable drum number
(e) Size of cable
(f) Laid from where to where
(g) Length of cable
(h) Date laid

E06.4.11 Inspection of Cables

The Contractor shall be solely responsible for inspecting all cables before backfilling to ensure that the correct type and number of cables have been installed. All cable installation will be inspected by the Engineer prior to backfilling commences.

The Contractor shall give the Engineer 24 hours' notice to do the inspections. No inspections shall be undertaken on Saturdays, Sundays and public holidays.

E06.4.12 Measurement of Cables

Full detail of the cable length shall be recorded by the Contractor. The report will be presented to the Engineer as the final quantities for such installation. The Contractor shall be responsible to keep all records as proof of progress and as basis for claims for payment. Inspections and measurements shall be completed before the any backfilling commences.

The Contractor shall give the Engineer 24 hours' notice to be present when cables are measured. No measurements shall be undertaken on Saturdays, Sundays and public holidays.

E06.4.13 Sifted Sand topping

A 50mm layer of sifted bedding sand free from sharp objects and rocks shall be laid and levelled on top of the installed cables, prior to laying of the protective concrete tiles. If the soil for the sand bed and sand cover has to be sifted, a sieve with holes 6mm or smaller shall be used. Where this material is not available, the contractor shall import suitable material for such purposes.

E06.4.14 Concrete Protective Slabs

Protective concrete tiles will be installed above the sifted sand topping. 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.

E06.4.15 Cable Warning Tape

Cable warning tape shall be installed on all cable routes (LV and MV) at 300 mm above the protective concrete slabs. Where a cable route exceeds 600 mm in width, multiple warning tapes shall be run in such a way that the space between adjacent warning tapes does not exceed 185 mm.

The plastic cable warning tape shall consist of a strip of polyethylene of thickness 0,04mm and of nominal width 230 mm. The tape will be completely impregnated with a pigment such that the colour of the tape is yellow, colour No B49 of SANS 1091. A black-triangle and an electric flash symbol and the words "Danger, Gevaar, Ingozi" will be printed on the tape at intervals not exceeding 1m along its length.

E06.4.16 Backfill

When the protective tiles are installed, the trench shall be backfilled with soil containing not more than 40% rock or shale which shall be able to pass through a 100 mm sieve and which is approved by the Engineer.

Where more than 40%, but less than 70% rock occurs, the Contractor shall replace the rock with imported soil. However, should more than 70% rock occur then all the backfilling material shall be imported.

(a) The Contractor may import further stone-free material to the site or sieve the excavated material for sand bedding and cover but payment shall only be compensated for the actual quantity of imported material required as determined by the engineer. The quantity of imported material required shall be calculated from the nominal trench width.

(b) The excavated material shall be backfilled in layers of 150 mm and shall be well compacted and consolidated to 90% MOD AASHTO. Where necessary the Engineer may require that a mechanical vibrator be used for compacting the trench.

(c) The Contractor shall maintain the completed sections of the cable trench in a proper safe condition for the duration of the contract. The Contractor shall refill and compact the trench where subsidence occurs.

(d) After completion of the work, the route of the cable shall be neatly finished off and cleared. All stones bigger than 25 mm as well as all loose organic material and rubble shall be removed.

E06.4.17 Identification and Marking of Cable Routes

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 “ELECTRICAL CABLES”, the cable voltage and the direction indicated in which the cables run. If there are C&I cables in the same trench, there must be a separate label engraved with “C&I CABLES”, 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.

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 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).

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.

Cable route markers must be protected in areas of high vehicle traffic.

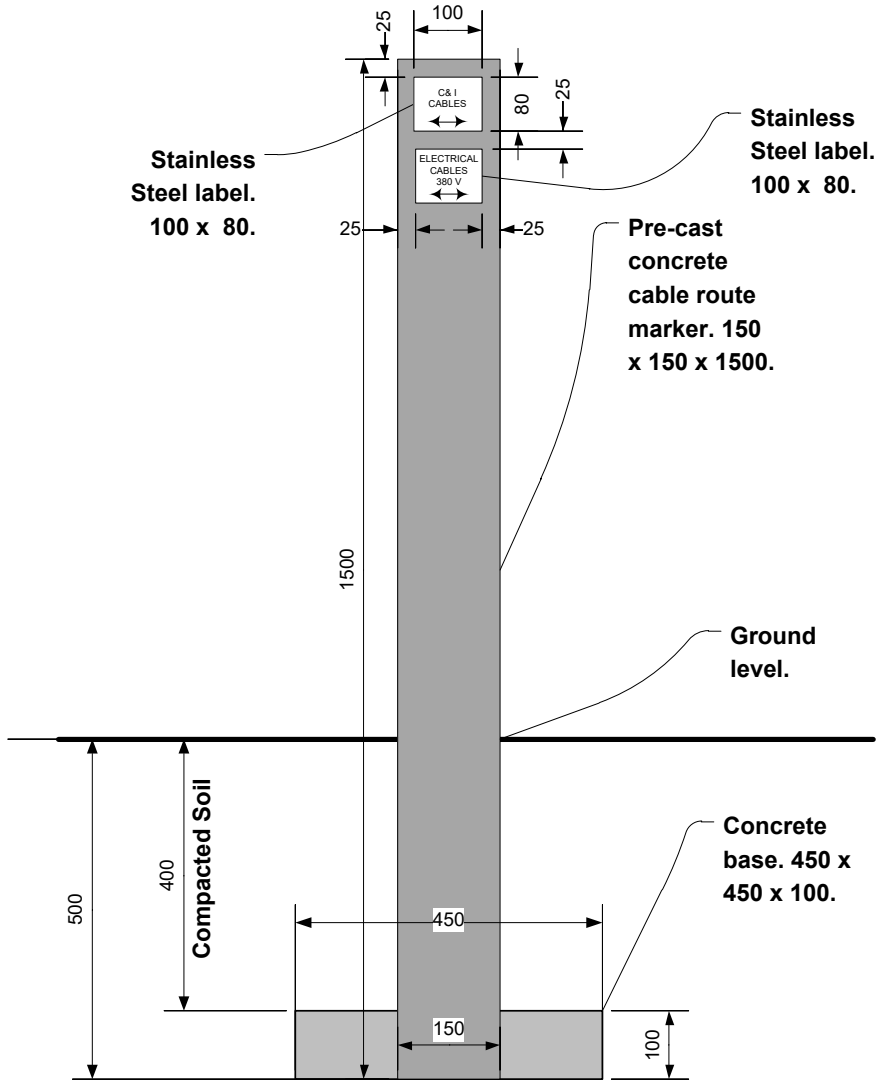



Figure 1 below provides the required detail of these cable route markers.

**Figure 1:** Cable Route Markers

E06.4.18 Road Crossings

The cable sleeves shall be installed 1,5m below ground level to avoid damage when the roads are constructed.

Unless otherwise specified, two additional sleeves shall be installed for future use at each road crossing.

Sleeves used for crossings shall be straight and undamaged. Bends shall not be allowed in road crossings. Sleeves shall be extended for a distance of 1,0m outside the roadway.

After the installation of the sleeves, the sleeves shall be meticulously backfilled so that no air pockets are left. The trench shall thereafter be backfilled in layers of 150 mm and compacted with mechanical vibrators to 95% modified AASHTO density.

The Contractor shall lay and join the cable sleeves and compact the trench to the satisfaction

of the engineer. After installation, the sleeves shall be cleaned and a galvanised steel draw wire installed in the sleeve prior to the sleeve ends being sealed by means of plastic plugs.

E06.4.19 Crossing of Services

Where a cable crosses over other services, the cable shall not be installed at a depth less than 800 mm below ground level and if this is not possible, the cable shall be installed underneath the other service and shall be protected in the prescribed manner by means of concrete slabs. The depth of the cable shall be maintained for one metre on either side of the crossing.

If it is not possible to cross over or underneath a service in the prescribed manner, the matter shall be referred to the Engineer for a decision.

The following minimum clearances shall be maintained between electrical cables and other services:-

| | Vertical | Horizontal |
|---|---|---|
| Water pipes | 0,3 | 1,0 |
| Sewer pipes | 0,3 | 1,0 |
| Storm water pipes | 0,3 | 1,0 |

## E06.5 CABLE INSTALLATION IN CABLE DUCTS

E06.5.1 General

This paragraph covers the installation of cables in build-up trenches, service ducts, etc. inside buildings. The trenches, ducts, etc. will be constructed and installed by others.

The use of this method of cable routing should be avoided where possible as it exposes the cables to high risk of theft. Open channels shall not be used for cable routing on any site.

E06.5.2 Installation

Cables shall be installed in one of the following ways:

(a) On vertical cable trays or.
(b) On metal supports fixed to the side of the trench with suitable clamps.

Cables shall be clamped in position.

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

E06.5.3 Covers

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

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

E06.5.4 Filled Trenches

Where specified herein, floor trenches shall be filled with sand.

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

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

(a) Reinforced concrete covers;
(b) 100mm of 20MPa concrete;
(c) Removable chequer plates. However, this will not be acceptable in open spaces.

Reinforced concrete covers shall be used where vehicular traffic may be encountered over trenches. Unless otherwise specified herein, allowance for a mass of 2 tons shall be made.

## E06.6 CABLE JOINTS

E06.6.1 General

Joints in cable runs will not be allowed unless authorized by the Engineer.

Jointing shall be carried out strictly in accordance with the manufacturer's instructions. Only personnel competent in the installation of the specific joint will carry out the work.

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

The crossing of cores in joints shall not be permitted under any circumstances. The electrical continuity of all the conductors, screens and armouring shall not be impaired by the joints and the earth continuity shall be accomplished within the joints, i.e. no external earth continuity conductor that will be subject to corrosion, is acceptable.

Joints shall be waterproof and airtight and shall be free of voids and air pockets. The joint shall not impair the anti-electrolysis characteristics of the cable. In the case of joints in cables with an outer PVC anti-electrolysis sheath, the joints shall be subject to the same electrical insulation test as the outer sheath of the cable.

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

E06.6.2 Medium Voltage Cable Joints

Medium voltage cable joints shall be of the heat shrink type.

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

The materials shall comply with VDE 0278 and the supplier shall be called upon to confirm this aspect before acceptance of the materials or installation.

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

Joint kits shall be of a reputable brand.

E06.6.3 Low Voltage Cable Joints

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

The resin filled joint kit shall comprise a self-sealing plastic mould of high mechanical strength having sufficient connector space. The exact amount of cold hardening resin shall be provided

in a two-compartment plastic bag. The resin shall have absolute minimum shrinkage. The mould and resin shall be waterproof and non-hygroscopic and shall be resistant to ultraviolet radiation.

Joint kits shall be of a reputable brand.

## E06.7 CABLE TERMINATION

E06.7.1 General

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

(a) Conductor no 1 : left (red)
(b) Conductor no 2 : centre (white)
(c) Conductor no 3 : right (blue)

Exposed armouring is not acceptable. Glands will be properly fitted with shrouds to cover any bare armouring.

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

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

Cable cores shall be marked with heat-shrunk sleeves where necessary to identify the phases. Refer to SANS 10142.

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

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

E06.7.2 Cable Glands

All cable glands for indoor and outdoor use shall be Ex rated as per SABS 1213 and have corrosion proof guard. It shall have a minimum IP rating of 68.The cable glands shall be suitable for use in hazardous areas classified for zone 1,2,21 and 22.

Cable glands shall be of the adjustable type gland suitable for indoor use and shall be suitable for use with PVC PVC SWA PVC cables complying with the latest edition of SANS 1507. All glands shall be installed with non-deteriorating neoprene shrouds.

Outdoor use cable glands shall be similar to the indoor use cable glands with an additional feature of a nipple gasket and an inner seal kit, rendering the gland suitable for type "EXe" equipment (increased safety equipment).

In high corrosive areas, such as chlorination, chemical dosing and inlet works areas, the cable gland shall

(a) offer a minimum degree of ingress protection of IP 66 according to SANS 60529;
(b) be suitable for type " EXe " equipment;
(c) be corrosion proof;
(d) Have a positive seal internal to the cable gland that seals over the cable outer sheath. For these applications, no shrouds are required.

For all gland installations on armoured cable, the outer sheath of the cable shall be cut back in accordance with the gland manufacturers' recommendations, so that a minimum of armouring is exposed between the gland and the outer sheath after gland installation. The shroud shall seal on the outer sheath of the cable.

E06.7.3 Cable Lugs

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

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

Lugs crimped to aluminium shall be subjected to thorough inspection with relation to the material and quality of crimping by the Engineer. Bi-metallic aluminium-copper lugs shall be used according to the manufacturer's specifications, where solid aluminium conductors are terminated onto copper busbars.

Fixing bolts shall be manufactured of cadmium plated high tensile steel and shall match the lug hole size. Contact surfaces between the lug and the busbar shall be thoroughly cleaned and smoothed.

When cutting away insulation from cable conductors to fit into lugs, care shall be taken that no strands are left exposed. Under no circumstances may any of the conductor strands be cut away to fit into lugs. Care must be taken when cutting the insulation not to damage the conductors.

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

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

E06.7.4 Medium Voltage Cable Terminations

Heat shrinkable termination kits shall be used for all high voltage (above 1 kV) terminations and shall be applied strictly in accordance with the manufacturer’s recommendations.

The complete termination kit shall be packed in a container that is marked for the type of cable insulation and construction as well as the voltage range for which the materials are suitable. An illustrated set of instructions for the installation of the materials shall accompany every termination kit.

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

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

The materials shall comply with VDE 0278 and the supplier shall be called upon to confirm this aspect before acceptance of the materials or installation.

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

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

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

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

E06.7.5 Cable Identification

Cables shall be identified at all terminations (both ends). The identification of MV cables installed in cable ladders, ducts or to structures shall be to SANS 10142-1.

Both ends of the cable shall be marked with the cable number in accordance with the cable schedule. The cable tag shall comprise of a punched stainless steel strap that shall be tied onto the cable by means of a thin stainless steel tape

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

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

## E06.8 TESTING OF THE INSTALLATION

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 accepted/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:

(b) The Occupational Health and Safety Act (OHSA) 1994;

(c) SANS 97 (Electric cables - Impregnated paper-insulated metal-sheathed cables for rated voltages 3,3/3,3 kV to 19/33 kV)

| **SANS 97** Test Wave | Duration (min) | Commissioning test voltage between conductors (V) | | | Commissioning test voltage between conductors / sheath (V) | | |
|---|---|---|---|---|---|---|---|
| | | 3300/ 3300 | 3800/ 6600 | 6350/ 11000 | 3300/ 3300 | 3800/ 6600 | 6350/ 11000 |
| AC (r.m.s) | 15 | 7000 | 13000 | 22000 | 7000 | 8000 | 13000 |
| DC | 15 | 9000 | 19000 | 31000 | 9000 | 11000 | 19000 |

(d) SANS 1339 (Electric cables - Cross-linked polyethylene (XLPE) insulated cables for rated

voltages 3,8/6,6 kV to 19/33 kV)

| SANS 1339 Test Wave | Duration (min) | Commissioning test voltage between conductors (V) | | | |
|---|---|---|---|---|---|
| | | 6600 | 11000 | 22000 | 33000 |
| VLF (0.1 Hz) | 60 | 11000 | 19000 | 38000 | 57000 |
| Power frequency | 60 | 8000 | 13000 | 25000 | 38000 |
| DC | 10 | 6000 | 10000 | 20000 | 30000 |

DC voltage testing is likely to cause irreversible damage to XLPE-insulated cable systems. The voltage and duration should be limited to the appropriate values given in the table above. The contractor shall use a DC test set to apply the test voltage. After completion of the DC test, the contractor shall soft-discharge the cable, using either the DC test set or a discharge stick where after the cable will be fully discharged by solidly earthing it for at least 8 h but preferably for 24 h. DC testing shall only be carried out with written permission from the Engineer,

(e) SANS 1507 (Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V));

| SANS 1507 Test Wave | Duration (min) | Commissioning test voltage between conductors (V) | | | Commissioning test voltage between conductors / earth (V) | | |
|---|---|---|---|---|---|---|---|
| | | 300/ 500 | 600/ 1000 | 1900/ 3300 | 300/ 500 | 600/ 1000 | 1900/ 3300 |
| AC (rms) | 15 | 1000 | 2000 | 6000 | 1000 | 2000 | 3500 |
| DC | 15 | 1500 | 3000 | 9000 | 1500 | 3000 | 5000 |

## E06.9 COMPLETION

The Engineer reserves the right to inspect the installation at any stage during the course of construction. However, such inspections will not deem the portions inspected as being complete or accepted and the Contractor shall remain responsible to complete the installation fully in accordance with this specification.

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

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

(a) Overall length of each cable;

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

(c) The location of all cable markers in relation to permanent reference points;

(d) Identification numbers of all cables.

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

**JOHANNESBURG WATER PARTICULAR SPECIFICATION:**

**VOLUME E08: ELECTRICAL WIRING**

**CONTENTS**

## 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:

(f) The Occupational Health and Safety Act (OHSA) 1994;

(g) 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 PARTICULAR SPECIFICATION :

VOLUME E09 : ELECTRICAL BUILDING INSTALLATION

CONTENTS

## 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), | Stainless steel 3CR12 and epoxy powder |

| | | |
|---|---|---|
| | laundries, dewatering buildings, pump stations or other damp areas damp areas. | 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 45º 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

(e) ..... 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 PARTICULAR SPECIFICATION : VOLUME E11 : GENERAL ELECTRICAL GENERAL EARTHING AND LIGHTNING PROTECTION

CONTENTS

## 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.

### E11.6.6 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.

### E11.6.7 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).

### E11.6.8 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.

### E11.6.9 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.

### E11.6.10 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.

### E11.6.11 Components

All material and components used in a LPS must conform to the requirements specified in SANS 62561.

### E11.6.12 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.

E11.8.2 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.

E11.8.3 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.

E11.8.4 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.

E11.8.5 Telecommunication and Instrumentation lines

Please refer to Automation and Control Design Standards, Volume 5: Clean Power and Surge Protection.

E11.8.6 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).

E11.8.7 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 component | Material | Cross-section (sq. mm) |
|---|---|---|
| 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.

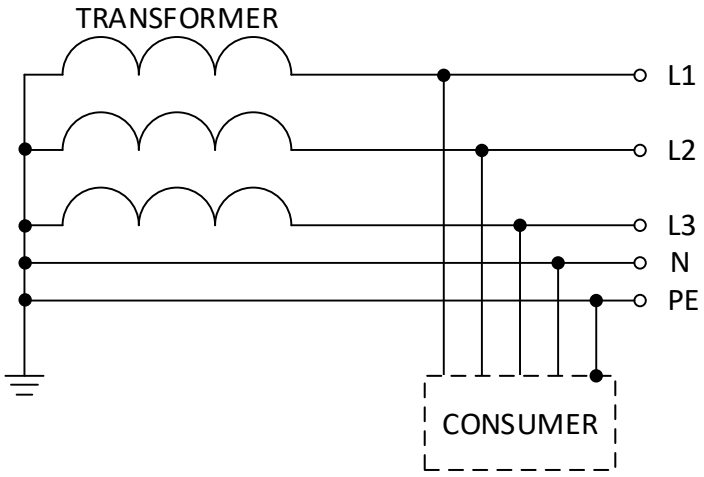



**Figure 1**. *TN-S System earthing*

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.

## E11.13 LIGHTNING PROTECTION SYSTEM (LPS)

Figure 2 shows a typical LPS as implemented by Johannesburg Water

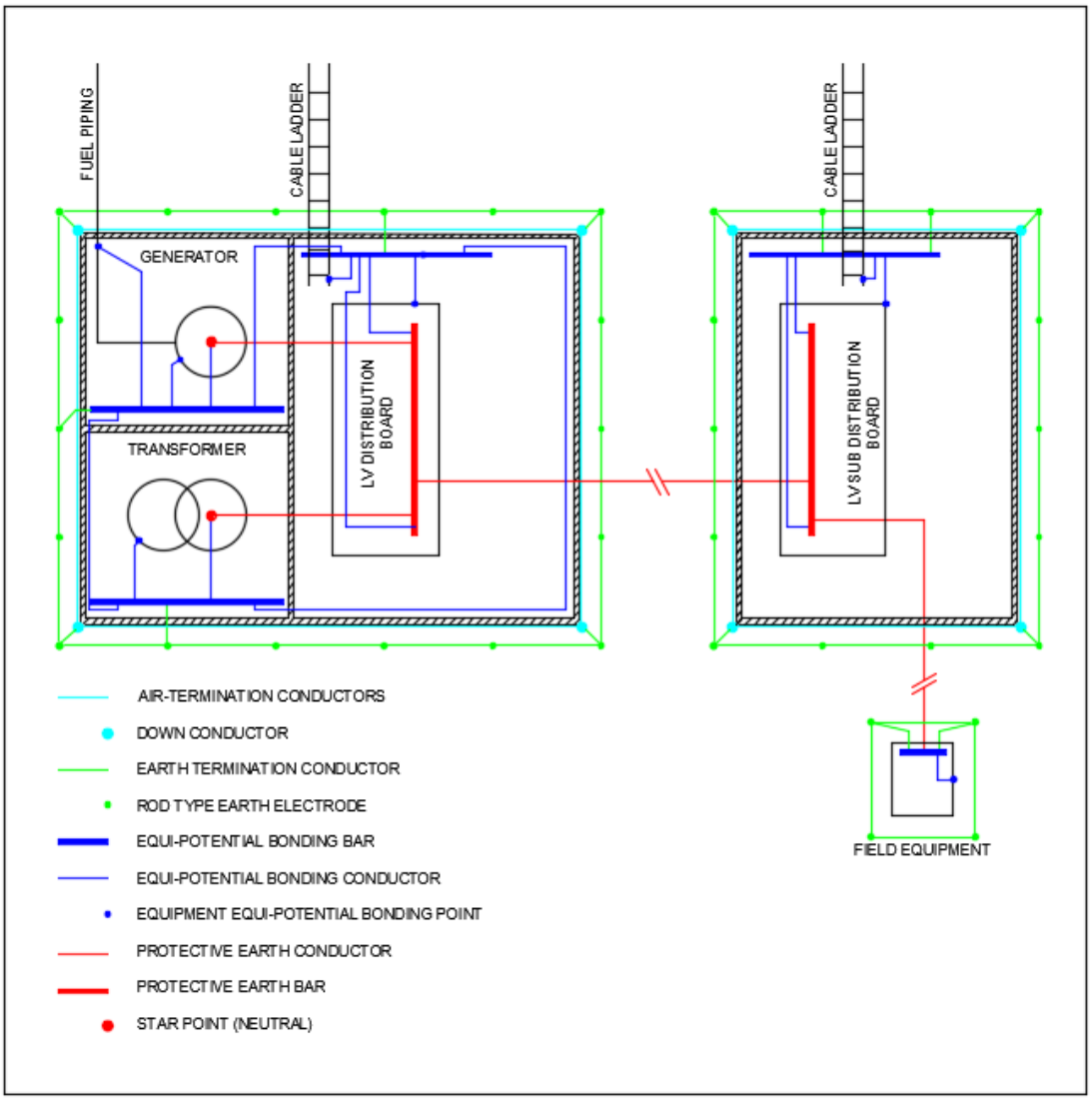



**Figure 2**. *Lighting Protection System (LPS)*

## E11.14 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.

# PARTICULAR SPECIFICATION: VOLUME E12: ELECTRICAL MEDIUM VOLTAGE CABLES

## CONTENTS

## E12.1 INTRODUCTION

This specification covers the following:

(a) Medium Voltage (MV) cables for underground and surface installation;

(b) The type of MV cables that shall be used;

(c) The general requirements of the MV cables;

(d) The practice to be followed when storing, installing and testing the cables.

## E12.2 SCOPE

E12.2.1 General

This specification details the requirements for single-core and three-core, MV cables. The preferred type of MV cables which is detailed in this specification is:

(a) Paper insulated and lead covered double steel tape armoured 6.35/11kV cables to SANS 97;

(b) Three-core cross-linked polyethylene (XLPE) insulated PVC bedded, steel wire armoured, PVC sheathed 6.35/11kV cables to SANS 1339 Type A (Individually screened).

E12.2.2 Work to be included

The scope of work includes the supply, delivery and storage of MV cables prior to installation of the cables.

The following is specifically included in the scope:

(a) Description of the MV cables required for the work.

(b) Marking and labelling of the cables and cable drums.

E12.2.3 Work to be excluded

The following work and items are specifically excluded from the scope of work:

(a) All civil works

(b) Installation, laying or termination of any cables.

## E12.3 STATUTORY DOCUMENTS AND STANDARDS

E12.3.1 Standards

The cables and their installation methods shall comply with the requirements of this specification including the valid and relevant requirements of the following Acts, Codes of Practice and Standards:

| | | |
|---|---|---|
| SANS 10142-1 | : | The wiring of premises Part 1: Low-voltage installations |
| SANS 10142-2 | : | The wiring of premises Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 MVA installed capacity |

| | | |
|---|---|---|
| BS EN 13601 | : | Copper and copper alloys. Copper rod, bar and wire for general electrical purposes |
| SANS 97 | : | Electric Cables – Impregnated paper-insulated metal-sheathed cables for rated voltages 3.3/3.3 kV to 19/33 kV |
| SANS 1339 | : | Electric cables - Cross-linked Poly-ethylene (XLPE) insulated cables for rated voltages 3.8/6.6kV to 19/33kV |
| SANS 1507 | : | Electrical cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) |
| SANS 1411 | : | Materials of insulated electric cables and flexible cords |
| SANS 1520 | : | Flexible electrical trailing cables for use in mines |
| IEC 60287 | : | Electric cables - Calculation of the current rating |
| VDE 0250 | : | Cables, wires and cords for power installation |
| SANS 10198 | : | The selection, handling and installation of electric power cables of rating not exceeding 33kV |

a) The Occupational Health and Safety Act (Act 85 of 1993)

E12.3.2 Particular Specifications to be read in conjunction with this specifications

The following particular specifications shall be read in conjunction with the Project Specification:

| | | |
|---|---|---|
| E23 | : | ELECTRICAL SPECIFICATION FOR COLOUR CODE |
| G02 | : | PARTICULAR SPECIFICATION FOR CORROSION PROTECTION |
| E06 | : | ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION |

## E12.4 DEFINITIONS

| | |
|---|---|
| PILC Cable | Single-core and three-core, paper insulated lead covered electric cables |
| Armour | A layer or layers of galvanized steel wires applied to the cable to provide mechanical protection or earth continuity, or both. |
| Sheath | A solid extruded protective covering applied as the exterior of a cable or a flexible cord. |
| Bedding | A layer of extruded compound applied to the cable beneath the armouring. |
| Core | A single insulated conductor without protective covering. |
| XLPE | Cross-linked Poly-ethylene cable |

## E12.5 CABLE REQUIREMENTS

E12.5.1 General

PILC cables shall comply with the requirements of SANS 97.

XLPE cables shall comply with SANS 1339

The nominal cable voltage will be 6.35/11kV.

The cores of three-core cables shall be identified by the colours Red, White and Blue (R, W, B) or numbers 1, 2 and 3.

E12.5.2 Specific Requirements of MV Cables

*E12.5.2.1 Voltage Frequency*

The cable is needed for an underground, three phase, medium voltage, 50 hertz, alternating current distribution system.

*E12.5.2.2 Core Screen*

The conductor core shall be individually screened. The core screen shall be strippable.

*E12.5.2.3 Metal Sheath*

The metal sheath shall comprise of pure lead for PILC.

XLPE cables shall be PVC.

*E12.5.2.4 Bedding*

A bitumen impregnated fibrous bedding complying with SANS 97 shall be provided.

XLPE cables must be PVC bedded.

*E12.5.2.5 Armour*

Double steel tape armouring in accordance with SANS 97.

XLPE cables to have a steel or aluminium wire armour.

*E12.5.2.6 Outer Sheath (Serving)*

A PVC outer sheath will be required for XLPE, An impermeable black PVC sheath in accordance with SANS 97 shall be provided for PILC.

*E12.5.2.7 Conductors*

The standard conductor shall be copper or aluminium with cross-sectional areas as specified in Table 1:

| CONSTRUCTION | PILC | | XLPE TYPE A | |
|---|---|---|---|---|
| | NOMINAL VOLTAGE (kV) | | NOMINAL VOLTAGE (kV) | |
| | 3.8 / 6.6 | 6.35 / 11 | 3.8 / 6.6 | 6.35 / 11 |
| | AREA (sq mm) | | AREA (sq mm) | |
| 1 CORE Copper/Aluminium | - | - | 50 | 50 |
| | - | - | 70 | 70 |
| | - | - | 95 | 95 |
| | - | - | 120 | 120 |
| | 150 | 150 | 150 | 150 |
| | 185 | 185 | 185 | 185 |
| | 240 | 240 | 240 | 240 |
| | 300 | 300 | 300 | 300 |
| 3 CORE Copper/Aluminium | 25 | 25 | 25 | 25 |
| | 35 | 35 | 35 | 35 |
| | 50 | 50 | 50 | 50 |
| | 70 | 70 | 70 | 70 |
| | 95 | 95 | 95 | 95 |
| | 120 | 120 | 120 | 120 |
| | 150 | 150 | 150 | 150 |
| | 185 | 185 | 185 | 185 |
| | 240 | 240 | 240 | 240 |
| | 300 | 300 | 300 | 300 |

**Table 1**: Standard Cable Conductor Cross Sectional Areas

*E12.5.2.8* *Cable Markings*

Cables shall be legibly marked as specified in SANS 97, including:

(a) Conductor size in square millimetres

(b) Number of cores

(c) Conductor material (copper)

(d) The specification number (SANS 97) to which the cable has been manufactured.

(e) The year of manufacture

(f) Nominal voltage

Typically cable marking – MAKE YEAR 6.6/11kV XXmm$^2$ x 3 Cu SANS 97

## E12.6 MARKING, LABELLING AND PACKAGING

E12.6.1 Packaging

Cables shall be supplied on wooden drums.

Unless otherwise stated, standard drum lengths shall be 300m for all 3-core cables.

E12.6.2 Marking of drums

On the cable drums, weatherproof and well legible labels shall be fixed, containing the information as follows:

(a) Cable manufacturer;

(b) Complete cable identification according to applied standard;

(c) Delivery length (in meter);

(d) Overall weight;

(e) Cable drum number;

(f) Rolling direction arrow.

## E12.7 TESTING OF CABLES

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) SANS 10142-2

(c) SANS 97 (Electric cables - Impregnated paper-insulated metal-sheathed cables for rated voltages 3,3/3,3 kV to 19/33 kV)

| **SANS 97** | Duration (min) | Commissioning test voltage between conductors (V) | | | Commissioning test voltage between conductors / sheath (V) | | |
|---|---|---|---|---|---|---|---|
| Test Wave | | 3300/ 3300 | 3800/ 6600 | 6350/ 11000 | 3300/ 3300 | 3800/ 6600 | 6350/ 11000 |
| AC (r.m.s) | 15 | 7000 | 13000 | 22000 | 7000 | 8000 | 13000 |
| DC | 15 | 9000 | 19000 | 31000 | 9000 | 11000 | 19000 |

(d) SANS 1339 (Electric cables - Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV)

| **SANS 1339** | Duration (min) | Commissioning test voltage between conductors (V) | | | |
|---|---|---|---|---|---|
| Test Wave | | 6600 | 11000 | 22000 | 33000 |

| | | | | | |
|---|---|---|---|---|---|
| VLF (0.1 Hz) | 60 | 11000 | 19000 | 38000 | 57000 |
| Power frequency | 60 | 8000 | 13000 | 25000 | 38000 |
| DC | 10 | 6000 | 10000 | 20000 | 30000 |

DC voltage testing is likely to cause irreversible damage to XLPE-insulated cable systems. The voltage and duration should be limited to the appropriate values given in the table above. The contractor shall use a DC test set to apply the test voltage. After completion of the DC test, the contractor shall soft-discharge the cable, using either the DC test set or a discharge stick where after the cable will be fully discharged by solidly earthing it for at least 8 h but preferably for 24 h. DC testing shall only be carried out with written permission from the Engineer,

(e) The requirements of the Local and Supply Authorities.

## E12.8 QUALITY ASSURANCE

All cables supplied under the scope of works of this project shall be designed and manufactured under a quality control system, typically to the ISO 9000 series. The contractor must supply proof of manufacturer's certification.

## E12.9 MEASURE AND PAYMENT

All cables supplied under the scope of works of this project shall be designed and manufactured under a quality control system, typically to SANS ISO 9000 series.

**Item** **Unit**

Supply and delivery of medium voltage paper insulated cable .....m

The unit of measurement shall be the metre of cable supplied and installed.

The tendered rate shall include full compensation for the supply and delivery of the specified cable to the site.

# ANNEX A

## Derating Factors FOR PILC Cables

## For Installation Conditions other than Standard

| Variations of depth of laying - single and multicore PILC cables | | | | |
|---|---|---|---|---|
| Depth of laying | Direct in ground | | In single way ducts | |
| m | Up to 300 $mm^2$ | Above 300 $mm^2$ | Single core | Multi- core |
| 0,5 | 1,15 | 1,15 | 1,15 | 1,15 |
| 0,6 | 1,10 | 1,10 | 1,10 | 1,10 |
| 0,8 | 1,00 | 1,00 | 1,00 | 1,00 |
| 1,0 | 0,98 | 0,97 | 0,98 | 0,99 |
| 1,25 | 0,96 | 0,95 | 0,95 | 0,97 |
| 1,5 | 0,95 | 0,94 | 0,93 | 0,96 |
| 2,0 | 0,92 | 0,90 | 0,90 | 0,94 |

| Variations of thermal resistivity of soil - single and multicore PILC cables | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Conductor Size | Direct in ground | | | | In single way ducts | | | |
| | Size Soil resistivity (K.m/W) | | | | Size Soil resistivity. K.m/W | | | |
| $mm^2$ | 1 | 1.5 | 2 | 2.5 | 1 | 1.5 | 2 | 2.5 |
| 25 | 1.06 | 0.93 | 0.85 | 0.78 | 1.03 | 0.96 | 0.91 | 0.86 |
| 35 | 1.06 | 0.93 | 0.85 | 0.78 | 1.03 | 0.96 | 0.9 | 0.85 |
| 50 | 1.07 | 0.93 | 0.84 | 0.77 | 1.03 | 0.96 | 0.9 | 0.85 |
| 70 | 1.07 | 0.93 | 0.84 | 0.77 | 1.03 | 0.96 | 0.9 | 0.85 |
| 95 | 1.07 | 0.93 | 0.84 | 0.77 | 1.03 | 0.95 | 0.89 | 0.84 |
| 120 | 1.07 | 0.92 | 0.83 | 0.76 | 1.03 | 0.95 | 0.89 | 0.83 |
| 150 | 1.07 | 0.92 | 0.83 | 0.76 | 1.04 | 0.95 | 0.89 | 0.83 |
| 185 | 1.07 | 0.92 | 0.82 | 0.75 | 1.04 | 0.95 | 0.88 | 0.82 |
| 240 | 1.07 | 0.92 | 0.82 | 0.75 | 1.04 | 0.95 | 0.88 | 0.82 |
| 300 | 1.07 | 0.92 | 0.82 | 0.74 | 1.04 | 0.95 | 0.87 | 0.82 |
| 400 | 1.07 | 0.91 | 0.81 | 0.74 | 1.04 | 0.94 | 0.86 | 0.81 |
| 500 | 1.08 | 0.91 | 0.8 | 0.72 | 1.05 | 0.94 | 0.84 | 0.78 |
| 630 | 1.08 | 0.91 | 0.79 | 0.72 | 1.05 | 0.94 | 0.84 | 0.78 |
| 800 | 1.08 | 0.9 | 0.79 | 0.71 | 1.06 | 0.93 | 0.83 | 0.77 |
| 1000 | 1.08 | 0.9 | 0.79 | 0.71 | 1.06 | 0.93 | 0.83 | 0.76 |

| Ground Temperature derating factors | | | | | |
|---|---|---|---|---|---|
| Maximum sustained conductor temperature °C | Ground Temperature °C | | | | |
| | 25 | 30 | 35 | 40 | 45 |
| 70 | 1.00 | 0.95 | 0.90 | 0.85 | 0.80 |
| 80 | 1.00 | 0.96 | 0.92 | 0.88 | 0.83 |

| Derating factors for grouping of multicore PILC cables in horizontal formation in ground or ducts | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. of cables in group | In ground - Axial spacing m | | | | | In ducts - Axial spacing m | | | |
| | Touch | 0,15 | 0,30 | 0,45 | 0,60 | Touch | 0,30 | 0,45 | 0,60 |
| 2 | 0,80 | 0,85 | 0,89 | 0,90 | 0,92 | 0,88 | 0,91 | 0,93 | 0,94 |
| 3 | 0,69 | 0,75 | 0,80 | 0,84 | 0,86 | 0,80 | 0,84 | 0,87 | 0,89 |
| 4 | 0,63 | 0,70 | 0,77 | 0,80 | 0,84 | 0,75 | 0,81 | 0,84 | 0,87 |
| 5 | 0,57 | 0,66 | 0,73 | 0,78 | 0,81 | 0,71 | 0,77 | 0,82 | 0,85 |
| 6 | 0,55 | 0,63 | 0,71 | 0,76 | 0,80 | 0,69 | 0,75 | 0,80 | 0,84 |

| No. of circuits | Derating factors for Grouping of single core PLIC cables (3.3 to 22kV) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Horizontal formation in single way ducts | | | Horizontal formation laid direct | | | | | |
| | Axial spacing | | | Axial spacing of circuits | | | | | |
| | m | | | m | | | | | |
| | Touch | 0.45 | 0.60 | Touch | | 0.15 | 0.30 | 0.45 | 0.60 |
| | | | | Trefoil | Flat | | | | |
| 2 | 0.85 | 0.88 | 0.90 | 0.78 | 0.80 | 0.81 | 0.85 | 0.88 | 0.90 |
| 3 | 0.75 | 0.80 | 0.93 | 0.66 | 0.69 | 0.71 | 0.76 | 0.80 | 0.83 |
| 4 | 0.70 | 0.76 | 0.80 | 0.60 | 0.63 | 0.65 | 0.72 | 0.76 | 0.80 |
| 5 | 0.67 | 0.73 | 0.77 | 0.55 | 0.58 | 0.61 | 0.68 | 0.73 | 0.77 |
| 6 | 0.64 | 0.71 | 0.76 | 0.52 | 0.55 | 0.58 | 0.66 | 0.72 | 0.76 |
| 7 | 0.62 | 0.70 | 0.75 | 0.49 | 0.52 | 0.55 | 0.63 | 0.70 | 0.74 |
| 8 | 0.61 | 0.69 | 0.74 | 0.47 | 0.51 | 0.54 | 0.62 | 0.69 | 0.74 |
| 9 | 0.59 | 0.68 | 0.73 | 0.45 | 0.49 | 0.52 | 0.61 | 0.68 | 0.73 |
| 10 | 0.58 | 0.67 | 0.73 | 0.44 | 0.48 | 0.51 | 0.60 | 0.67 | 0.73 |
| 11 | 0.58 | 0.66 | 0.72 | 0.43 | 0.46 | 0.49 | 0.59 | 0.67 | 0.72 |
| 12 | 0.57 | 0.66 | 0.72 | 0.42 | 0.46 | 0.49 | 0.58 | 0.66 | 0.72 |

| Derating factors for variations in ambient air temperature | | | | |
|---|---|---|---|---|
| Maximum sustained conductor temperature °C | Ground Temperature °C | | | |
| | 30 | 35 | 40 | 45 |
| 70 | 1 | 0.94 | 0.87 | 0.79 |
| 80 | 1 | 0.95 | 0.89 | 0.79 |

## ANNEX B

### Derating Factors FOR XLPE Cables

### For Installation Conditions other than Standard

| RATING FACTORS FOR DEPTH OF LAYING | |
|---|---|
| Depth of Laying (mm) | Factor |
| 500 - 800 | 1.00 |
| 850 - 1000 | 0.97 |
| 1050 - 1200 | 0.95 |
| 1250 - 1400 | 0.93 |
| 1450 - 1600 | 0.92 |

| RATING FACTORS FOR GROUND TEMPERATURE | | |
|---|---|---|
| Ground Temperature | Conductor Temperature | |
| °C | 90°C | 65°C |
| 25 | 1.00 | 1.00 |
| 30 | 0.96 | 0.94 |
| 35 | 0.92 | 0.87 |
| 40 | 0.88 | 0.79 |

| RATING FACTORS FOR THERMAL RESISTIVITY OF GROUND | |
|---|---|
| Thermal Resistivity K.m/W | Factor |
| 0.7 | 1.23 |
| 1.0 | 1.08 |
| 1.2 | 1.00 |
| 1.5 | 0.90 |
| 2.0 | 0.80 |
| 2.5 | 0.72 |
| 3.0 | 0.66 |

| GROUP RATINGS FOR 3-CORE VULTEX CABLES IN FLAT FORMATION IN GROUND | | | |
|---|---|---|---|
| No. of cables in same trench | Spacing | | |
| | Touching | 0.25 m | 0.7 m |
| 2 | 0.79 | 0.85 | 0.87 |
| 3 | 0.69 | 0.75 | 0.79 |
| 4 | 0.63 | 0.68 | 0.75 |
| 5 | 0.58 | 0.64 | 0.72 |
| 6 | 0.55 | 0.60 | 0.69 |

| | | | |
|---|---|---|---|
| 8<br>10 | 0.50<br>0.46 | 0.56<br>0.53 | 0.66<br>0.64 |

| RATING FACTORS FOR AMBIENT AIR TEMPERATURE | | | | | |
|---|---|---|---|---|---|
| Conductor Temp. °C | Air temperature °C | | | | |
| | 30 | 35 | 40 | 45 | 50 |
| 90 | 1.00 | 0.95 | 0.89 | 0.84 | 0.78 |

| XLPE cable on trays, ladders or building structures | | | | | | |
|---|---|---|---|---|---|---|
| Type of laying | | | No. of ladders or trays | Number of cables | | |
| | | | | 1 | 2 | 3 |
| | | | | Rating factors | | |
| Horizontal on metal tray | Touching | | 1 | 0.97 | 0.85 | 0.74 |
| | | | ≥ 2 | 0.97 | 0.83 | 0.71 |
| | Spacing | ≥ 30mm, ≥ D max 30mm | 1 | 0.97 | 0.96 | 0.93 |
| | | | ≥ 2 | 0.97 | 0.94 | 0.90 |
| Horizontal on metal tray | Touching | | 1 | 1.00 | 0.86 | 0.74 |
| | | | ≥ 2 | 1.00 | 0.82 | 0.71 |
| | Spacing | ≥ 30mm ≥ D, max 30mm | 1 | 1.00 | 1.00 | 1.00 |
| | | | ≥ 2 | 1.00 | 1.00 | 1.00 |
| Horizontal on floor | Touching | | | 0.94 | 0.80 | 0.66 |
| | Spacing | ≥ 30mm, ≥ D max 30mm | | 0.94 | 0.90 | 0.87 |
| Vertical on wall | Touching | | | 0.94 | 0.80 | 0.66 |
| | Spacing | ≥ 30mm, ≥ D max 30mm | | 0.94 | 0.90 | 0.87 |
| Horizontal in ceiling | Touching | | | 0.89 | 0.76 | 0.57 |
| | Spacing | ≥ 30mm, ≥ D max 30mm | | 0.89 | 0.81 | 0.77 |

## PARTICULAR SPECIFICATION: VOLUME E13: ELECTRICAL MEDIUM VOLTAGE SWITCHGEAR

## CONTENTS

## E13.1 SCOPE

This specification covers the supply, delivery, installation, testing and commissioning of indoor metal-clad switchgear and associated equipment.

## E13.2 STATUTORY DOCUMENTS AND STANDARDS

E13.2.1 STANDARDS

All materials and apparatus shall be new and of the best quality and shall comply with the relevant current specifications of the SANS, BSI or IEC and as stated in this document.

The following standards may be used as a guide but must not be regarded as a complete list.

| | | |
|---|---|---|
| SANS 62271-1 | : | High-voltage switchgear and controlgear Part 1: Common specifications for alternating current switchgear and controlgear |
| SANS 62271-200 | : | High-voltage switchgear and controlgear Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV |
| SANS 62271-103 | : | High-voltage switchgear and controlgear Part 103: Switches for rated voltages above 1 kV up to and including 52 kV |
| SANS 62271-100 | : | High-voltage switchgear and controlgear Part 100: Alternating-current circuit-breakers |
| SANS 62271-102 | : | High-voltage switchgear and controlgear Part 102: Alternating current disconnectors and earthing switches |
| SANS 62271-105 | : | High-voltage switchgear and controlgear Part 105: Alternating current switch-fuse combinations for rated voltages above 1 kV up to and including 52 kV |
| SANS 62271-107 | : | High-voltage switchgear and controlgear Part 107: Alternating current fused circuit-switchers for rated voltages above 1 kV up to and including 52 kV |
| SANS 62271-206 | : | High-voltage switchgear and controlgear Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV |
| SANS 60282-1 | : | High-voltage fuses Part 1: Current-limiting fuses |
| SANS 60529 | : | Degrees of protection provided by enclosures (IP Code) |
| SANS 60044-8 | : | Instrument transformers Part 8: Electronic current transformers |
| SANS 61869-2 | : | Instrument transformers Part 2: Additional requirements for current transformers |

| | | |
|---|---|---|
| SANS 61869-3 | : | Instrument transformers Part 3: Additional requirements for inductive voltage transformers |
| IEC 62271-1 | | High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear |
| IEC 60255 | : | Measuring relays and protection equipment |

E13.2.2 PARTICULAR SPECIFICATIONS TO BE READ IN CONJUNCTION WITH THIS SPECIFICATIONS

The following particular specifications shall be read in conjunction with the Project Specification:

| | | |
|---|---|---|
| (a) E06 | : | ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION |
| (b) E05 | : | LOW VOLTAGE POWER AND CONTROL CABLE |
| (c) E20 | : | BATTERY TRIPPING UNIT |
| (d) E08 | : | WIRING |

## E13.3 SERVICE CONDITIONS

| | |
|---|---|
| Nominal voltage | 11 kV |
| Rupturing capacity | 20 kA |
| Impulse level | 95 kV |
| Highest system voltage | 12 kV |
| Rated short-time withstand current (Ik) | 20 kA (1 S) |
| Frequency | 50 Hz |
| Phases | 3 |
| Power factor | 0,5 - 0,85 lagging |

All switchgear and auxiliary equipment shall be designed to withstand the stresses of an unearthed system.

## E13.4 EXTENT OF WORK

The successful Tenderer will be responsible for the delivery, off-loading and erection on site, testing and putting into operation of the switchgear. The Contractor shall furthermore be responsible for checking all connections made by others and for commissioning the switchgear. All paintwork damaged during transport and/or erection and/or connecting up, etc., shall be made good to the satisfaction of the Engineer.

## E13.5 SWITCHGEAR LAYOUT

The switchboard shall be designed as a continuous assembly in a straight line, capable of being extended at either end.

The switchboard will be located in a totally enclosed, naturally ventilated chamber and shall be suitable for installation directly on a finished floor.

## E13.6 CUBICLE CONSTRUCTION

### E13.6.1 GENERAL

All cubicles shall be of the totally enclosed, floor mounted type and shall be vermin proof and where possible dustproof. The cubicles shall have a minimum enclosure rating of IP 42 to SANS 60529.

Cubicles shall be designed so that it is possible to add additional panels to existing switchboards without undue difficulty.

### E13.6.2 SEGREGATION OF CIRCUITS

Each circuit in a switchboard shall be provided with an individual cubicle so arranged that accidental contact with live parts in adjacent circuit cubicles is impossible.

It shall be possible to terminate the cables of any circuit without exposure to any live conductors of the same circuit while the busbars are energized.

### E13.6.3 DOORS

Where doors are provided on circuit breaker switch cubicles, the doors shall be fitted with handles consisting of a push-button-and-handle combination with a spring-loaded latch or a rotary handle-and-catch combination. The closing mechanism shall be designed to draw the door closed. Flush mounted ring type handles or square key operated latches are not acceptable. Locking latches shall be padlockable.

Doors shall be suitably braced and stiffened to carry the weight of equipment installed in doors and to prevent warping.

Control panel doors shall be fitted with handle closing mechanisms as described above. Alternatively, captive knurled bolts designed to be screwed in by hand may be used.

Doors shall have stops to prevent overswing of the door when opening and to prevent interference with adjacent panels.

Doors shall be fitted with suitable rubber or synthetic rubber seals.

All doors shall be bonded to the framework by a braided copper earth strap.

#### *E13.6.3.1 EARTHING*

All metal parts other than those forming part of electrical circuits shall be connected to the cubicle earth bar.

All non-current carrying conductive parts, including relays, instruments, transformer and contactor cores, etc. shall be effectively connected to the earth bar either by means of their mounting arrangements on the panel or by means of a special earthing conductor fitted with lugs for attaching to the earth bar.

## E13.7 CIRCUIT BREAKERS

#### *E13.7.1.1 GENERAL CONSTRUCTION*

Circuit breakers may be of the trip-free, double break, SF6 or vacuum type.

Circuit breakers shall be of the horizontal draw-out truck mounted type with either vertical or horizontal isolation action.

Each circuit breaker shall be installed in a freestanding metal clad cubicle and the front of each panel shall be totally enclosed.

It shall be possible to remove the circuit breakers from the cubicles without moving the cubicle, without removing parts thereof or without disconnecting any wiring thereto.

Any circuit breaker shall be interchangeable with any other panel of the board of the same rating. It shall not be possible to insert a circuit breaker into a higher rated circuit.

Contact spouts, bushings, covers, busbar insulators, etc. shall be designed to minimise dust collection.

Mechanical stops shall be provided to ensure accurate location of the circuit breaker truck prior to racking into the service position. The breaker carriage shall be locked in position on both sides of the cubicle with a robust mechanical lock that will not distort or jam under fault conditions.

All openings, joints, etc., in the entire switchboard shall be adequately vermin proofed.

All components including screws, nuts, bolts, washers, etc. used in the construction of or fixing of components shall be rendered corrosion proof.

### *E13.7.1.2 CIRCUIT BREAKING FEATURES*

The circuit breaker contacts shall ensure rapid and consistent extinction of the arc with a minimum release of arc energy under all loading and fault conditions and a low power factor.

The arcing contacts shall be tipped or coated with an erosion resistant material, preferably a tungsten alloy.

The main contacts shall be self-aligning with a high contact pressure and a self-cleaning action.

### *E13.7.1.3 BUSBAR AND CIRCUIT SHUTTERS*

Protective shutters, which automatically cover the contacts of the fixed portion of the switchgear when the circuit breaker is withdrawn to the isolation position, shall be provided.

The busbar orifices shall be provided with automatic separate shutters.

Facilities shall be provided for padlocking the shutters in the closed position.

All shutters shall close automatically after being opened by hand and it shall not be possible for the shutters or shutter operating links to be jammed by the circuit breaker.

Shutters shall be painted and designated as follows:

(a) Busbar shutters
The word "BUSBAR" in black lettering on a red background.

- Circuit shutters
  The word CABLE in black lettering on a yellow background.
- Earthing shutters
  The word "EARTH" in black lettering on a green background.
- Lettering shall be a minimum of 40 mm high.

*E13.7.1.4 INTERLOCKS*

The switchgear shall be mechanically interlocked in accordance with SANS 62271 and all interlocks shall be robust and shall not distort or jam in the event of an incorrect operation. The minimum safety features provided shall prevent the following actions:

(a) A closed circuit breaker from being withdrawn from or inserted into the isolating contacts. The circuit breaker shall trip if an attempt is made to do so.

(b) The closing of the circuit breaker except when it is correctly located and fully racked in the "service" or "earthing" positions or in the fully lowered position. It must, however, be possible to close the circuit breaker when it is fully withdrawn from the cubicle.

(c) The lowering of the tank of circuit breakers unless the circuit breaker is fully withdrawn and the racking-in of the circuit breaker unless the tank is securely bolted in position.

(d) The circuit breaker from being closed when the secondary circuits are not fully engaged. It shall also not be possible to remove the secondary circuit plugs unless the circuit breaker contacts are fully open.

(e) Electrical tripping of the circuit breaker when the circuit breaker is in the earthed position. Padlocking facilities shall also be provided to lock off the mechanical trip lever on the breaker mechanism.

(f) The integral earthing switch (where applicable) from closing unless the circuit breaker is in the correct earth position. It must not be possible to close the earth switch onto live busbars.

*E13.7.1.5 SECONDARY ISOLATING CONTACTS*

The connections in the secondary circuit between the fixed and moving portions of the equipment shall be by means of self-aligning contacts. Robust guide pins or other approved guides shall engage before the contacts.

Circuit breaker auxiliary contracts for functions common to the various panel type specified, shall be wired to secondary isolating contacts in the same relative position on all panel types specified.

The secondary isolating contacts must be so arranged that when the circuit breaker is in the lowered or racked down position the secondary isolating contacts can still be made without the addition of separate jumper equipment.

*E13.7.1.6 POSITION STOPS*

Immediately prior to racking in, positive stops shall be engaged to locate the circuit breaker in the correct position relative to the busbar selection guides or other approved means shall be provided to ensure accurate entry into the guides.

A positive stop shall be provided to ensure correct location without danger of "over-run" in the "racked in" position.

*E13.7.1.7 EARTHING*

Integral earthing facilities shall be provided.

Integral earthing facilities through the circuit breaker are preferred, but separate earthing devices or earthing switches mounted on separate trucks are acceptable.

Where separate earthing devices or earthing trucks are supplied, the gear shall be suitable for use on all the circuit breakers in a switchboard and shall also be suitable for earthing either the busbar or the cables. A full set of earthing devices or earthing trucks shall be supplied for

each switchboard.

Earthing equipment shall have a making capacity and a rated short-time withstand current (Ik) equal to the rest of the switchboard.

*E13.7.1.8 CAPACITIES AND FAULT LEVELS*

The complete primary circuit (CB's, busbars, etc.) shall be capable of withstanding the rated short time withstand current.

The circuit breakers shall have continuous current ratings as specified in the Detail Technical Specification.

There shall be no audible corona discharge under working conditions. These requirements shall be taken to be complied with only if the audible corona extinction voltage is less than 9 kV to earth or 14 kV between phases.

Compliance may be conceded if it can be shown that any discharge below the specified levels takes place at points remote from all dielectric materials, and cannot cause their deterioration.

The switchgear shall have an assigned impulse rating of not less than 95 kV at sea level, supported by recent test certificates proving successful testing, using a standard 1/50 micro-second voltage wave, on identical units manufactured in the factory from which an order would be executed.

Circuit breaker tanks and top plates shall be capable of withstanding, without permanent distortion, a hydraulic pressure of 700kPA for 1 minute, unless a lower pressure is approved after reference to actual pressures measured during short circuit tests.

Each circuit breaker shall be clearly and indelibly marked to show the current and voltage ratings and breaking capacities.

*E13.7.1.9 CLOSING MECHANISMS*

The closing mechanism shall be either of the hand charged, spring or hand operated, spring assisted or motor wound spring charging or solenoid operated types as specified in the Detail Technical Specification.

The closing action of the hand operated, spring assisted mechanisms shall ensure that once closing is initiated the action becomes independent of the operator.

All mechanisms shall be of the trip-free type and it shall not be possible for the mechanism to maintain the circuit breaker in a "closed" position during fault conditions or when the "open" signal has been initiated.

The electrical closing circuitry shall be open circuited as soon as the closing sequence has been completed to prevent continued electrical loading of the closing circuitry and to deactivate the closing signal until a new sequence is initiated.

Where auto-reclosing duties are specified, the mechanisms shall be capable of performing a "BREAK-MAKE-BREAK" operation.

All electrically operated closing devices shall be at least suitable for operation at any voltage between 80% - 120% of the nominal control voltage at the device terminal. The nominal control voltages are specified in the Detail Technical Specification.

Anti-pumping devices shall be provided on all mechanisms to prevent pumping while the closing circuit remains energised and the circuit breaker either fails to latch or trip during closing due to the operation of the protection system. The arrangement shall be to the approval of the Engineer.

*E13.7.1.10 TRIPPING MECHANISMS*

A manual tripping mechanism shall be provided on each circuit breaker. It shall be clearly marked "MANUAL".

Where shunt tripping is specified DC shunt trip coils shall be provided. The rated control voltage shall be as specified in the Detail Technical Specification.

Shunt trip coils shall be suitable for operation at any voltage between 80% - 120% of the nominal voltage at the device terminals.

Secondary contacts operated by the circuit breaker mechanism shall be provided and rated to interrupt the maximum trip coil current after the circuit breaker has opened. These contacts shall close the tripping circuitry before the circuit breaker closes.

*E13.7.1.11 RACKING MECHANISMS*

The racking mechanisms for inserting or withdrawing the circuit breaker shall be designed and constructed to provide a positive action throughout the operations.

*E13.7.1.12 INDICATING DEVICES*

Each circuit breaker shall be equipped with mechanical indicators to indicate the switching positions and the state of the spring mechanisms (if applicable).

A mechanical indicator shall also be provided to indicate whether the circuit breaker is racked in or out.

All mechanical indicators shall be clearly visible from the front of the panel.

In all cases positive indication must be provided.

*E13.7.1.13 AUXILIARY CONTACTS*

Circuit breakers shall be provided with sufficient auxiliary contacts to suit the circuits served.

Auxiliary contacts shall be positively driven in both directions and shall be readily accessible for maintenance and shall be properly adjusted where necessary.

At least two spare normally open and two spare normally closed contacts shall be provided and shall be completely wired to an accessible terminal block.

## E13.8 NON-AUTOMATIC SWITCHES AND FUSED SWITCHES

E13.8.1 GENERAL

The switches shall be of the fault-making, load-breaking type with earthing and testing facilities.

The switches shall be manufactured and tested in accordance with SANS 62271.

E13.8.2 CONSTRUCTION

The switches shall be totally enclosed, metal-clad, air or SF6-insulated type.

The switch units shall be designed for extension with circuit breaker panels described in this specification and/or similar switch units.

Each unit shall be installed in a free standing metal clad cubicle and the front of the cubicle shall be totally enclosed.

The switch may be either of the horizontal draw-out with vertical or horizontal isolation, or non-

withdrawable fixed tank types.

E13.8.3 BUSBAR AND CIRCUIT SHUTTERS

Busbar and circuit shutters shall be provided on all withdrawable type switches as specified for circuit breakers.

E13.8.4 INTERLOCKS

The mechanism shall be incapable of moving directly to the "EARTH" position from the "ON" position.

A time delay shall be built into the mechanism to prevent immediate opening of the switch after closure. This shall be achieved by means of non-reversible operating handles, mechanical sliding interlocking gates or a non-reversible movement.

Padlocking facilities shall be provided.

Access to the testing facilities shall only be possible with the switch in the "EARTH" position. With the testing devices fitted operation to either the "ON" or "OFF" positions shall be prevented.

Interlocks shall be provided on withdrawable type switches to prevent:

- The switch from being withdrawn from or inserted into the isolating contacts.
- The closing of the switch except when it is correctly located or fully withdrawn.
- The opening of the tank unless the switch is fully withdrawn and the racking-in of the switch unless the tank is securely fitted.

*E13.8.4.1 OPERATING MECHANISM*

The switch shall have three positions, namely "ON", "OFF" and "EARTH".

Except for removing the earth, the switch actuating mechanism shall have a positive action and shall be spring assisted to ensure that once the operation is initiated, it becomes completely independent of the operator.

The fused switch shall close fully when making onto a fault to ensure full clearance of the fault by the fuses before tripping and opening the switches.

A blown fuse on any of the three phases shall open all three phases of the switch and shall inhibit the closure of the switch pending fuse replacement.

*E13.8.4.2 EARTHING*

Integral cable earthing facilities shall be provided for non-withdrawable switch units. For withdrawable switches earthing facilities similar to that of circuit breakers shall be provided.

*E13.8.4.3 CABLE TEST FACILITIES*

Cable test facilities are required and must be easily accessible.

Refer to paragraph 8.4 regarding interlocking of test facilities.

In the event of a separate test unit being provided, it shall be easily fitted.

*E13.8.4.4 RATINGS*

The fault making capacities, impulse levels and busbar ratings shall be identical to the ratings of the circuit-breakers installed in the same switchboards.

The continuous current rating of a switch shall not be less than 400 A and that of a fused switch not less than 90 A.

Each unit shall be clearly marked to show the current and voltage ratings and fault making capacity.

*E13.8.4.5* *INDICATING DEVICES*

Each switch shall be equipped with positive mechanical indicators to indicate the switching position and the racked mode (where applicable).

All indicators shall be visible from the front of the panel.

Potential indicator lights shall be provided to indicate the status of all three phases of the cable circuit.

*E13.8.4.6* *FUSES*

Fuses shall comply with SANS 60282-1.

Fuse links shall be of the striker pin type, hermetically sealed and shall be suitable for use under oil.

The fuse link carriage shall be suitable to accept either 254 mm or 359 mm long fuses both with a diameter of 63,5 mm. The carriage shall be adjustable for this purpose and shall not necessitate additional parts.

Automatic shutters shall be provided to safeguard against inadvertent contact with live parts when the fuse carriage is removed.

The ratings of the fuses shall be as specified.

## E13.9 BUSBARS

E13.9.1 DESIGN AND RATING

Busbars shall be manufactured of solid drawn high conductivity copper with rectangular cross-section in accordance with BS 159, SANS 1195 and BS 13601, where applicable.

The busbars shall be rated for the continuous current carrying capacity specified in the Detail Technical Specification and the fault levels specified in paragraph 1.3. The busbars shall be designed to withstand mechanical and temperature stresses for normal and fault conditions taking into account correction factors for different configurations, "proximity and skin" effects, the effect of ferrous enclosures, ventilation, etc. The maximum allowable temperature of busbars carrying full load at the specified ambient temperature is 80°C. Tables 1 and 2 may be used as a guide to determine the current rating of the busbars.

**Table 1 :Derating Factors for Laminated Busbars**

| Area of cross-section (mm) | Number of parallel busbars per phase | | |
|---|---|---|---|
| | 2 | 3 | 4 |
| 500 | 1,78 | 2,24 | 3,13 |
| 1 000 | 1,72 | 2,36 | 3,00 |
| 1 500 | 1,65 | 2,24 | 2,84 |
| 2 000 | 1,60 | 2,16 | 2,70 |

| | | | |
|---|---|---|---|
| 2 500 | 1,55 | 2,10 | 2,60 |
| 3 000 | 1,52 | 2,02 | 2,52 |
| 3 500 | 1,48 | 1,98 | 2,48 |
| 4 000 | 1,44 | 1,96 | 2,45 |

**Table 2 : Current Rating of Single Copper Busbars (A)**

| Width (mm) | Thickness (mm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 2,5 | 3,15 | 4,0 | 6,3 | 10 | 12,5 | 16 |
| 12,5 | 155 | 180 | | | | | |
| 16 | 190 | 220 | 250 | | | | |
| 20 | 230 | 265 | 300 | | | | |
| 25 | 280 | 320 | 365 | 470 | | | |
| 31,5 | 340 | 385 | 440 | 560 | | | |
| 40 | 420 | 475 | 540 | 680 | 870 | | |
| 50 | 510 | 575 | 650 | 820 | 1030 | 1160 | |
| 63 | | | 790 | 990 | 1240 | 1370 | |
| 80 | | | 970 | 1200 | 1480 | 1640 | |
| 100 | | | 1160 | 1430 | 1760 | 2180 | |
| 125 | | | | 1710 | 2100 | 2310 | 2570 |
| 160 | | | | 2070 | 2530 | 2780 | 3090 |
| 200 | | | | | | 3290 | 3660 |
| 250 | | | | | | 3900 | 4300 |
| 315 | | | | | | 4630 | 5120 |
| 400 | | | | | | | 6230 |

In additions to current rating busbars shall comply with the following fault level rating:

A = 8,2 x I x (t)

where:

A = minimum cross section (mm)

I = prospective fault current (kA)

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

(Minimum allowable value for t = 3s.)

Where a busbar consists of two or more busbars per phase (laminations), the laminations shall be separated by a minimum distance of the thickness of one lamination. The laminations shall be clamped together with copper spacers at intervals not exceeding 450 mm in order to equalize the current distribution in the laminations.

Busbars shall be able to carry the rated current along their entire length. Tapering is not permitted.

The manufacturer shall, where requested, provide design calculations of the busbar ratings.

Busbars shall be as short and straight as possible.

Busbars shall be adequately ventilated and shall be situated in separate, totally enclosed, dust free, metal enclosures.

At each end of a switchboard a removable cover shall be fitted to the busbar chamber in order to extend the switchboard in both directions in the future.

The busbar ends shall be suitably manufactured and drilled for future extensions without modifications to the existing busbars.

*E13.9.1.1 INSULATION AND JOINTS*

All busbars and connections shall be air insulated and shall be shrouded with heat-shrinkable sleeving or shall be epoxy resin encapsulated. PVC taping, insulating compound or oil immersion is not acceptable. The colours shall correspond to the colour of the supply phase:

| | |
|---|---|
| Red, Yellow or White | Phases |
| Blue or Black | Neutral |

Busbar joints and tees shall be encased in a non-hardening compound and taped with PVC tape unless suitable shrouds are provided.

The complete primary system shall withstand the full power frequency test voltage specified by SANS 62271 and the insulations level of all busbars and connections shall be in accordance with the values specified in paragraph 8.3.

Where connections between busbars and any other part of the switchgear consist of bare copper conductors, and no other insulation except air exists between phases or phases and earth, the clearance distances and insulator lengths shall be in accordance with SANS 62271 with correction for altitude as required.

*E13.9.1.2 EARTH BUSBAR*

An earth busbar shall be installed in a convenient position along the entire length of the switchboard. The cross-sectional area of earth busbars shall be calculated in accordance with the following formula in IEC 439 with a minimum cross-section of 6,3 x 20 mm:

$$S = \frac{Ix(t)}{X(dT)}$$

where

S = cross-section (mm)
I = the r.m.s. value of the current (A)
X = 13 for Copper
t = operating time of protective equipment (s)

(Minimum value for t = 3 s)

dT = temperature rise (°C)
= 120°C for insulated conductors
= 180°C for uninsulated conductors

If t is between 2 s and 5 s then dT may be increased in the same formula

to:

dT = 145°C for insulated conductors
= 215°C for uninsulated conductors

In addition the longer side of the earth bar shall be at least twice the diameter of the largest bolt that will be fitted to the busbar.

## E13.10 SECONDARY CIRCUITRY

### E13.10.1 CABLING

Gland plates, suitably drilled to accept the glands for all the external power, control protection and DC supply cables, shall be provided.

The internal wiring to be connected to the cabling mentioned above shall be terminated on numbered terminal strips in close proximity to the gland plate in order that the cable cores can be connected directly to the opposite sides of the terminal strips.

#### *E13.10.1.1 WIRING*

All wiring shall present a neat appearance and shall be suitably braced, placed in wiring channels or clipped and/or laced.

Connections to equipment mounted on doors shall be arranged to give a twisting motion and not a bending motion to the conductors.

All panel and equipment terminals, labels, etc. shall be completely accessible after the wiring and cabling has been completed.

Conductors shall be identified at both ends by means of durable closed ring interlocking cable marking ferrules. PVC or other tape is not acceptable. The numbers on the markers shall also be shown on the wiring diagrams.

Where conductors are terminated on equipment terminals that do not require the use of lugs, the identification ferrules shall be fixed so that they do not fall off when disconnecting a conductor.

Identification ferrules shall read from the terminal along the wire.

All wiring terminating on meters, fuse holders and other equipment with screwed terminals, shall be fitted with lugs. The lugs shall be soldered or crimped to the end of the conductor.

Secondary wiring shall generally consist of insulated stranded copper conductors with a minimum cross-sectional area of 2,5 $mm^2$. Solid core conductors are not acceptable. Flexible cords not smaller than 1,0 $mm^2$ shall be installed between equipment mounted on doors and the rest of the switchboard. For voltage ratings in excess of 50 V the wiring insulation shall withstand a test voltage of 2 kV to earth for one minute. For voltages of 50 V or less the insulation shall withstand 500 V to earth for one minute.

All wiring between different panels within the same switchboard shall be installed in wiring channels. Grommets shall be installed in each hole in the metalwork through which conductors pass. Wiring shall also be kept away from exposed metal edges or shall be protected where they cross metal edges. All wiring shall be installed away from terminals, clamps or other current carrying parts.

Conductors may be jointed at equipment terminals or numbered terminal strips only.

To minimize the effect of electrolysis, DC circuits shall be so arranged that the isolating or N/O operation contacts are connected to the positive pole of the battery.

#### *E13.10.1.2 SECONDARY TERMINALS*

All external wiring and connections to auxiliary contacts, all alarm, protection, intertripping, DC supply circuits, etc. shall terminate on numbered terminal strips. All numbers shall appear on the switchboard drawings.

Terminals of the type where clamping screws are in direct contact with the conductor are not acceptable.

Where stud type terminals are provided they shall have a minimum size of 0 B.A.

Approximately 10% with a minimum of 2 spare terminals shall be provided on each terminal strip.

Terminal and test blocks of a reputable manufacturer, complying with the requirements of SANS 60947-7-1 shall be provided in each panel for the secondary wiring of the current transformers.

## E13.11 CURRENT TRANSFORMERS

### E13.11.1 GENERAL

Current transformers shall comply with the requirements of SANS 60044-8 with the exception of the required impulse test level, refer to paragraph E13.11.6 below.

### E13.11.2 RATINGS

Current transformers shall be suitable for the primary currents and secondary ratings as specified in the detail specification.

Current transformers shall have secondary outputs of 2.5, 5, 10, 15 or 30 VA as applicable in terms of the burden of the instruments and interconnecting wiring. The current transformer output shall match the actual instrument burden as closely as possible in order not to introduce unnecessary errors.

#### *E13.11.2.1 ACCURACY CLASS*

For metering applications, accuracy classes of 0.1, 0.2, 0.5, 1, 3 or 5 are applicable. Where no accuracy class has been specified, the following table may be used as a guide:

| Application | Primary current | Suggested class |
|---|---|---|
| Indicating instruments | All | 5 |
| Metering applications | Up to 200 A | 2 |
| Metering applications | 250 to 600 A | 0,5 |
| Metering applications | 800 A and above | 0,2 |

Where ring type current transformers are specified, the aperture shall not be unnecessarily large as accuracy is thereby reduced.

The classes for protection are 5P, 10P, 15P, 20P or 30P with 5P and 10P being standard. Turns compensation shall be employed on protection current transformers for ratios greater than 30/1.

Class X current transformers shall be used in differential protection systems.

Manufacturers shall supply the magnetization curve details and saturation factors for each different transformer ratio.

#### *E13.11.2.2 MARKINGS*

All current transformers shall come complete with a label on which the following information is indelibly stamped:

- Manufacturer
- Serial No. or Type

- Rated primary and secondary current
- Rated frequency
- Rated output and accuracy class
- Highest system voltage
- Rated insulation level

A duplicate of this label must be attached in a position which is clearly visible on the inside of the protection panel. The specific connections for both the high and low ratio's of a dual-ratio CT, must be clearly labelled at a visible position in the protection panel.

*E13.11.2.3 FAULT CURRENT*

Current transformers shall be capable of withstanding the dynamic forces resulting from the maximum through-fault current which may be encountered at the point where they are installed. The short time current rating of current transformers shall be at least equal to that of the associated circuit-breaker.

*E13.11.2.4 IMPULSE LEVEL*

Current transformers used in system voltages in excess of 660 V shall withstand an impulse test level of 95 kV.

*E13.11.2.5 TESTS*

One protection current transformer of each type used in a contract shall be tested to confirm the estimated characteristics. The following results shall be submitted:

(a) Magnetization curve

(b) Secondary resistance

(c) Secondary leakage reactance, if not negligible or if required by the Engineer.

The power frequency, secondary to earth and overvoltage interturn tests in accordance with BS 3938 shall be conducted on all current transformers. Impulse tests shall be conducted on all current transformers intended for use in system voltages in excess of 660 V.

## E13.12 VOLTAGE TRANSFORMERS

E13.12.1 GENERAL

Voltage transformers shall comply with SANS 61869-1 and 3 where applicable.

The voltage transformers are of the epoxy resin insulated type and are used to supply measurement and protection devices. VT's can be installed as a fixed assembly or installed on removable and withdrawable trucks. Fixed voltage transformers can be installed directly on the main busbar system in a dedicated VT compartment. Withdrawable trucks must allow replacement of the fuses with the switchgear in service. The withdrawable truck arrangement must be fitted with automatic shutters between the live parts of the switchgear and the instrument compartment. The VT can have one pole (L-N) with a secondary voltage of 110/√3 (63.5V) or two poles (L-L) in which case the secondary voltage shall be 110 V unless specified to the contrary.

*E13.12.1.1 VOLTAGE TRANSFORMER PROTECTION*

The primary side of all voltage transformers shall be connected to the circuit through high voltage HRC fuses. Fixed VT installations will have external MV fuses and withdrawable VT

installations will have internal MV fuses.

Secondary HRC fuses or protective circuit breakers shall be provided on the output terminals, located in the LV compartment.

*E13.12.1.2 VOLTAGE TRANSFORMER RATINGS AND TESTS*

The voltage transformers shall have an output suitable for the connected load but at least 200 VA per phase at class B accuracy.

The voltage ratios shall be suitable for the primary busbar and the required output voltages.

Voltage transformers shall be tested in accordance with BS 3941 and shall withstand an impulse level of 95 kV.

## E13.13 CURRENT AND VOLTAGE SENSORS

Current and voltage sensors shall comply with SANS 61869.

(a) IEC 61869-10: Instrument transformers - Part 10: Additional requirements for low-power passive current transformers

(b) IEC 61869-11: Additional requirements for low power passive voltage transformers

Current and voltage sensors are designed without the use of a ferromagnetic core. The current sensor is based on the principle of Rogowski coil. Voltage sensor uses the principle of resistive voltage divider. The main benefit is that the behaviour of the sensor is not influenced by magnetizing curve that results in a highly accurate and linear response across a wide dynamic range of measured quantities. The linear and highly accurate characteristic curve of the sensor across its full operating range enables several metering and protection classes to be combined in one particular winding.

## E13.14 PROTECTION RELAYS

Protection relays shall comply with IEC 60255: Measuring relays and protection equipment.

Digital protection relays which use a microprocessor to analyse power system voltages, currents or other electrical quantities for the purpose of detection of faults in an electric power system will be supplied. The characteristics and behaviour of the protection relay must be programmed to requirements. The protection relay must offer multifunctional protection (overcurrent and earth-fault as a minimum).

The protection relay should offer the following features:

(a) Self-checking facility;

(b) Local HMI display with basic system parameters shown;

(c) Low burden on current and voltage sensors;

(d) Communication port for the connection to a LAN;

(e) Adaptive relaying schemes which can vary its setting parameters in response to changes in the power system;

(f) Storage of historical data with time stamping;

(g) Simple and easily maintainable.

## E13.15 INSTRUMENTS

### E13.15.1 GENERAL REQUIREMENTS

Instruments shall be suitably rated for the supply voltage and frequency to be applied, which shall be 400/230 V, 50 Hz unless specified to the contrary.

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

All instruments shall comply with IEC 60051-1.

Instruments shall be screened against magnetic interference and shall have anti-static against magnetic interference and shall have anti-static, impact-resistant faces.

Preference will be given to locally manufactured instruments.

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

All instruments shall be splash proof and dustproof unless more stringent requirements are specified for hazardous locations.

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

For normal environmental and supply conditions, instruments shall be suitable for use inside the limits specified in IEC 60051-1.

All instruments shall be capable of withstanding overloads of continuous or short duration in accordance with IEC 60051-1.

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

#### *E13.15.1.1 VOLTMETERS AND VOLTMETER SELECTOR SWITCHES*

Voltmeters shall be of the moving iron type with class 1,5 accuracy as specified in IEC 60051-1.

A zero adjustment screw shall be provided.

Unless specified to the contrary, a single voltmeter and selector switch shall be provided. The voltmeter switch shall have an "OFF" and three metering positions to indicate readings between neutral and each of the three phases.

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

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

#### *E13.15.1.2 AMMETERS*

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

Current transformer operated ammeters shall be 5 A full scale, calibrated to read actual primary circuit currents. The current transformer ratio shall be indicated on the faceplate.

A zero adjustment screw shall be provided.

Where combined maximum demand and indicating ammeters are specified, a bimetallic spiral

element shall be provided in the same housing to indicate mean value over a 15 minute period.

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

The bimetal element shall be designed to compensate for limits of ambient temperature between -20°C and 70°C.

Full load or rated current shall be clearly indicated, preferably with a red line. Unless specified to the contrary, a 100% condensed over scale shall be provided for instantaneous reading instruments and no over scale for combined maximum-demand ammeters.

The intrinsic error, expressed in terms of the fiducial value in accordance with IEC 60051-1, shall be class 1,5 for the instantaneous readings and class 2,5 for the mean maximal.

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

## E13.16 AUXILIARY EQUIPMENT

### E13.16.1 CONTROL SWITCHES

Circuit-breaker closing and tripping control switches shall close the associated circuit breaker when rotated clockwise.

Control switches may be fitted with one pair of lazy contacts, i.e. contacts which make when the control switch is turned to the closed position, remain closed when the handle returns to the neutral position and only open when the control switch is moved to the trip position.

The switches shall be provided with a suitable faceplate indicating the angle of throw and the switching positions.

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

Control switches shall be lockable in the "NEUTRAL" or "OFF" position.

### E13.16.2 FUSES

All fuses for the protection of auxiliary circuits shall be of the high rupturing capacity cartridge type and shall be mounted on insulated draw-out carriers which shall hold the fuses positively after withdrawal.

The top terminal shall be the live terminal in all cases.

HRC fuses shall be provided in the positive leads of all DC circuits.

Fuses shall be so positioned that they are readily accessible to a person standing on the floor in front of the panel.

Labels shall be fitted adjacent to fuses stating their use, rating and duty.

### E13.16.3 INDICATOR LAMPS

The following indications shall be provided:

Function ..... Colour

Circuit-breaker closed ..... Red

Circuit-breaker open ..... Green

Incoming supply available (on incoming panel only) ..... White

Auto-trip..... Amber

Trip circuit healthy ..... White

A lamp test pushbutton for all the indicating lights shall be provided on each switchboard.

The "trip circuit healthy" indication shall normally be off and a pushbutton shall be provided to indicate the status. The purpose of the indication is to ensure that the tripping voltage supply is available on the panel before the circuit-breaker is closed. An indicator light with pushbutton is required on each panel and one indication per switchboard is not sufficient. The circuitry shall be arranged to provide indication with the circuit breaker in both the "OPEN" and "CLOSED" positions.

The conditions indicated shall be designated below each light.

E13.16.4 VOLTAGE INDICATOR SYSTEM

All switchgear will be fitted with a capacitive divider voltage indicator system (VDS) connected to the cable side of the switchgear. All systems supplied will permit phase comparison (with specialised measuring Units) All VDS's will comply with IEC 61243-5.

E13.16.5 INSTRUMENT TEST BLOCKS

For the purpose of connecting external test equipment or instruments in the secondary circuits of the current transformer or potential circuits, these circuits shall be wired via an approved test block mounted on each panel.

The test blocks shall be fitted with terminal strips and links for performing the various short circuiting and bridging functions.

E13.16.6 LABELS

Labels shall be made of durable material to approval. Metal labels where used shall be engraved or etched. Labels made of trifoliate or other similar materials shall have engraved lettering. Self-adhesive printed tape labels shall not be used. All labels shall be fixed mechanically.

## E13.17 CABLE END BOXES

Cable end boxes to accept the cables specified for each panel shall be provided.

The boxes shall be of the metal clad type suitable for indoor use. These shall be equipped with armour clamps and brass or gunmetal conical wiping glands for lead covered steel tape or galvanized steel wire armoured, paper-insulated cables or XLPE galvanized steel wire armoured cables (as specified in the Detail Technical Specifications).

The cable boxes shall be fitted with insulating pieces to allow for the possible future installation of frame leakage busbar zone protection when specified in the Detail Technical Specifications.

Cable boxes shall be so designed that cable terminal connections can be made below compound level.

## E13.18 FINISH

The switchboards shall be finished with a high quality paint applied according to the best available method. Baked enamel, electrostatically applied powder coating or similar proven methods shall be used.

## E13.19 LABELS

Care shall be taken to ensure that all equipment is fully labelled.

Panel designation labels shall appear on the front and back of each panel and on the circuit breaker truck.

Engraved sandwiched interchangeable plastic or ivory strips shall be used throughout. The strips shall bear white lettering on a black background.

Labels shall be secured by means of brass bolts, nuts and washers. Where this is not practicable cadmium-plated self-tapping screws may be used. The gluing of labels will not be acceptable. Sufficient fixing screws shall be provided to prevent labels from warping.

## E13.20 BATTERY TRIPPING UNIT

Please refer to specification E24: Electrical battery Tripping Unit

A battery tripping unit, suitable for connection to a 230 V, 50 Hz, single-phase ac supply shall be provided with each switchboard. The charger shall be metal-clad and shall be suitable for charging a Ni-Cad battery with voltage and capacity as specified in the detail specification. The charger shall be such that the change-over from trickle to boost charge is automatic. The tripping unit shall be supplied complete with fuses on the ac supply side and on the outgoing dc. side of the charger, an ammeter to indicate the charging current, a voltmeter with spring-loaded push buttons to indicate battery voltage and a circuit to test the state of battery charge.

## E13.21 TESTS

All component parts of the equipment shall be subject to type tests and routine tests in accordance with the relevant SANS, BSI or IEC standard specifications.

Circuit breakers shall be subjected to the following tests in accordance with IEC 62271-1, adjusted for atmospheric correction:

(a) Type Tests

- Mechanical endurance
- Temperature rise
- Dielectric strength and impulse voltage
- Making and breaking capacity and short time current

(b) Routine tests

- Power, frequency, voltage
- Resistance of the main circuit
- Mechanical operation.

### E13.21.1 ON SITE TESTS

The equipment shall be tested on site after erection and prior to commissioning.

The following minimum tests shall be performed:

(a) Pressure tests on the primary and secondary circuits in accordance with IEC 62271-1.

(b) Insulation resistance tests.

(c) Primary injection tests.

(d) Earth continuity and earth resistance tests.

(e) Operating tests.

(f) Any other tests which may be required to ascertain the correct functioning of the equipment.

The contractor is to provide a schedule of tests to be done on site prior to commencement of manufacture for approval by the engineer. This schedule must be ticked off prior to commissioning.

After putting the panel to service for a minimum 1 week, a thermal image must be scanned and analysed for any hot spots. The image should be presented as part of the Operations and Maintenance manual.

E13.21.2 TEST CERTIFICATES

Copies of type test certificates shall be submitted together with the tender.

Copies of test certificates of all other tests i.e. routine tests and on site tests shall be forwarded to the Engineer on completion of the tests.

E13.21.3 TEST PERFORMANCE AND INSPECTION

The Engineer shall be notified in writing at least two weeks in advance of any tests to be conducted to allow its representative to be present at such tests.

The Engineer shall also be notified timeously of the completion of the equipment in order that an inspection may be carried out prior to delivery.

## E13.22 TOOLS AND AUXILIARY EQUIPMENT

The following equipment shall be provided with each switchboard and the cost shall be included in the tender price:

(a) One raising and lowering handle for every three circuit breakers.

(b) One complete set of special maintenance tools for all sizes of circuit breakers.

(c) A full set of earthing devices or earthing trucks.

(d) One wall mounted steel box for the storage of the above loose equipment. The door shall be padlockable.

(e) At least six spare HRC fuses of each rating for secondary circuits and three high voltage HRC fuses for the voltage transformer.

(f) One cable test unit for each size circuit breaker or oil switch housed in a wall-mountable metal box.

## E13.23 TECHNICAL INFORMATION

Tenderers shall submit descriptive literature of the equipment with their tenders.

Three copies of erection, operating and maintenance instruction manuals covering each type of equipment shall be provided with each switchboard.

## E13.24 DRAWINGS AND DIAGRAMS

E13.24.1 DRAWINGS FOR APPROVAL

A set of three prints of the following drawings shall be submitted to the Engineer for approval.

- General arrangement drawings
- Detailed dimensional drawings
- Schematic diagrams
- Wiring diagrams
- Foundation drawings.

The approval of drawings shall not relieve the Contractor of his responsibility to the Engineer to supply the switchboards according to the requirements of this Specification.

E13.24.2 FINAL DRAWINGS

On completion, a complete set of final transparent drawings shall be delivered to the Engineer. These drawings shall include the following:

(a) An accurate "as built" wiring diagram of the complete installation showing circuit numbers, terminal strip numbers, conductor colours and numbers, etc.

(b) A schematic diagram clearly showing the functions of all equipment.

(c) An equipment schedule showing the make, model and characteristics of all components used, including a recommended spare list.

(d) Fully dimensioned "as built" physical layout of the panel.

## E13.25 COMPLETION

The contract shall be regarded as incomplete until all tests have been conducted successfully and all drawings and manuals have been handed to the Engineer.

## E13.26 MEASUREMENT AND PAYMENT

| Item | Unit |
|---|---|
| Supply medium voltage switch or fused switch panels | No |

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

The rate shall include full compensation for the supply and delivery of switch panel complete with busbars, cable boxes and potential indicators as specified. Separate items will be scheduled for switch and fused switch panels.

| Item | Unit |
|---|---|
| Install medium voltage switch or fused switch panels | No |

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

The rate shall include full compensation for the installing, testing and commissioning of switch panels by the manufacturers of the equipment complete with the connecting of the busbars, secondary wiring and all the material required to complete the installation. Separate items will be scheduled for switch and fused switch panels.

| Item | Unit |
|---|---|

Supply medium-voltage circuit breaker panel ..... No

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

The tendered rate shall include full compensation for the manufacture, supply and delivery of the circuit breaker panel complete with busbars, relays, switches and other equipment as specified in the Detail Specification, to site.

**Item** **Unit**

Install medium-voltage circuit breaker panel ..... No

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

The tendered rate shall include full compensation for the installing, testing and commissioning of the circuit breaker panel complete with the connecting busbars, secondary wiring and other material required.

**Item** **Unit**

Supply battery tripping unit ..... No

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

The tendered rate shall include full compensation for the supply and delivery of the battery tripping unit complete as specified in the detailed specification.

**Item** **Unit**

Install battery tripping unit ..... No

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

The tendered rate shall include full compensation for the installing of the battery tripping unit and shall include the cable for the DC connection between the battery tripping unit and the switchboard as well as the cable from the mains outlet to the battery tripping unit.

**Item** **Unit**

Supply and install voltage transformer ..... No

The unit of measurement shall be the number of transformers supplied and installed.

The tendered rate shall include full compensation for the supply and installing of the voltage transformer where the voltage transformer is specified separately.

**Item** **Unit**

Remove existing MV circuit breakers ..... No

The unit of measurement shall be the number of MV circuit breakers removed.

The tendered rate shall include full compensation for the removal of the busbars to which the switchgear are connected, as well as the delivery of the equipment to a location not further than 5km from the original location. The rate shall furthermore provide for the disconnecting of all the MV and LV cable terminations from the switchgear.

**Item** **Unit**

Remove existing MV switches ..... No

The unit of measurement shall be the number of MV switches removed.

The tendered rate shall include full compensation for the removal of the busbars to which the switchgear are connected, as well as the delivery of the equipment to a location not further than 5km from the original location. The rate shall furthermore provide for the disconnecting

of all the MV and LV cable terminations from the switchgear.

## PARTICULAR SPECIFICATION: VOLUME E14: ELECTRICAL SUPPLY AND INSTALLATION OF A STANDBY GENERATOR

### CONTENTS

## E14.1 SCOPE

This section covers the design, manufacture works testing, delivery to site, site erection, site testing, commissioning and handover of 50 Hz 380V standby diesel generator sets.

## E14.2 STANDARDS AND STATUTORY DOCUMENTS

All materials and apparatus shall be new and of the best quality and shall comply with the relevant current specifications of the SANS, BS or IEC and as stated in this document.

The equipment offered and work performed, shall comply with the requirements of the governing occupational Health and Safety act, at time of tender.

The standby generator shall be produced in a factory with ISO9000 rating and the applicable quality assurance standards.

E14.2.1 Standards

| | | |
|---|---|---|
| (a) SANS 60439 | : | Low-voltage switchgear and control gear assemblies |
| (b) SANS 60529 | : | Degrees of Protection Provided by Enclosures (IP Code) |
| (c) SANS 60947 | : | Low-voltage switchgear and controlgear |
| (d) SANS 10142-1 | : | The wiring of premises Part 1: Low-voltage installations |
| (e) SANS 60439 | : | Low-voltage switchgear and controlgear assemblies |
| (f) SANS 1195 | : | Busbars |
| (g) SANS 61238 | : | Compression and mechanical connectors for power cables for rated voltages up to 30 kV (Um = 36 kV) Part 1: Test methods and requirements |
| (h) SANS 342 | : | Automotive fuel - Requirements and test methods for diesel |
| (i) SANS 62271-206 | : | High-voltage switchgear and controlgear Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV |
| (j) SANS 8528 | : | Reciprocating internal combustion engine driven alternating current generating sets |
| (k) BS 5000-3 | : | Rotating electrical machines of particular types or for particular applications - Part 3: Generators to be driven by reciprocating internal combustion engines - Requirements for resistance to vibration |
| (l) BS 2869 | : | Fuel oils for agricultural, domestic and industrial engines and boilers |
| (m) SANS 10219 | : | The determination of performance (at net power) of industrial internal combustion engines |

(n) BS 800 : Limits of radio interference.

E14.2.2 Particular Specifications to be read in conjunction with this specification

The following particular specifications shall be read in conjunction with the Project Specification:

| | | |
|---|---|---|
| E06 | : | ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION |
| E05 | : | LOW VOLTAGE POWER AND CONTROL CABLES |
| E08 | : | WIRING |
| E11 | : | GENERAL EARTHING AND LIGHTNING PROTECTION |

## E14.3 ENVIRONMENTAL CONDITIONS

The engine shall be amply rated for the site electrical demand, load characteristics and power factor as specified in the detail specification. The engine shall be derated for the specific site conditions as stated in the detailed specification. The engine shall be capable of delivering the specified real power (kW) output continuously at the stated site conditions without overheating.

## E14.4 GENERAL REQUIREMENTS

The standby power installation shall automatically take over the load in the event of a mains failure, under voltage or any abnormal voltage condition on any one or more phases after this condition has persisted for a pre-set (but adjustable) period. The transition shall be done automatically via an automatic mains transfer equipment with sufficient intelligence and logic.

E14.4.1 Operation

The most common form of backup generator to the mains supply is a single generator in “standby” mode. When the mains supply fails, the load is left without power until the generator is started. Once the set is “available”, the transfer switch changes over so that the load is supplied by the generator. Typically, the “down time” will be around 15 seconds, but may be longer depending upon the time taken to run the engine to nominal speed and other application dependent factors. When the mains supply returns, the load-switching device (contactors/breakers) will momentarily remove power from the load (typically 1 second) before transferring the load back to mains supply power.

The break in supply when transferring back to the mains can be eradicated by synchronising the generator supply to the returned mains supply, and closing the supplies in parallel with each other for a short period. Then, the generator load switch is opened, returning the mains to supply power to the load. There has been no break in supply to the load during this return transfer process. Terms often used for this procedure are “bumpless transfer”, “no break return” and “no break transfer”. Additionally, the same procedure can be used to transfer from mains supply to generator supply enabling, for instance, “on load” testing of the generator set with no break in supply to the load. This can also be performed if the supply authority informs customers of a scheduled break in supply.

An Automatic Load Transfer system shall be provided which shall:

(a) Monitor the mains power supply continuously to ensure it is within limits.

(b) In the event of any mains abnormality (parameters pre-set but generally adjustable) initiate the disconnection of the load from the mains supply.

i. Start the diesel alternator set;

ii. Monitor the generator output (voltage and frequency);

iii. Automatically transfer the load to the standby power installation as soon as the alternator output is within specified limits and stable.

(c) In the event of any mains return (parameters pre-set but generally adjustable) initiate the transfer of the load from the generator to the mains supply.

Two modes of operation are possible as specified in the detail specification:

i. Break Transfer

The Automatic Load Transfer system will momentarily remove power from the load (typically 1 second) before transferring the load back to mains supply power

ii. No-break transfer

Reconnect the load to the mains after the stable re-establishment of the mains by synchronising the generator to the mains and transferring the load to the mains before disconnecting the generator.

(d) Transfer the load from mains supply to generator supply when a scheduled break in mains supply is scheduled by the supply authority.

A detailed description of the sequence of operation, time delays, adjustment parameters, set points, etc., may be found under clauses dealing with the generator control system.

E14.4.2 Rating

The rating of the standby power installation shall be such that the prime mover and the alternator with all deductions for auxiliaries are amply rated for the site electrical output, load characteristic and power factor as specified in the detail specification.

(a) The engine should be Prime Rated

A Prime rated generator is capable of providing power to a varying load for an unlimited number of hours per year (maximum 8760 hour/year less service), if:

i. The maximum average load factor over a 24-hour period does not exceed 70% of Prime Rated Power (PRP), including the following;

- Full Prime Rated Power (PRP) for a period of time;
- Ten present (10%) overload of Prime Rated Power (PRP) during emergencies. Operating at 110% is restricted to a period of 1 hour within a 12-hour period of operation and the total operating time at the 10% overload power cannot exceed 25 hours per year;

(b) Should the load fall below 30% of the engine maximum power (kWe), a dummy load (resistive load bank) must be automatically connected to the generator to add load to above the 30% margin.

(The diesel engine should be run at loads greater than 30% of its maximum power (kWe) for optimum engine life. This ensures that the exhaust temperature will be high enough to burn up the majority of particulate in the exhaust gas. Incomplete combustion at low loads can cause increased valve wear and degradation in the turbochargers, both of which increase maintenance needs and decrease reliability.)

## E14.5 ENGINES

### E14.5.1 General

The prime mover shall be a diesel fuelled, compression ignition, direct injection, four-stroke industrial engine designed for stationary duty.

The output of the engine under the specified site conditions shall be the net available output power after allowance for all auxiliary equipment including air filter, radiator and fan, oil pump, water pump, battery charging alternator, governor, etc., has been made. The engine shall be rated for diesel fuel complying with BS 2869 as amended, Class A1 or SANS 342, as amended, for diesel fuel with a minimum octane number of 40 and a minimum nett calorific value of 10 000 kcal/kg.

The starting period from either automatic or manual switching until the taking over by the generating set of a load equal to the specified site electrical demand shall not exceed 25 seconds or the time as in the detail specification. The load acceptance shall comply with the requirements stated in the detail specification.

The engine speed shall be 1500 rpm.

The engine and installation shall be of neat appearance and all water, lubricating and diesel oil lines, filters and stopcocks shall be leak free.

All service connections to the engine shall be flexible to allow the free movement of the set and to prevent the transmission of vibration to the building or other structural elements.

All engine flexible or rigid piping not heat resistant shall be adequately protected against damage by radiant heat.

Engine wiring shall be of the heat-resisting type.

The crankcase vent pipe shall terminate inside the plant room above the drip tray to collect condensate.

All moving parts shall be adequately protected mechanically against accidental contact.

It shall be the responsibility of the Contractor to design the dynamic system comprising engine, flywheel and alternator rotor. The Contractor shall ensure that the vibration stresses in the crank and rotor shafts shall not exceed allowable tolerances.

Tenderers shall state in the technical data sheets the specified fuel consumption of the complete set with auxiliary equipment in kg/kWh of alternator output at 100%, 75% and 50% load to an accuracy of ± 10%. These figures shall be guaranteed.

Modern electronic engine control units (ECU) that monitor and manage engine status and operating conditions of the generator set and can be interfaced to an external computer for monitoring diagnostic purposes and setting of operation limits are preferred. A digital interface for remote status and alarm monitoring based on a common industrial communication protocol is also preferred.

### E14.5.2 Flexible Connections

Any supply line or hose connected to the generator set, including exhaust coupling and exhaust pipe hangers, jacket water connections, heat recovery systems and fuel lines must be fitted with a flexible section that can withstand vibrations incurred by the operating generator set. These flexible connections should be installed as close to the generator set as possible and be designed to prevent line leaks or breaks.

E14.5.3 Lubrication

The engine shall have a forced feed pressure lubrication system adequately rated to supply circulating lubrication oil to all bearings, gear trains and important moving parts.

The filter(s) shall be suitable for use with detergent type lubricating oils and shall be fitted between the lubricating oil pump and the engine circuit. It shall be equipped with replaceable elements capable of 500 hours working time without attention and shall be placed for easy access and maintenance.

An engine oil heater (250Vac) must be installed to maintain the engine oil in the sump between 40 and 50°C to ensure coming online at the engine's rated speed and full load rating within a short period without engine damage.

An oil temperature gauge shall be fitted in the case of air-cooled engines and if required as per the Detailed Specification.

A semi-rotary hand operated sump drain pump shall be fitted if draining the sump is difficult. The drainpipe and shut-off valve shall be placed in a convenient position outside the bedplate frame to facilitate drainage. The successful Tenderer must advise the Engineer whether additional concrete plinths are required for the generator set, in order to drain the sump properly.

A stainless steel or galvanised mild steel, removable, drip tray shall be placed under the engine. The tray must be large enough to catch a drip from any part of the engine and must be at least 25 mm deep.

The tender price shall include

(a) Supply and fill all lubricating oils (first fill)

(b) Supply and install all filter elements

E14.5.4 Cooling

Water-cooled or air-cooled engines may be offered.

Careful attention shall be paid at the time of tendering to the cooling system and the building requirements to accommodate the cooling system. Any special building requirements shall be stated by the Tenderer in his submission.

Where radiators are used, they shall be heavy duty, air blast tropical type pressurised radiators, adequately sized for rated load operation of the set. The radiator fan may be either engine or motor driven and shall be complete in all respects including fan, drive, guards, filling and drain connections. The fan shall be arranged to draw cooling air from the plant room and exhaust the air to atmosphere. The capacity of the fan shall be sufficient to provide the required engine cooling and plant room ventilation.

Engine jacket water shall be circulated by an engine mounted centrifugal pump that is driven by the engine.

A water jacket heater (250Vac) must be installed to maintain the cooling water between 40 and 50 °C to ensure coming online at the engine's rated speed and full load rating within a short period without engine damage.

E14.5.5 Engine Fuelling

An engine-mounted fuel pump shall be fitted.

The governor-controlled fuel injection pump(s) shall be fitted between the lift and injection pumps and shall be arranged for easy access and easy maintenance.

A micro filter with replaceable elements suitable for the full flow rate of the injection pump(s) shall be fitted between the lift and injection pumps and shall be arranged for easy access and easy maintenance.

The filter element shall be capable of filtering out particles down to 5 microns in size.

An additional heavy-duty primary filter (sludge filter), suitable for the full flow rate of the fuel pump, shall be fitted in the fuel line between the fuel tank and the lift pump. The filter shall be rated for 500 hours service without attention. The filter shall be arranged for easy access and maintenance.

Interconnection fuel piping shall be neatly run in copper tubing from the sludge filter to the other component parts of the fuel system.

The overflow from the engine fuel and injection pumps shall be returned to the fuel tank via a steel return pipe.

All piping shall be securely fixed by means of saddles and clamps.

Connections between static and vibrating components shall be flexible.

Should the engine require a particular grade of fuel, this shall be clearly stated in the tender.

E14.5.6 Combustion Air

The engine shall be fitted with a high efficiency air filter adequately sized for 500 hours running without attention.

Dry type, cartridge air filters are preferred and, if offered, shall be complete with a service indicator.

E14.5.7 Instrumentation

The Engine Control Unit (ECU) must give digital indication for:

(a) Enine speed (RPM)
(b) Battery volts (DC volts)
(c) Generator operating hours
(d) Engine oil pressure (kPa)
(e) Engine coolant temperature (°C)
(f) Output volts (L-L and L-N)
(g) Output frequency (Hz)
(h) Current (Amps - per phase and average)
(i) ekW, kVA, kVAR, kW-hr, %kW, PF

Alarm/Trip (shutdown) with indication for:

(a) Low lubrication oil pressure
(b) High coolant temperature
(c) Low coolant temperature
(d) Low coolant level
(e) Overspeed
(f) Emergency stop

(g) Failure to start (overcrank)

E14.5.8 Engine Speed Governing

(a) Break transfer

A solid-state isochronous electronic speed governor to SANS 8528-2, as amended, or better is required unless stated in the detail specification. Approved governors shall be provided with

i. Steady state speed bank, 0.25% isochronous control

ii. Speed regulation (droop), externally adjustable 0% to 15%.

(b) No-break transfer

An electronic governor with remote speed control capability must be supplied:

i. Digital signals (raise/lower inputs) to control engine speed (droop control must be configured in the governor);

ii. An analogue signal is used to control engine speed;

iii. An electronic engine with an Electronic Control Unit (ECU) with CANbus that supports speed control over the engine data link (CAN).

(c) Operating voltage

24Vdc unless starting battery bank nominal voltage is different in which case the operating voltage is to be the same as the nominal starter motor voltage.

When commissioning the set, the normal nominal speed shall be accurately set with the aid of a frequency meter.

E14.5.9 Automatic Voltage Regulator (AVR)

An electronic AVR must be supplied. The AVR must be sourced from a reputable manufacturer and must be from a known brand. The AVR must match the type of alternator supplied. The AVR must be installed, commissioned and tested in the generator supplier's facility.

E14.5.10 Exhaust Gas

The exhaust gases shall be ducted into the atmosphere through insulated piping and an exhaust silencer.

A baffle or absorption type silencer shall be installed in the plant room.

The silencer shall be of such a size and construction that sound level measurements taken within two meters of the exhaust opening shall not exceed 70 dB absolute.

The silencer shall be of stainless steel construction.

The silencer shall be fixed independently of the exhaust pipe and engine. All material including brackets, hanger/s clamps, etc., to support the entire exhaust system form part of this contract.

The exhaust pipe shall be of stainless steel construction.

The exhaust pipe diameter shall be sufficiently sized to ensure that the back-pressure limits of the engine are not exceeded. It shall be taken overhead and protrude through the wall at a height of not less than 2 meters. Exhaust gases shall be expelled into the open air. If exhaust angle is vertical, the exhaust pipe end should be fitted with a flap lid to avoid ingress of rain into the pipe.

A stainless steel, concertina type, flanged, flexible section shall be installed between the exhaust manifold and the exhaust line to allow relative movement between the engine and

exhaust pipe as well as thermal expansion and contraction without placing any strain on the exhaust manifolds and silencer. Except for the length of flexible exhaust pipe mentioned above the exhaust pipe shall be of rigid construction. All bends shall have a radius of at least two and a half times the pipe diameter.

The exhaust system shall be sufficiently offset from the centre-line of the engine to allow for the installation of a crawl beam above the centre of the engine for maintenance on the engine without fouling the exhaust system.

Where the exhaust pipe arrangement specified above passes through the engine room wall a weatherproof anti-vibration seal complete with insulation and/or expansion gaskets shall be provided.

The exhaust pipe outlet will be protected with a stainless steel mesh wire (horizontal pipe) to prevent access of birds or other foreign objects. If the exhaust pipe is vertically installed, a stainless steel counterbalanced flapper type rain cap will be installed on the pipe opening to prevent water and debris from entering the pipe. The flapper should be installed at a point that allows clearance for counterweight rotation.

The exhaust system shall be lagged with 25 mm thick asbestos rope, cloth wrapped and thereafter clad in bright polished stainless steel sheeting. On bends, the cladding shall be segmented to provide a semi-smooth neatly curved appearance.

E14.5.11 Starting (Electrical)

The engine shall be easily started from cold under summer as well as winter conditions without the use of special starting equipment.

Water-cooled engines shall be fitted with thermostatically controlled immersion heaters capable of maintaining jacket water temperature to ensure successful starting in the lowest ambient temperature stated. The rated heater voltage shall be the same as the mains voltage and shall be wired to the control panel and the circuit protected by suitably rated circuit breakers or fuses.

A 24 Volt DC starter motor, fitted with an approved positive engagement device, shall be used. The motor will be controlled by the panel mounted starter control circuitry and will be supplied from a 24V battery set.

Arrangement shall be made to ensure that the starter motor cannot be engaged unless the engine is at rest, i.e. the starting system shall be blocked while the engine is running or running down.

The contractor shall provide all necessary auxiliary equipment, i.e. solenoids, bendix drives etc. for the full automatic operation of the system.

E14.5.12 Battery

The set shall be supplied with a fully charged lead-acid battery rated for the voltage and current requirements of the starting motor(s) and control equipment, but shall not be rated for less than 150 ampere hour.

The battery discharge capacity at 5°C shall be such that the full cranking current can be drawn for 60 seconds with cell voltage falling to not less than 1,5 Volt, taking into account locked motor current and minimum motor cranking voltage. Where the control equipment is operated from the engine starting battery, the battery voltage, after six starting attempts at 5°C (i.e. six starting cycles of 10 seconds each shall be sufficient to provide satisfactory operation of the control equipment and five rest periods of 10 seconds in between starts).

Should the required battery ampere/hour rating be specified in the detail specification, for the

purpose of obtaining comparable tenders, the Contractor would be relieved of the responsibility for meeting the requirements of the above clause.

The cells shall be of 2 Volts per cell, and shall be mounted on an angle iron frame of sufficient size to allow 50 mm clearance between units for ventilation and mounted as close as possible to the starter motor.

E14.5.13 Battery Charging Systems

The battery shall be charged from an engine driven brushless alternator/rectified with automatic rate control during engine operation.

A battery charging system must be supplied to maintain batteries while the generator unit is on standby. The charging system must be mounted in the control panel

The charging system must:

(a) Recharge batteries quickly in the constant current mode, then automatically switches to maintain charge in a constant voltage mode

(b) Recharge completely dead batteries or those with no open circuit voltage

(c) Float and equalize batteries, which maintains charge with minimal water loss in cells

(d) Match charger capacity to the battery's ampere-hour (AH) capacity. Charger output should be between C/5 and C/20, where C equals the battery AH capacity. For example, a 10 amp unit can charge batteries between 50 and 200 AH.

(e) Offer short circuit protection to prevent damage to any DC powered controls, and allows engine cranking without disconnecting the charger

(f) Diagnostic functions or alarms complete with an output voltage sensor to detect power loss as well as overcharging problems. The voltage sensor must be time delayed to prevent false alarms caused by power drains from engine cranking

E14.5.14 Engine Protection

The necessary sensors for low oil pressure protection and engine over-temperature protection shall be fitted. Over speed and/or under speed protection shall be derived from the frequency sensor.

A continuously rated fail-safe engine-stop solenoid (energised to run), shall be provided. If a separate short time rated pull-in winding is employed, the linkage must ensure transfer to the full-time rated hold-in winding. The engine protective devices shall cut off the solenoid hold-in current and shut the engine down.

A fail-safe series circuit for the engine-mounted protection devices shall actuate the fuel cut-off solenoid in the event of the operation of a sensor, failure of a sensor, breaks in wiring or failure of the associated timing or control circuits.

A fail-safe device shall bypass the protection circuits during engine cranking and the protection circuits shall become operative with the start-discontinue signal. This device and the associated protection control circuitry shall be incorporated in the control section of the generator panel.

The sensors shall also operate the parallel protection circuits as stated.

All protection devices shall cut off the engine-run solenoid hold-in current to shut the engine down. Provision must be made in the control circuitry of each engine to disconnect the load immediately should the engine shut down for any reason whatsoever. The alternator must not be connected to load during the "run down" period.

Water-cooled engines shall be fitted with a water temperature gauge and an engine over-temperature cut-out system. A high engine water temperature cut-out system on its own is not acceptable. In the case of an air-cooled engine, the over-temperature protection shall be derived from the oil-temperature. For both water and air-cooled engines the over temperature protection shall de-energise the engine stop solenoid on the engine and give the required alarms.

An oil pressure gauge shall be fitted in the main lubrication oil circuit after the oil filter(s).

Digital engine protection with status monitoring provide via an engine control unit is preferable. All engine protection parameters must be accessible at the set mounted control panel as either indicator lamps or a scrollable LCD display. In the event of a fault, the screen mode should be in alarm display mode for the faults to be displayed. A reset button must be provided for clearing faults after correction.

E14.5.15 Fuel Tank

A proper constructed diesel fuel tank shall be supplied complete with all pipework and shall be installed in the plant room.

a) The fuel tank shall be sized to supply fuel to the generator for 24h operation without refilling the tank

b) The fuel tank shall preferably be mounted in such a position that fuel is gravity fed to the engine.

c) The tank shall be designed and positioned such that access to the set and the movement of maintenance personnel will not be impeded.

d) The tank shall be fitted with a full height transparent gauge glass.

e) A flange will be fitted on the tank for the future installation of an ultrasonic fuel level transmitter. The flange will comply to EN-1092-1, with

- Type 1 Plate flange for welding
- Nominal diameter DN 300mm
- Nominal pressure PN2.5
- Sealed with a matching blind flange
- Mounted 300mm above the top of the fuel tank (offset on a matching pipe DN300mm)

f) The tank shall be designed to collect water and sludge at the lowest point to be drained off.

g) A manual outlet shut-off valve in the fuel line to the engine shall be fitted.

h) A manual outlet shut-off valve in the fuel return line from the engine shall be fitted.

i) The fuel pipe to the primary sludge filter and the return pipe shall be steel.

j) The fuel shall be supplied directly from and returned to the tank. The fuel return pipe shall be connected directly to the fuel tank and shall terminate at the same depth as the fuel feed pipe.

k) The fuel feed pipe shall be connected to the tank in such a manner that any sludge or sediment formed in the tank will not enter the fuel line.

l) A semi-rotary, hand-operated, wing-pattern pump with hose shall be provided to facilitate filling the service tank from 200 litre drums.

m) It is the responsibility of the Contractor to supply and install fuel pipes of adequate diameter. Galvanised materials or materials containing zinc shall not be used in the fuel lines.

n) The engine fuel pumps shall be amply rated to overcome any height difference that may exist between the suction point and engine.

Base mounted fuel tanks are also acceptable, provided the above requirements are met.

E14.5.16 Engine/alternator Coupling

The engine shall be directly or closely coupled to the alternator without a reduction gearbox and the engine power shall be correctly matched to the alternator output at 1 500 rpm.

The coupling shall be by means of a flange adaptor ring or bell housing within which a shock absorbing flexible coupling shall be fitted.

## E14.6 ALTERNATORS

E14.6.1 Standards

The alternator shall be a 4 pole, self-excited, brushless, 3 phase, 4 wire, 50 Hz unit alternator complying with SANS 60034, as amended.

E14.6.2 Rating

The site rating of the alternator shall be no less than the site rating of the prime mover.

The alternator shall be capable of delivering the output specified in the detail specification continuously as well as on overload of 10% for one (1) hour in any period of twelve (12) hours consecutive running under the site conditions as stated without exceeding the temperature limits of SANS 60034, as amended.

The kVA rating shall be derated strictly in accordance with SANS 60034, as amended, for the worst engine room conditions specified in the detail specification. (installation at an altitude above 1000m).

E14.6.3 Insulation

The alternator shall be tropically insulated, i.e. special precautions shall be taken against the attack by harmful fungi on the insulation.

Both stator and rotor windings shall be fully impregnated for tropical climate and shall have an oil resisting anti-tracking finishing varnish.

The insulation provided shall be Class H or better throughout.

E14.6.4 Enclosure

The alternator shall be self-ventilated, screen protected and of IP23 construction.

E14.6.5 Shaft

The shaft shall be horizontal for direct coupling to the prime mover.

The shaft shall be either a single bearing or a two-bearing version designed to be suitable for commercially available heat engines. The bearings shall be of the “permanently greased” type.

A second shaft extension is not a requirement but would be an advantage for unforeseen additions such as tacho-generators, etc.

E14.6.6 Main Windings

The main field shall be of the rotating salient pole type and shall employ laminated poles in order to reduce eddy current losses to a minimum.

The rotor shall be dynamically balanced and the windings, excitation and regulating equipment shall be suitably braced to allow an over speed of 20%.

E14.6.7 Damper Windings

Brazed copper damper windings shall be provided on the main field poles.

The alternator damper windings shall allow an unbalanced load of 25% under steady state conditions.

E14.6.8 Winding Terminations

All alternator windings shall terminate in a suitable terminal box with removable cover plate. The terminal box shall be large enough to accommodate the cables and cable glands.

E14.6.9 Excitation

The alternator shall be provided with brushless, solid state excitation and automatic voltage regulation.

Excitation shall be provided by a rotating-armature AC exciter, flange-mounted on the alternator shaft on the non-drive side.

The rotor-mounted 3 phase AC exciter and full-wave rotating rectifier bridge shall supply a DC field current controlled by a solid state Automatic Voltage Regulator (AVR). The inherent damping of the exciter shall limit overshoot and hunting.

The rotating silicon diodes shall be protected from voltage spikes by means of a selenium diode which shall rotate with them. Alternative surge suppression means may be submitted for consideration.

In cases where a compounding circuit is provided, it shall be possible to remove the AVR when it fails and by a simple adjustment run the machine on compound regulation only.

E14.6.10 Steady State Voltage Performance

The voltage regulation shall be better than ± 1% of the nominal voltage specified at all loads with a power factor between unity and 0,8 and within the engine speed variations of 4,5% between 0% and 100% of full load.

The steady state voltage regulation may deteriorate under the unbalanced conditions as specified under Damper Windings above but shall not be worse than ± 3% under steady state conditions with phase power factors individually varying between 0,8 to unity power factor and engine speed variations of 4,5%.

E14.6.11 Transient Voltage Performance

The excitation system shall be designed to promote rapid voltage recovery following the sudden application of full load.

With instantaneous application of full load (70% in the case of turbocharged engines) from the no-load condition the voltage drop must not exceed 10% and recovery to rated voltage must be within 300 milliseconds.

The voltage recovery and voltage dip specified shall apply on site for the engine offered and do not refer to laboratory test conditions where large prime movers may be used.

E14.6.12 Voltage Adjustment

Alternator voltage adjustment over a range of ± 5% of nominal rated voltage shall be provided.

E14.6.13 Wave Form

The output waveform shall be sinusoidal and the deviation from a true sine wave shall not exceed 5% when measured in accordance with BS or VDE standards.

The line-to-line harmonic content or distortion (Distortion Factor) when measured between any of the phases at any linear load capacity of the alternator shall not exceed 4%.

E14.6.14 Overload Factor

The overload capacity of the alternator shall be such as to allow overloads of 10% for one hour or 50% for two minutes or any straight line interpolated intermediate overloading condition in between once every twelve hours.

Unless exactly equally rated, the site rating of the alternator shall always exceed the net site rating of the prime mover (as specified under clause - "Engines (General)") taking due cognisance of the overload factors applying in both cases. For power factors of 0,8 or higher it shall therefore not be possible for the alternator to be damaged by overloading.

E14.6.15 Radio Interference Suppression

The alternator output shall comply with the RF suppression requirements of EN 55011 group 1 class B standard, and the requirements of the Supply Authority, the Department of Posts and Telecommunications and any other statutory body having authority.

## E14.7 SET MOUNTING

E14.7.1 Main and Sub Frames

The engine and alternator shall be built together and bolted onto a common painted mild steel frame.

The base frame shall be placed on adequate anti-vibration mounting blocks, fit for the specific installation, on a concrete floor.

The frame must be high enough off the floor to facilitate easy installation and removal of the drip tray specified and for the draining of engine oil.

The outer casing of the alternator, the engine and all parts of the base frame shall be earthed to the plant room main earth busbar.

E14.7.2 Lifting and Transportation

The frame shall be of rigid construction enabling the complete set to be transported without dismantling.

The frame shall have lifting hooks or holes to facilitate handling during transportation and when positioned on site.

## E14.8 CONTROL SYSTEM

E14.8.1 General

The control panel shall be freestanding, all metal construction with a rated level of protection of IP55 according to SANS 60529.

The control panel shall be divided into two compartments to separate the instrument and control circuits from the power circuits.

E14.8.2 Control Panel Equipment

All meters shall be either 96 mm 240° circular scale instruments or alternatively rectangular linear scale 64 mm x 192 mm (approximately).

The following flush mounted equipment shall be incorporated in the control panel, together with the associated apparatus:

- Three maximum demand ammeters, 96 mm x 96 mm with a red line at the full load amperes, conforming to SANS 61958.
- Frequency meter 45-55 Hz with prominent mark on 50Hz
- Protection and alarm devices as specified
- Battery charger: Automatic trickle and boost and shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC indication ammeter and voltmeter plus ON/OFF switch with automatic switching from normal mains supply to alternator.
- One flush voltmeter scaled 0 - 400 volt, indicating alternator voltage with a multi-position voltmeter selector switch with one off position, connecting the voltmeter between the various phases and phases and neutral.
- One flush maximum demand indicating kW meter scaled to suit alternator output. At 100% and 110% of engine output the scale is to be crosshatched with red lines. Above 110% of rated engine output the scale is to be coloured solid red.
- One flush power factor meter.
- "running hours" meter with cyclometer counter.
- Adequately rated main MCB with overload and short circuit protection
- Automatic start stop cranking module with a four position mode selector OFF, MANUAL, AUTO and TEST with START and STOP pushbuttons operating on the manual mode.
- Voltage failure relay monitoring the voltage and phase rotation of the main supply working in conjunction with the AUTO mode of the automatic start/stop cranking.
- Over and under voltage relay, phase unbalance relay, phase reversal relay and earth fault relay.
- One set of potential fuses.

All instruments shall match and shall be clearly scaled for maximum legibility.

LCD display capable of providing multiple-parameter-viewing with critical parameter recording, networkable via common industrial protocol is preferable (Ethernet).

E14.8.3 Sequence of operation

In the event of a mains failure (for description of mains failure refer to the clause - "MAINS VOLTAGE SENSING"), the sequence of events shall be generally as described in the clause - "OPERATION". The timing of the detailed sequence shall be as follows:

*Mains Disconnection*

As a mains failure may also include single phasing, incorrect phase sequence, phase angle deviations or under/over voltage, a positive disconnecting of the mains is required immediately after detection of a fault. This shall be effected by operation of the Mains/Standby transfer switch.

*Engine Start Command*

Following a mains fault a start command shall be given to the engine after an adjustable delay of 0 to 60 seconds (pre-set at 10 seconds).

If the mains fault is cleared before the expiry of the adjustable start delay period the start command shall not be given.

Instead, a command shall immediately be given for the immediate changeover by the Mains/Standby transfer switch back to the healthy mains.

*Start Attempts*

Three start attempts by the starting system of 10 seconds each with a 15 second interval between each attempt shall be provided.

Restoration of the mains after the first engine start command has been given shall not interrupt the complete starting and power transfer sequence.

*Alternator Output CB Closure*

Assuming the engine has started correctly the alternator output circuit breaker, or contactor as specified, shall be closed approximately two seconds after the output has reached voltage and frequency to specification, or, alternatively, immediately after the output is stable and within specification.

Restoration of the mains or clearance of the mains fault shall not inhibit the transfer from Mains to Standby, the sequence shall however advance to a "mains restored" situation.

*Mains to Standby Changeover*

A changeover command shall be given to the mains/standby transfer switch immediately after the alternator output ACB closure if the mains fault has not been cleared.

*Mains Restored, Standby to Mains Changeover*

A changeover command shall be given to the mains/standby transfer switch after a period adjustable from 10 to 60 minutes (pre-set at 10 minutes) after restoration of the main supply. Transfer from standby power to mains will be break or no-break transfer as specified in the detailed specification.

*Engine No-load Rundown*

An engine stop command shall be given after an engine cooling period of no load adjustable from 5 to 15 minutes (pre-set at 5 minutes).

E14.8.4 Auto/test/manual/off selector switch

A key operated, four-position selector switch shall be provided.

(a) Auto

In this position, the generator and control circuit shall operate automatically under control of one or more of the logic modules detailed hereunder.

(b) Test

The generator shall start automatically but the alternator circuit breaker shall not close. The mains control shall not be affected.

It shall be possible to prove the operation of the automatic synchronising unit (if provided) without closing the alternator circuit breaker.

The operation of the engine/alternator protective devices shall be provided by simulating a fault by means of test buttons.

(c) Manual

In this position, all automatic control circuits shall be inoperative. The set shall be started from a pushbutton or switch on the control board. The alternator circuit breaker, voltage and engine speed shall also be controlled by pushbuttons or potentiometers.

(d) Off

In this position, the set shall be completely disconnected from the automatic control for cleaning and maintenance purposes. The mains control selection shall, however, still operate normally.

A digital interface for selecting any of the above may be provided, in which case a by-pass switch should be provided to allow for test mode.

E14.8.5 Mains voltage sensing module

A mains voltage sensing module shall be provided. This shall monitor all three phases and the neutral both individually and jointly and shall initiate the starting sequence upon failure or malfunction of any one or all three phases and the neutral.

The over-voltage drop-out shall be adjustable between 110% and 120% of the normal supply voltage (400 V) and adjusted to 110%.

The under-voltage dropout shall be adjustable between 80% and 90% of the normal supply voltage (400 V) and adjusted at 90%.

Phase unbalance sensing shall be provided in the form of a phase unbalance monitor. A phase angle unbalance shall be adjustable between 5 to 20% and pre-set at 5%.

E14.8.6 Alternator Voltage Sensing Module

An alternator voltage/frequency sensing module shall be supplied.

The module shall provide voltage monitoring features as detailed above.

The unit shall incorporate a frequency monitor, adjustable to within limits of ± 10% of 50 Hz.

Three separate outputs from the module shall be provided: one for voltage and two for frequency. These outputs shall initiate operation of the over speed, under speed, as well as abnormal voltage trip and alarms but shall be sufficiently delayed to overcome short time voltage or frequency variations.

Visual monitoring facilities in the form of LEDS or LCD display shall be provided for voltage and frequency.

E14.8.7 Timing Module

A time delay unit which upon mains failure, initiates start delay of 0 - 60 seconds (set at 15 seconds) shall be provided. If the mains should return during the start delay, the start-up cycle shall not proceed.

E14.8.8 Start Control Module

A control module incorporating the start command circuits shall be provided which shall, in the event of a power failure as sensed by the mains voltage sensing module and the mains having been restored by the time the start delay timer has elapsed, initiate the automatic starting

sequence and thereafter prevent interruption of the starting sequence even if power is restored before starting is achieved.

The control panel, after the delay start timer has timed out, shall initiate three 10 second attempts with a 15 second delay between each attempt.

E14.8.9 Protection and Alarm Module

A protection and alarm circuit module offering engine protection and alarm circuits shall be provided which shall include:

| ALARMS NON-URGENT (Visual only) | ALARMS URGENT (Visual + audible + engine shutdown) |
|---|---|
| Selector switch not in auto<br>Starter battery charger failed<br>Low fuel<br>Low cooling water | Low oil pressure (engine)<br>High temperature (engine)<br>Under speed (engine)<br>Over speed (engine)<br>Start failure (engine)<br>Abnormal output voltage (alternator)<br>Reversed power (alternator)<br>CB O/C trip (alternator) |

Operation of each of the protection circuits shall interrupt the fuel cut-off solenoid supply and give a separate visual indication on the module.

The protection circuits shall be reset by a push-button and a further push-button shall be provided for lamp testing of the visual indicators.

The protection and alarm indication circuits shall be operated from the starter battery.

A spare voltage-free single pole changeover contact rated at 5 amps 220 AC shall be provided for each alarm indication. Each contact shall be wired to terminals to enable a remote alarm panel to be installed by others.

The protection and alarm module may be digital, separate or integral to the main control module or engine control unit.

E14.8.10 Battery charging module

One mains-operated battery charger module, complete with ammeter, voltmeter and protection, which shall charge the engine starter battery shall be provided.

The charger shall operate in parallel with the engine-driven generator and shall have self-adjusting, stepless control characteristics (constant voltage, current limiting).

A loss-of-charge current alarm shall be provided to indicate failure of the mains charger. This may be a current or voltage monitor. The alarm signals (contacts or voltage) shall be brought to terminals for connection to an external monitoring system.

The module shall be suitable for connection to the 230 Vac mains with a maximum voltage variation of ± 15% and a maximum frequency deviation of ± 3 Hz.

Output voltage shall be kept within 1% of the float charge voltage designed for maximum water conservation and maximum life of the battery.

The ripple content in the output of the charger shall be less than 2%.

The battery charger shall be equipped with the following additional equipment:

(a) Overload protection

(b) One 48 mm x 48 mm dial shielded voltmeter and associated push-button for the indication of battery volts

(c) One 48mm x 48 mm dial shielded type ammeter for the indication of battery charging current.

## E14.9 POWER SYSTEM

E14.9.1 General

Unless detailed otherwise in the detail specification to suit a particular installation, an integral, free floor-standing switchboard/control unit shall be provided which shall house the control system covered under the clause - "CONTROL SYSTEM" as well as a switchboard as describe below.

For installations where the changeover equipment forms part of the set requirements, the section "400 V switchboards" shall apply, in addition to any additional requirements as set out in the detail specification.

E14.9.2 Control system

The control system shall comply with the requirements as set out under the clause "CONTROL SYSTEM".

E14.9.3 Changeover Distribution Board

The Changeover Distribution Board must comply with all requirements as stipulated in the specification E04: ELECTRICAL LOW VOLTAGE DISTRIBUTION BOARDS AND MOTOR CONTROL CENTRES

The following shall be provided:

(a) 25 mm x 6 mm earth bar and terminal stud.

(b) Terminal blocks as necessary (approved).

(c) One fully automatic supply change over assembly, which will function as the automatic closing and opening device to connect or disconnect the alternator supply from the main LV switchboard.

(d) Copper busbars (3 phases and neutral). The busbars shall be drilled to accept suitably sized copper lugs.

(e) A removable gland plate which shall be located a minimum of 800 mm above floor level and shall be large enough to mount the glands of all the power cables plus 50% spare capacity for sensing, control and LT supply cables.

(f) The copper busbar shall be connected by means of secondary busbars to the outgoing terminal stubs of the CB and are to be spaced well apart and firmly braced.

The star-point (neutral) of the alternator shall be earthed to the earth bar in the switchboard. The size of the earth wire shall be at least 50% of the cross-sectional area of the supply cable connected to the generator and switchboard with a maximum size of 70 $mm^2$.

## E14.10 TESTING

E14.10.1 General

The complete testing including the provision of test facilities, instruments, dummy loads and switchgear at both the manufacturer's premises and on site, as well as fuel at both sites shall form part of this Contract.

For both tests at the manufacturer's premises and on site, the Engineer shall be notified two weeks in advance in order that a representative can be sent to witness these tests.

The test instruments provided shall in all cases be of high quality and suitable to adequately assess the quantities being measured or the equipment being tested. The test equipment remains the property of the Contractor.

E14.10.2 Testing at works

The necessary tests to prove compliance with this Specification shall be carried out at the manufacturer's premises.

These tests shall include, but not necessarily be limited to, the tests detailed below:

(a) Full load and overload output with all auxiliary equipment attached.

(b) Cold starting and load acceptance

(c) Governing for steady and step-loads.

(d) Fuel consumption

(e) All relevant pressures, flows, speeds, etc.

(f) Alternator characteristics including rated full load and overload output, harmonic distortion, regulation under steady and step-loads, voltage transients, recovery times and overshoot, etc.

(g) Systems operation and fault protection circuits

(h) Switchgear and instrumentation

(i) Insulation of alternator, cables and switchboard

(j) Battery capacity

(k) All relevant operating temperatures including cooling medium, alternator windings, bearings, exhaust gas, etc.

E14.10.3 Procedures (Works testing)

The set shall be run long enough to satisfactorily determine all the relevant quantities under stabilised conditions.

A varying load test shall be carried out at the manufacturer's premises where the set must be run at various loads from no-load to 10% overload and back to no-load, the following readings being taken at 20% load steps:

(a) Voltage

(b) Current

(c) Power factor (alternatively wattage)

(d) Frequency

(e) The test sequence is to be carried out at unity power factor and a second test sequence

at 0,85.

(f) It has to be ensured that the machine was stationary for a minimum period of six (6) hours before the test is performed.

(g) The engine water heaters may be supplied from the mains for the purpose of the test.

E14.10.4 Testing at site

(a) The final acceptance tests at site shall include, but not necessarily be limited to, the tests listed below:

(b) Insulation and continuity of wiring

(c) Cold starting and load acceptance

(d) System operation, fault protection circuits and alarm

(e) Switchgear and instrumentation

(f) Battery capacity and battery charger

(g) A six (6) hour test. The set shall be subjected to prime rated load for five (5) hours followed by 10% overload for one (1) hour. The following readings shall be taken at 30 minute intervals during the five hour period and at 10 minute intervals under overload:

- temperature (oil, water and exhaust gas)
- oil pressure
- alternator voltage, frequency, power factor or wattage
- battery voltage and charging current
- ambient temperature

(h) The alternator and engine shall be inspected after the test.

E14.10.5 Test Reports

At the completion of all tests, a comprehensive test report shall be compiled and submitted to the Engineer in duplicate.

The tests at the manufacturer's premises and the on-site tests shall be shown separately. In addition, the test reports shall be included in the manuals as specified.

A thermal image of the generator running under normal operating conditions shall be taken and presented as part of the Operation and Maintenance Manuals.

## E14.11 INSTALLATION

E14.11.1 Handling, Hoisting and Crane Usage

The Contractor shall provide and carry out everything necessary to complete the whole installation and put it into service.

The set is to be located as indicated on the drawings and the subcontractor is to allow for all handling, hoisting, crane usage and other equipment necessary for installing the set in position.

The time of arrival on site and method of handling and installation is to be fully discussed with

the Building Contractor in order that this may be co-ordinated with the construction programme.

E14.11.2 Erection

Before erection commences the equipment shall be inspected and properly cleaned to remove the protective coverings and coatings applied before dispatch.

All coils, instrument windings and relays shall be tested by means of a 500 Volt Megger to ascertain whether any breakdown of insulation has taken place.

All components shall be examined for visible signs of damage and all damage shall be reported in writing to the Engineer.

The Contractor shall carry out the erection, including cutting holes for holding down bolts, positioning and grouting holding down bolts in accordance with jigs or drawings supplied, observing all erection instructions and precautions for erection that may be issued by the manufacturers of the equipment.

The Contractor is to make sure that the complete set has been properly aligned and that all bolts and connections and mating parts have been properly assembled.

All bolts and any other fastenings are to be tightened up and all electrical connections checked for tightness.

All wedges and packings installed at manufacturer's works to prevent damage to moving or delicate components during transport are to be removed.

The paintwork is to be touched up with matching paint.

E14.11.3 Cabling

The Contractor must include for the complete installation and wiring of the set, including the termination and connection of those cables as shown on the drawings.

The installation is to comply with the requirements of the relevant Machinery and Occupational Safety Act and the relevant regulations of the Factories, Machinery and Building Works Act of 1941, as amended, and with the Code of Practice for the Wiring of Premises, as amended.

For the alternator circuit PVC insulated steel wire armoured and PVC sheathed cables are to be used and for control circuits multi-core PVC cable or PVC insulated wires in buried conduit may be used.

E14.11.4 Notices

In the plant room a clearly legible and indelible warning notice must be mounted in a conspicuous position. The notice shall be made of a non-corrodible and non-deteriorating material, preferably plastic, and must read as follows, in red letters on a white background:

| DANGER<br>The engine will start without notice<br>Turn selector switch on control board to “OFF” before working on the plant |
|---|

A metal danger plate of 250 mm x 150 mm complete with skull and crossed bones with the following words engraved on the plate shall be supplied and installed on the door leading into the plant room:

DANGER

All other notices as required by the Machinery and Occupational Safety Act, and the relevant

regulations of the Factories, Machinery and Building Works Act, as amended, shall be supplied and installed both inside the plant room and outside on the entrance doors.

An additional notice or engraved metal plate shall be fitted to the engine to indicate the type, grade and manufacture of the lubricating oils for the engine.

An "Operator's Check List" shall be mounted in a suitable position below one of the emergency lights. The Check List shall contain a step-by-step procedure to be carried out should the set fail to start. The Check List shall be printed in bold, black letters and shall either be made of plastic or metal or shall be printed on stiff paper and mounted behind Perspex or glass.

The drawings as mentioned under the clause - "DRAWINGS AND MANUALS" are required.

E14.11.5 Tools and Loose Equipment

A wall-mounted sheet steel cabinet is to be provided containing a recommended set of tools for the service, maintenance and small repairs of the complete installation. All equipment shall be neatly hung in the cabinet for easy identification. The cabinet shall be padlockable.

A list of the proposed items shall be submitted with the Tender.

## E14.12 DRAWINGS AND MANUALS

E14.12.1 Drawings Submitted for Approval

As soon as possible after the award of the Contract, the successful Tenderer shall, at his expense, submit to the Engineer for approval three prints of the drawings scheduled below:

(a) All general arrangement drawings, including a dimensioned plant room layout.

(b) Installation drawings for the cooling and exhaust systems.

(c) Detailed dimensioned drawings of all plant and equipment.

(d) Complete wiring diagrams and block schematic diagrams.

(e) Dimensioned general arrangement drawing of all equipment on the switchboard.

E14.12.2 "As-built" Drawings

On completion of the Contract, all drawings required for the manuals shall be prepared and included in the manuals as specified. In addition a set of transparencies shall be handed to the Engineer to form the "as-built" records. These final drawings shall include the drawings schedules below:

(a) A proper and accurate as-made wiring diagram of the complete installation showing circuit numbers, terminal strip numbers and conductor colours.

(b) A schematic diagram clearly showing functions and components of the control equipment and switchgear is to be included.

(c) Fully dimensioned as-made physical layout drawings of the generating set, substation, cooling and exhaust system.

(d) Fully dimensioned as-made physical layout of the switchboard.

(e) A detailed schedule of all wiring.

(f) The Contract shall be deemed incomplete until all drawings have been received by the Engineer.

(g) A print of the drawings under the second and third clauses of this section shall be

mounted on the wall of the plant room behind a Perspex or glass cover.

(h) The drawings must be professionally drawn on plastic transparencies with annotations.

(i) A copy of each wiring- and circuit-diagram shall be supplied mounted in a single glass-fronted timber frame adjacent to the switchboard.

E14.12.3 Manuals

(a) Upon completion of the Contract, three complete sets of manuals shall be handed to the Engineer.

(b) Each handbook shall contain complete information on the following aspects of all units comprising a working installation:

(c) Technical descriptions and specifications of equipment

(d) Engine workshop manual

(e) Erection and commissioning instructions

(f) Operating instructions

(g) Description of functioning, adjustment and maintenance of equipment

(h) Parts lists, with illustrations where necessary, for correct identification of components for ordering of replacements.

(i) The Contract shall be considered incomplete until all drawings and manuals have been received and approved by the Engineer.

(j) An additional notice or engraved metal plate shall be fitted to the engine to indicate the type, grade and manufacture of the lubricating oils for the engine.

(k) An "Operator's Check List" shall be mounted in a suitable position below one of the emergency lights. The Check List shall contain a step-by-step procedure to be carried out should the set fail to start. The Check List shall be printed in bold, black letters and shall either be made of plastic or metal or shall be printed on stiff paper and mounted behind Perspex or glass.

(l) The drawings as mentioned under the clause - "DRAWINGS AND MANUALS" are required.

## E14.13 OPERATING INSTRUCTIONS AND MAINTENANCE

E14.13.1 Training for Owner's Representative

After completion of the installation and when the plant is in running order, the Contractor will be required to train the Owner's (user) Engineer and/or attendant in the operation of the plant until he is fully conversant with the equipment and the handling thereof.

E14.13.2 Maintenance Period

The Contractor will be required to maintain the plant in good running order after the plant has been taken over by the Client for a period of twelve (12) months. The Contractor shall carry out the maintenance as described in the clause - "MAINTENANCE CONTRACT". The cost of this maintenance must be included in the tender price.

E14.13.3 Maintenance Contract

After the lapse of the maintenance period, the Contractor may be required to enter into a

maintenance agreement with the Owner. This agreement will initially be for one calendar year and may subsequently be renewed for yearly periods.

Tenderers shall prepare and submit a pro forma maintenance and service contract. This maintenance and service contract shall be a formal service agreement of the suppliers of the standby set signed by an authorised employee and shall include the monthly cost of the services to be provided. Tenderers must state to what extent the price quoted will be subject to variation.

The entering into of a Maintenance and Service Contract shall in no way invalidate the Guarantee.

Under this agreement the Contractor will undertake to arrange monthly visits to the plant by a qualified member of his staff, who shall effect the following:

(a) Report to the Officer-in-Charge, keeping the maintenance records and enter into a log book the date of the visit, the test carried out, the adjustments made, any further details that may be required.

(b) When necessary, clean the plant and its components.

(c) Grease and oil moving parts where necessary.

(d) Check the air filter and when necessary, clean the filter and replace filter oil.

(e) Check the lubricating oil and top-up when necessary.

(f) After the plant has run on one oil change for the number of hours stipulated by the makers, drain the sump and refill with fresh lubricating oil. The reading of the hour meter on the switchboard will be taken to establish the numbers of hours run by the plant.

(g) Clean the lubricating oil filter and/or replace the filter element at intervals recommended by the engine manufacturer.

(h) Check and when necessary adjust the valve setting and the fuel injection equipment.

(i) Check the battery and top-up the electrolyte when necessary.

(j) Test-run the plant for two hours and check the proper working of all parts, including the electrical gear, the protective devices and fault indicators, the change-over equipment and the battery charger. Make the necessary adjustments.

(k) Advise the Owner when it has become necessary to decarbonise the engine and submit a quotation for this service.

(l) Report to the Owner on any parts that have become unserviceable, through fair wear and tear, or damaged by causes beyond the control of the Contractor and submit a detailed quotation for the repair or replacement of such parts.

## E14.14 MEASUREMENT AND PAYMENT

**Item** **Unit**

Supply and deliver standby diesel generator ..... No

The tendered rate shall include full compensation for the manufacture, supply, testing and delivery of the standby diesel generator incorporating all options/extras as detailed in the detail specification. The tender price shall also include the supply and fill of all lubricating oils (first fill) and the supply and install of all filter elements

**Item** **Unit**

Install standby diesel generator ..... No

The tendered rate shall include full compensation for the installation, site testing and commissioning plus the 12 months maintenance of the standby diesel generator incorporating all options/extras as detailed in the detail specification.

| Item | Unit |
|---|---|
| Yearly maintenance contract ..... | Sum |

The tendered rate shall include full compensation for the work detailed under paragraph "maintenance contract" above.

# PARTICULAR SPECIFICATION: VOLUME E15: ELECTRICAL TRANSFORMERS

## CONTENTS

## E15.1 SCOPE

This section covers the design, manufacture, supply and delivery and assembling on site of oil filled distribution transformers.

## E15.2 STATUTORY DOCUMENTS AND STANDARDS

E15.2.1 Standards

The transformers offered in terms of this specification shall comply with the requirements as set out in the detailed specification as well as the relevant sections of SANS 780:2004.

The units offered will have the SANS mark of approval.

Any deviation from these conditions will be clearly indicated, and any equipment so offered will only be used with the express permission/concession, in writing, of the Engineer.

The equipment offered and work performed, shall comply with the requirements of the governing occupational Health and Safety act, at time of tender.

Transformer shall be produced in a factory with a SANS ISO 9001 accredited quality system.

| | | | |
|---|---|---|---|
| b) | SANS 780 | : | Distribution transformers |
| c) | SANS 60078 | : | Power transformers |
| d) | SANS 555 | : | Fluids for electro-technical applications |
| e) | SANS 60529 | : | Degrees of Protection Provided by Enclosures (IP Code) |
| f) | SANS 12944 | : | Paints and varnishes - Corrosion protection of steel structures by protective paint systems |
| g) | SANS 10064 | : | The preparation of steel surfaces for coating |
| h) | SANS 121 | : | Hot dip galvanized coatings on fabricated iron and steel articles |
| i) | SANS 1091 | : | National colour standard |
| j) | SANS 61958 | : | Indicating devices |
| k) | SANS 10142-2 | | The wiring of premises Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 MVA installed capacity |

E15.2.2 Particular Specifications to be read in conjunction with this specification

The following particular specifications shall be read in conjunction with the Project Specification:

| | | | |
|---|---|---|---|
| a) | E06 | : | ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION |

b) E05 : LOW VOLTAGE POWER AND CONTROL CABLES

c) E08 : WIRING

d) E11 : GENERAL EARTHING AND LIGHTNING PROTECTION

e) E26 ELECTRICAL SPECIFICATION FOR COLOUR CODES

## E15.3 Environmental Conditions

The transformers shall be suitable for use at full continuous rating, in terms of Paragraph 1.3 of the latest issue of SANS 780.

## E15.4 Construction Requirements

In addition to the requirements of SANS 780, the following will also be considered:

### E15.4.1 General

The transformer vector symbol shall be Dyn11 (step down transformer) of YNd11 (step-up transformers) as per SANS 780 unless otherwise specified in the detailed specification.

Total and component losses shall not exceed 10% of the loss figures as indicated in the tender.

The nominal voltages (primary and secondary) will be as specified in the detailed specification/data sheet.

Transformers will have a removable top lid for maintenance and repair purposes. The lid must be fixed with bolts and nuts, sized to contain integrity of the transformer tank under all circumstances.

All openings on the transformer tank must be sealed with cork gaskets.

The minimum transformer rating will be 500kVA.

The maximum transformer rating will be 1600kVA.

Transformers offered will be painted and finished in accordance with SANS 780.

### E15.4.2 Indoor Transformers

Transformers supplied will be free breathing in accordance with SANS 780.

(a) The contractor will specify the required room size to accommodate the transformer with sufficient free space for maintenance purposes.

(b) The doors to the transformer room should be sized to allow the installation/removal of the transformer without dismantling the unit.

(c) A bund wall must be erected around all oil-filled transformers. The bund area must be sized to hold 1.5 times the transformer oil. The bund wall must be

sealed to contain the oil, no seepage into cable trenches or surrounding areas will be allowed. The bund area must be supplied with a 50mm stop valve to allow drainage of spilled oil. The stop valve must be kept in the closed position at all times.

(d) An approved firewall must be erected between the transformer and all adjacent equipment/areas to prevent the spreading of smoke and fire. The firewall should have a fire rating of at least 1 hour.

E15.4.3 Cooling Method

The cooling method used shall be the method represented by the symbol group ONAN in accordance with SANS 780.

## E15.5 Transformer Oil

The transformers will be provided and delivered filled with the required quantity of insulating oil. Should the transformer be delivered with the conservator tank separate from the transformer (dismantled), the supplier will be responsible for assembling the transformer on site and filling it with oil. The oil shall be filtered and tested for break down voltage (BDV) and moisture content before filling. The oil shall be filled under vacuum. All oil shall be new and the use of recycled oil is not acceptable. The oil shall comply with SANS 555.

## E15.6 Transformer Losses

Low loss transformers are required for this tender. Accordingly, the Engineer shall retain the right to either not accept the transformers offered or to call for changes to be made to the transformers before acceptance,

Should in the Engineer's opinion, either the no-load losses or the full-load losses of the transformers supplied by the successful tenderer exceed the loss figures specified in the tender, by a quantity exceeding the permissible tolerances in accordance with SANS 780. Any such changes, called for by the Engineer, will be for the account of the tenderer.

Where any transformer is accepted with reduced performance figures and where tolerances exceed the provisions of paragraph 4.9 of SANS 780, the tender price will be adjusted and reduced by a sum equal to the capitalized value of the excess losses, calculated in accordance with the following capitalization formula:

$K = 1{,}46\ V + 2{,}86\ N$

Where

K = capitalized value of the losses in South African Rand (ZAR)

V = full - load losses at normal voltage and frequency, in watts

N = No - load losses at normal voltage and frequency, in watts

In view of adjusting the tender price, the said excess losses shall be taken as the quantity by which the actual losses exceed the loss figure in the tender document, without taking into consideration the permissible tolerances in accordance with SANS 780.

The no - load and full – load losses will be taken into consideration independently when calculating the adjustment of the tender price. Low full-load losses will not be able to compensate for high no-load losses, or vice versa.

Neither will the tender price be increased, should the actual no-load losses and/or full load losses be less than the losses tendered.

The above formula with V and N will be used in adjudicating the tender.

## E15.7 WINDINGS

HV and LV windings shall be wound from aluminium conductor. All internal busbars must be aluminium. The core/coil assembly shall be securely held in position to avoid any movement under short circuit conditions.

## E15.8 TAP CHANGER SWITCH

A off-load tap changer switch shall be installed. The switch shall have 5 tap positions, i.e. - 5%, - 2.5%, Normal, + 2.5%, + 5%.

Tap changing shall be carried out by means of an externally operated self-position switch. Provision shall be made for locking the taping switch handle in position. The tap setting shall be clearly visible in each step. The displayed tap numbers shall be referenced on the diagram plate.

## E15.9 FIXTURES

### E15.9.1 Conservator Tank

A conservator tank shall be provided on the transformer tank as per SANS 780.

### E15.9.2 Cable Box MV side

The transformer shall be fitted with a suitable cable box on the MV side to terminate one 11kV/ 3 core copper conductor cable up to 240 sq. mm The cable box must prevent the ingress of moisture into the box (IP54). The cable box shall be of the split type with machined faces and must be fitted with a quality gasket. It must be fitted with a separate split type gland with an earthing clamp (bottom cable entry unless otherwise specified in the detailed specification/datasheet). The bushings of the cable box shall be fitted with nuts and stem to take the cable cores without bending them. The stem shall be of copper with copper nuts. The cross section of the terminal rods shall be adequate for carrying the rated currents and shall have a diameter of not less than 12 mm. Cable support clamp should be provided to avoid tension due to cable weight. Phase windings shall be marked in both the terminal boards inside the tank and on the outside with capital letter 1U, 1V, 1W

### E15.9.3 Cable Box LV Side

The transformer shall be fitted with a suitable LV cable box having non-magnetic material gland plate with appropriate sized single compression glands on LV side to terminate (bottom cable entry unless otherwise specified in the detailed specification/datasheet) 1 kV/single core XLPE unarmoured cable (size as per detail requirement). Bushings shall

be marked by small letter 2u, 2v, 2w. The neutral point terminal shall be indicated by the letter 2n. Neutral terminal is to be brought out and terminated to the tank earthing point.

E15.9.4 Jacking Pads and Lifting Lugs

Sufficient jacking pads shall be fitted to jack the oil-filled transformer into position. The tank plate and the lifting lugs shall be of such strength that the complete transformer filled with oil may be lifted without the use of a sling spreader bar. A lifting procedure must be supplied.

E15.9.5 Wheels

Transformers must stand on skids. No wheels will be allowed. Where wheels are required to position the transformers, the wheels must be removed after positioning.

## E15.10 AUXILIARY EQUIPMENT

The required auxiliary equipment to be included are specified in the detailed specification.

E15.10.1 Oil Level Gauges

Oil level gauges shall be flush mounted with the gauge glass (of plastic material) securely attached to the tank throughout its length by means of a metal shroud. The oil in the gauge will not be in contact with the air outside the tank.

E15.10.2 Air Breather

Silica gel air breathers shall have a window for inspection of the condition of the silica gel and oil cup or other device to prevent continuous contact of the silica gel with the air outside the transformer.

E15.10.3 Buchholz Relays

Buchholz relays shall be of the double float or bucket type and shall be of approved manufacture.

The gas release cock for the relay shall be placed within easy reach from ground level and connected to the relay by small-bore non-ferrous tubing. The sight window of the relay will be clearly visible from ground level.

The Buchholz relays will be equipped with a set of alarm and trip contacts.

E15.10.4 Dual-type Thermometers

Dual-type thermometers will be graduated in °C for registering “top oil” temperatures. The instrument will be provided with resettable maximum-temperature indicator and a pair of adjustable alarm contacts that can be set to close at a predetermined temperature. An additional set of adjustable contacts will be provided for tripping purposes. All thermistors or other temperature sensors will be installed in oil pockets. Unused thermometer pockets will be fitted with a captive screw cap.

E15.10.5 Pressure Relief Device

A pressure relief device is not required.

E15.10.6 Oil Filling Point

A point must be provided to fill the oil level up. The point must be of the screw type and be sealed to prevent air intake when not in use.

E15.10.7 Oil Drain Point

A drain point must be provided to drain the oil from the transformer tank. A shut-off valve must be installed at the drain point. The drain point must be sealed with a screw type cover when not in use.

E15.10.8 Alarm and Trip Contacts

All alarm contact will be capable of breaking up to 20W DC, inductive, at the specified alarm and tripping voltages.

All contacts will be capable of making and carrying for 0.5 sec, a current corresponding to 150 watts at the specified alarm and tripping voltage.

All auxiliary relays associated with tripping shall be DC operated and suitable for the specified alarm and tripping currents.

Alarm and tripping contacts will be provided with un-grounded and electrically independent circuits.

## E15.11 PAINTING

The interior and exterior surfaces of a tank, the tank cover and the conservator tank shall be abrasive blast-cleaned or pickled, rinsed and dried (SANS 10064).

(a) Corrosion protection

A corrosion preventative layer will be applied to the interior surfaces of the transformer. The transformer and cooling radiators will be painted as specified in SANS 780 and SANS 12944.

(b) Final Coat Colour

The colour of the final paint coat is C12 Avocado Green (6022-G91Y) according to SANS 1091 unless specified otherwise in the detailed specification.

(c) Damaged Paintwork

Any damage occurring to any part of a painting scheme shall be made good to the same standard of corrosion protection and appearance as that was originally applied.

## E15.12 Tests REQUIREMENTS

Routine factory acceptance tests (FAT) in accordance with SANS 780 shall be performed at the supplier's facility prior to delivery. Type tests and special tests to SANS 780 shall be performed on one transformer of the size to be delivered in terms of this contract unless the manufacturer can provide certificates of previous tests done on identical transformers. The following routine tests will be carried out on the transformer as a

minimum (The tests are described in SANS 780) The Engineer reserves the right to witness the FAT tests.

(a) Measurement of winding resistance
(b) Insulation resistance measurement
(c) Measurement of voltage ratio
(d) Impedance test
(e) Vector group test
(f) Measurement of transformer losses
(g) Induced over voltage test
(h) Separate source voltage withstand test
(i) Tank effectiveness of sealing

The results of these tests will be made available to the Engineer for his evaluation prior to acceptance and delivery of the transformers. Two copies of test results will be provided to the Engineer.

The contractor must arrange for site acceptance tests (SAT) on all transformers. A schedule of all tests to be done must be provided by the contractor for approval prior to commencement of manufacture. The SAT must be witnessed by the Engineer or the client's representative. The results of the SAT will be recorded and issued to the Engineer.

The contractor shall arrange for thermal imaging of the transformer a minimum of 1 week after commissioning and while the transformer is in continuous use. The results of the imaging and SAT are to form part of the deliverable Operations and Maintenance Manuals.

## E15.13 Drawings

Tenderers shall furnish the following drawings together with their tenders:

(a) Outline drawings of the transformers, showing:
  i. All external fittings;
  ii. Typical mass of the transformer with and without oil;
  iii. Typical volume of transformer oil;
  iv. The most important external dimensions.
(b) Details of MV and LV bushings

The successful tenderer will provide three copies of each of the following drawings, to the Engineer, before manufacturing may commence:

(a) General Arrangement drawings indicating
  i. External fittings;
  ii. Lifting lugs and lifting requirements;

iii. The mass of the transformer with and without oil;

iv. The volume of the transformer oil;

v. Transformer dimensions with free space required;

vi. The transformer rating plate (to SANS 780);

(b) The internal construction of the transformer and the arrangement of the windings, giving full particulars of insulation, as well as the bracing of the cores and windings;

(c) A diagram of the connections showing the exact manner in which the leads are taken from the tank, as well as the number of windings;

(d) Schematic drawings of the alarm and trip circuits.

## E15.14 Sound Level

During design and manufacture of transformers, care should be exercised to limit transformer noise and vibration to within the parameters as recommended in SANS 780.

## E15.15 Identification Tags

All data on the identification tags shall be in SI units.

## E15.16 TESTING AND COMMISSIONING

During testing and commissioning, the contractor shall:

(a) Perform an transformer oil test prior to livening of the transformer;

(b) Perform a visual inspection to ensure that the installation complies to the requirements specified herein as well as in detailed specifications;

(c) Ensure the rating of all equipment is as specified;

(d) Test the function of all alarm and trip signals to ensure the transformer circuit breaker trips as required;

(e) Do a transformer insulation resistance test (as described in SANS 780).

(f) When the transformer is on load, the correct tap changer setting must be determined. Tap setting changes can only be done off-load.

## E15.17 Measurement and Payment

| Item | Unit |
|---|---|
| Supply, delivery and off-loading | No |

The tendered rate will include full compensation for the supply, delivery and off-loading of the transformers together with all other materials and ancillary equipment required to effect a complete installation.

| Item | Unit |
|---|---|
| Install, test and commission | No |

The tendered rate will include full compensation for installing the transformers in the designed positions and for the testing and commissioning of the transformers.

The rate shall include for the installation of the control cables between the transformer and the switchgear and all auxiliaries and the connection thereof.

The rate will include for the filling of the transformer with oil to the specified level, as well as the undertaking of any drying out process which may be required to ensure the transformers are ready for operation.

# PARTICULAR SPECIFICATION: VOLUME E16: ELECTRICAL UNINTERRUPTIBLE POWER SUPPLY UNIT

## CONTENTS

## E16.1 INTRODUCTION

This specification is for the supply and installation of Single Online Double Conversion Static Uninterrupted Power Supply Units (UPS) for use in office and industrial environments.

The UPS Unit will be used for backing up critical electrical loads, such as lighting, dedicated sockets, air conditioning in computer rooms etc.

The UPS Unit will be installed via Normal Power or via a Diesel Standby Generator.

## E16.2 SCOPE

The scope of work includes the furnishing of all labour, material and services for the design, supply, manufacture, delivery to site, off load, install in position, fix on site, testing, commissioning and inspection of the equipment and installation works at the manufacturers premises and on site of an UPS Unit and its installation.

The Tenderer has to complete all required returnable schedules. Failure to comply with this request will lead to immediate disqualification.

The Tenderer will be responsible for connecting electrical cables to their own equipment that is supplied and installed under this contract. All cables will be properly glanded to the units.

## E16.3 STATUTORY DOCUMENTS AND STANDARDS

E16.3.1 Standards

In addition to any client specifications and general operating procedures, the UPS Units shall comply with the requirement of the following specifications, and any amendments thereto, the SANS specification taking preference:

The equipment offered and work performed, shall comply with the requirements of the governing occupational Health and Safety act, at time of tender.

The Uninterruptible power supply system shall comply with the requirements of SANS 1474 or an International standard such as BS or DIN, and shall be produced in a factory with ISO9000 rating and the applicable quality assurance standards.

| | | |
|---|---|---|
| (a) SANS 60439 | : | Low Voltage Switchgear and Control Gear Assemblies |
| (b) SANS 60529/IEC 529 | : | Degrees of Protection Provided by Enclosures (IP Code) |
| (c) SANS 60947/IEC 947 | : | Low-voltage switchgear and controlgear |
| (d) IEC 60146 | : | General requirements and line commutated converters |
| (e) IEC 747 | : | Semi-conductor Devices (including Thyristors) |
| (f) IEC 60269-4 | : | Low-voltage fuses - Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices |
| (g) IEC 60269-5 | : | Low-voltage fuses - Part 5: Guidance for the application of low-voltage fuses |
| (h) SANS 10142-1 | : | The wiring of premises Part 1: Low-voltage installations |

(i) SANS 156 : Moulded-case circuit-breakers

(j) SANS 1195 : Busbars

(k) SANS 61238 : Compression and mechanical connectors for power cables for rated voltages up to 30 kV (Um = 36 kV)

E16.3.2 Particular Specifications to be read in conjunction with this specifications

The following particular specifications shall be read in conjunction with the Project Specification:

(a) E23 : ELECTRICAL SPECIFICATION FOR COLOUR CODE

(b) G02 : PARTICULAR SPECIFICATION FOR CORROSION PROTECTION

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

(d) E05 : LOW VOLTAGE POWER AND CONTROL CABLE

(e) E08 : WIRING

(f) E11 : GENERAL EARTHING AND LIGHTNING PROTECTION

## E16.4 GENERAL TECHNICAL SPECIFICATION

E16.4.1 General

(a) All Single Online Double Conversion Static UPS Units will be continuous duty single or three phase units.

(b) The UPS must be a TRUE on-line, double conversion transformer-based unit (i.e. using a transformer that 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.

(c) The UPS must employ PWM technology.

(d) The UPS must have battery backup for at least 30 minutes at the full rated load of the UPS.

(e) The output waveform shall be sinusoidal in form with the THD at full line load not exceeding 3%.

(f) The output voltage variation must not exceed 2%.

(g) Interference shall not exceed the limits laid down by ICASA

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

(i) 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.

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

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

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

(m) 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.

(n) 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.

(o) 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.

(p) Tenderers must satisfy themselves that the UPS rating is adequate to supply all the equipment which they are offering

(q) 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.

(r) 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.

(s) The rated output voltage must be user selectable from 220/230/240V.

(t) The output frequency must not vary by more than 3Hz.

(u) The UPS module shall consist of the following main components:

i. Transformer - choke input stage,
ii. Rectifier/Charger and DC link,
iii. Static Inverter,
iv. Static Bypass Switch and Manual Bypass Switch,
v. Control Panel and Mimic Panel with LCD Display,
vi. Output Isolation Transformer,

E16.4.2 UPS Rating

(a) 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.

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

(c) 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

E16.4.3 UPS Backup Batteries

(a) Tenderers must state the exact number of batteries that will be used.

(b) Tenderers must state the type of batteries that will be used.

(c) Tenderers must state the Ah rating of the batteries that will be used.

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

E16.4.4 UPS Standards

(a) All imported UPSs must have a CE rating

(b) The UPS must have CE, LGA/GS markings.

(c) The UPS must comply with safety conformance to EN-50091-1.

(d) The UPS must have EMC conformance to EN-50091-2 and EN-61000-3-2.

E16.4.5 Module Modes of Operation

The UPS unit will operate as an online, fully automatic system in the following modes:-

(a) Normal:

i. The inverter shall continuously supply the critical load.

ii. The Rectifier/Charger shall derive power from the commercial AC source and shall supply DC power to the Inverter while simultaneously float charging the batteries.

(b) Batteries:

i. Upon failure of the commercial AC power, the critical load shall continue to be supplied by the Inverter, which shall obtain power from the batteries without any operator intervention. There shall be no interruption to the critical load upon failure or restoration of the commercial AC source.

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

(c) Recharge:

i. Upon restoration of the AC source, the Rectifier/Charger shall recharge the batteries and simultaneously provide power to the Inverter.

ii. This shall be an automatic function and shall cause no interruption to the critical load.

(d) Bypass:

i. No-break transfer to and from Bypass mode shall be capable of being initiated manually, without operation of the static switch.

E16.4.6 Cabinets/Enclosures

The UPS Unit and the back-up batteries must each be supplied and installed in a freestanding double front steel metal cabinet/enclosure (safety shield behind doors) on adjustable/levelling feet, all pre-powder coated. The cabinets/enclosures shall be designed for industrial and computer room applications in accordance with the environment requirements. The cabinets will have a minimum standard Ingress Protection of 20 (IP20) in office environments and a minimum Ingress Protection of 23 (IP23) in dusty conditions.

Cabinets will be provided with lockable removable doors/panels and seal protection as required. These doors/panels will be cut to accommodate the control panel displays and metering as required. Cabinets must be provided with forced air-cooling ventilation fans. Should the fans be installed on the top section, the cabinets must be fitted with drip trays.

The cabinets must ensure that cable entry and connection will be from the bottom and additional support is provided for cable glands. A dedicated wire way shall be provided within the UPS module for routing user input and output wiring.

UPS Unit plus Battery Cabinet must line up and match up in style and colour.

Service Area Requirements: The UPS module shall require no more than 1 meter of front and side service access room.

Refer to Environment Conditions – Cabinets/Enclosures must be built to suit all temperatures and humidity conditions.

Cabinets/Enclosures must be labelled with 50mm high black engraved letters on white background fixed to cabinet with screw in centre of units.

E16.4.7 Manufacturer's Field Service

(a) Field Engineering Support:

i. The UPS manufacturer shall have a countrywide field service department staffed by factory-trained field service engineers dedicated to start-up, maintenance, and repair of UPS equipment. The organization shall consist of local offices managed from a central location.

ii. Field engineers shall be deployed in key population areas to provide on-site emergency response within 24 hours 80% of the time.

iii. Location of all field service offices must be submitted with the proposal.

iv. Third-party maintenance will not be accepted.

(b) Spare Parts Support:

i. Parts be available within 24 hours.

(c) Operational Training:

i. Before leaving the site, the field service engineer shall familiarize responsible personnel with the operation of the UPS. The UPS equipment shall be available for demonstration of the modes of operation.

(d) Product Enhancement Program:

i. The UPS manufacturer shall make available feature upgrade service offerings to

all users as they are developed. These products shall be proposed as a field-installable, optional kit.

E16.4.8 UPS Data Sheets (Returnable Schedule)

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 | |

## E16.5 QUALIFICATIONS

(a) The UPS manufacturer shall have a minimum of ten years' experience in the design, manufacture and testing of solid-state UPS. A list of installed UPS of the same type as the manufacturer proposes to furnish for this application shall be supplied with the proposal.

(b) The UPS manufacturer shall have ISO 9001 certification for engineering/R&D and manufacturing facilities.

(c) 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.

## E16.6 GUARANTEE

The successful vendor/supplier will guarantee the installation works and equipment for a period of twelve months after first delivery was taken by the Engineer.

## E16.7 TESTING AND INSPECTION:

(a) The testing and inspection procedures shall be approved prior to the commencement of manufacture.

(b) The Contractor shall assemble the complete UPS for inspection and factory testing, and present the system to the Engineer, to who it shall be demonstrated that the equipment meets the requirements of the specification.

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

(d) The Contractor shall provide suitably qualified personnel and all necessary equipment to carry out the tests to demonstrate conformance with the specification and simulate the operation of the system in its final operating state.

(e) The Contractor shall prepare a set of completed test and inspection certificates for approval.

(f) The contractor is required to perform site acceptance tests (SAT) on the UPS witnessed by the employer and the engineer, prior to commissioning the UPS. A schedule of the checks, tests and results of the SAT must be available for signing by the engineer at the completion of the SAT.

(g) A thermal imaging record of the UPS shall be taken after the UPS has been in operation for a minimum one week under typical normal conditions and while running. The thermal imaging record will form part of the deliverable documentation together with Operation and Maintenance Manuals and delivered to the employer on completion of the works.

## E16.8 PACKING AND MARKING

E16.8.1 Packing

The Contractor shall protect the equipment against scratching and damage by suitable wrapping, packing and crating of the equipment items.

E16.8.2 Marking

Each separately packed and transported piece of equipment shall be clearly marked.

## E16.9 MEASUREMENT AND PAYMENT

| Item | Unit |
|---|---|
| Supply and deliver UPS | No |

The tendered rate shall include full compensation for the manufacture, supply, testing and delivery of the UPS incorporating all options/extras as detailed in the detail specification.

| Item | Unit |
|---|---|
| Install UPS | No |

The tendered rate shall include full compensation for the installation, site testing and commissioning plus the 12 months maintenance of the UPS incorporating all options/extras as detailed in the detail specification.

| Item | Unit |
|---|---|
| Supply and deliver support platform/stand for UPS | No |

The tendered rate shall include full compensation for the manufacture, supply, testing and delivery of the support platform/stand for UPS as detailed in the detail specification.

| Item | Unit |
|---|---|
| Install support platform/stand for UPS | No |

The tendered rate shall include full compensation for the installation of the support platform/stand as detailed in the detail specification.

# PARTICULAR SPECIFICATION : VOLUME E17 : VARIABLE SPEED DRIVES

## CONTENTS

## E17.1 SCOPE

This specification shall cover all variable speed drives to be designed, supplied installed and tested that shall drive any of the items of equipment to be supplied under the contract.

## E17.2 INTERPRETATIONS

E17.2.1 Abbreviations

In this Specification, the following abbreviations will apply:-

| | | |
|---|---|---|
| (a) VSD | : | Variable Speed Drive |
| (b) ANSI | : | American National Standards Institute |
| (c) ASTM | : | American Society for Testing and Materials |
| (d) BS | : | British Standards Institution |
| (e) SANS | : | South African National Standards |

E17.2.2 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 60529 | : | Degrees of Protection Provided by Enclosures (IP Code) |
| (b) IEC 60 664 –1 | : | Degree of Pollution – no condensation permitted during operation |
| (c) IEC 60721-3-3 | : | Classification of environmental conditions - Part 3-3: Classification of groups of environmental parameters and their severities - Stationary use at weather protected locations |
| (d) BS EN 55011 | : | Industrial, scientific and medical equipment — Radio-frequency disturbance characteristics — Limits and methods of measurement |
| (e) IEC 61800-3 | : | Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods |

E17.2.3 Particular Specifications to be read in conjunction with this specifications

The following particular specifications shall be read in conjunction with the Project Specification:

(a) E04 : PARTICULAR SPECIFICATION FOR MCC

**E17.3 GENERAL REQUIREMENTS**

(h) The VSD units shall control asynchronous motors with standard constant torque, variable standard torque or optimized torque.

(i) The VSD units shall be specifically designed to offer extensive flexibility in water and wastewater applications.

(j) The VSD units shall be provided with six programmable, isolated digital inputs (24V DC, positive or negative logic).

(k) VSD units shall have three programmable relay outputs (1 with NO/NC contacts and 2 with NO contacts)

(l) The VSD units shall be provided with 3 programmable analogue inputs (configurable as voltage (0...10 V) or current (0-20 mA/4-20 mA), 2 of them including probes (PTC, PT100, PT1000 or KTY84)).

(m) The VSD units shall have two programmable analog outputs configurable as voltage (0...10 V) or current (0-20 mA).

(n) The VSD units will have the option to extend the I/O with optional modules.

(o) The VSD shall have low-noise motor operation due to high pulse frequencies.

(p) The VSD unit shall have complete protection for motor and inverter.

(q) The VSD units shall comply with the requirements of the EU low-voltage guideline.

(r) The VSD unit shall have the CE marking.

(s) All VSD units shall have the same interface, including a control panel, I/O connections and software, regardless of power rating, voltage or enclosure (IP rating).

(t) All VSD units shall be supplied with an internal Class A filter. The requirements are fulfilled using shielded cables with maximum length of 25m.

(u) The VSD units shall be supplied with line commutating choke in line with EN61 000-3-2
Regulations “Limits for harmonic currents with device input current < =16A per phase”.

(v) The maximum permissible motor cable lengths (shielded/unshielded) for a mains voltage of 400V are 150 m/ 225 m.

(w) The VSD units shall be supplied with integrated category C3 EMC filters.

(x) The VSD units shall be supplied with graphic display terminal for parameterising the inverter, complete with mounting kits for installation in the control cabinet doors.

(y) The unit shall have complete protection for motor and inverter.

(z) The VSD units shall have the following standard communication modules Modbus/TCP, Modbus serial link.

(aa) The VSD units shall have the following optional communication modules EtherNet/IP and Modbus/TCP Dual port, ProfiNet, CANopen, Profibus DP V1,

DeviceNet, and BACnet MS/TP.

(bb) Depending on the power rating and application, the VSD unit should be available as a wall mounted unit, a cabinet integration unit or a floor-standing unit.

(cc) **Note**:
Attention shall be given to ventilation to prevent the accumulation of heat in cubicles 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 cubicle. Natural convection cooling will not be accepted. All specific requirements from the VSD OEM must be adhered to.

## E17.4 WORKING VOLTAGE AND SUPPLY SYSTEMS

Depending on the power rating and application, the following power supply alternatives shall be available:

i. Single-phase: 200...240 V
ii. Three-phase: 380...480 V

## E17.5 ENVIRONMENTAL LIMITS

E17.5.1 Operating Temperature

The VSD must be able to operate in the specified operating temperature without any derating of the specified output power

i. 0... 40 °C as standard
ii. 40...50 °C with derating

E17.5.2 Relative humidity

i. 5...95% without condensing.

E17.5.3 Storage and transport temperature

i. -40…+70 °C

E17.5.4 Operating altitude:

i. 0…1,000 m without derating
ii. 1,000...2,000 m with derating of 1% per 100 m

E17.5.5 Withstand to harsh environments:

i. Chemical class 3C3 conforming to IEC/EN 60721-3-3 (1)
ii. Mechanical class 3S3 conforming to IEC/EN 60721-3-3 (1)
iii. Electronic cards with protective coating

E17.5.6 Ingress Protection:

i. IP 00 for mounting in an enclosure.
ii. IP 20/21/UL type 1 for wall mounting in a plant room and in an enclosure
iii. IP 55 for wall mounting, with protection against dust and water jets
iv. Floor-standing IP 21
v. Floor-standing IP 54, with protection against dust and water jets

## E17.6 PROTECTION FUNCTIONS

The following protection functions shall be available:

(a) Under voltage
(b) Overvoltage
(c) Overload
(d) Earth faults
(e) Short-circuits
(f) Stall prevention
(g) Locked motor protection
(h) Motor over temperature
(i) Inverter over temperature parameter change protection.

## E17.7 ASSEMBLY METHOD AND PROTECTION CLASS

The VSD units should be available with listed mounting types and IP classes:

(a) Wall-mounting
  i. IP 20/21/UL Type 1 from 0.75 to 315 kW,
  ii. IP 55 from 0.75 to 90 kW.
(b) Floor standing
  i. IP 21 and IP 54 from 110 to 315 kW
(c) Cabinet integration
  i. IP 20 from 0.75 to 90 kW.

## E17.8 DOCUMENTATION

Technical details shall be delivered with the offered VSD unit:

User manual, describing systematically how to install, start up, trouble shoot and maintain the VSD. It shall be optionally possible to acquire multiple manuals together with a delivery unit.

Documents to be delivered per order:

a) Dimensional drawings (both AutoCAD and .pdf formats)
b) Customer connections and power wiring diagrams (both AutoCAD and .pdf

formats).

c) Power losses and cooling air temperature (both in .xls and .pdf formats).

d) Manufactures statements on output currents available continuously in different ambient temperature up to 50°C. Type of product needed at 50°C continuous operations must be clearly listed.

e) Environmental product declaration according to life cycle assessment (LCA).

## E17.9 INSTALLATION, TESTING AND COMMISSIONING

The contractor will supply a factory test certificate with the VSD unit.

The VSD shall be installed and commissioned by a competent person approved and accredited by the manufacturer. The installer must provide a method statement for transporting, storage, installation, testing and commissioning processes for approval by the engineer.

The installer is required to perform site acceptance tests (SAT) on the VSD witnessed by the employer and the engineer, prior to commissioning the VSD. The contractor will be responsible for the VSD setup, including software configuration and settings. A schedule of the checks, tests and results of the SAT must be available for signing by the engineer at the completion of the SAT. The contractor will provide the final VSD setup and software settings to the Engineer on a USB flash drive.

A thermal imaging record of the VSD shall be taken after the VSD has been in operation for a minimum one week under typical normal conditions and while running. The thermal imaging record will form part of the deliverable documentation together with Operation and Maintenance Manuals and delivered to the employer on completion of the works.

## E17.10 MEASUREMENT AND PAYMENT

VSD units shall not be paid as a separate item in the Bill of Quantities. VSD unit form part of motor starter circuits and payment thereof shall be included in the price/s of motor control centres.

# PARTICULAR SPECIFICATION: VOLUME E19: ELECTRICAL 11kV RING MAIN UNIT

## CONTENTS

## E19.1 SCOPE

This specification covers the design, supply, delivery, installation, testing and commissioning of 11kV medium voltage ring main unit (RMU).

## E19.2 STANDARDS

E19.2.1 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:

| | | |
|---|---|---|
| SANS 62271-1 | : | High-voltage switchgear and controlgear Part 1: Common specifications for alternating current switchgear and controlgear |
| SANS 62271-200 | : | High-voltage switchgear and controlgear Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV |
| SANS 62271-102 | : | High-voltage switchgear and controlgear Part 102: Alternating current disconnectors and earthing switches |
| SANS 60529 | : | Degrees of Protection Provided by Enclosures (IP Code) |
| SANS 62271-103 | : | High-voltage switchgear and controlgear Part 103: Switches for rated voltages above 1 kV up to and including 52 kV |
| SANS 62271-102 | : | High-voltage switchgear and controlgear Part 100: Alternating-current circuit-breakers |
| SANS 62271-105 | : | High-voltage switchgear and controlgear Part 105: Alternating current switch-fuse combinations for rated voltages above 1 kV up to and including 52 kV |
| SANS 61869-2 | : | Instrument transformers Part 2: Additional requirements for current transformers |
| SANS 61869-3 | : | Instrument transformers Part 3: Additional requirements for inductive voltage transformers |
| IEC 60255 | : | Measuring relays and protection equipment |

E19.2.2 Particular specifications to be read in conjunction with this specification

The following particular specifications shall be read in conjunction with the product specification:

| | | |
|---|---|---|
| (a) E26 | : | ELECTRICAL COLOUR CODING OF EQUIPMENT |
| (b) G02 | : | PARTICULAR SPECIFICATION FOR THE CORROSION PROTECTION |

## E19.3 CONSTRUCTION AND OPERATION REQUIREMENTS

The RMU will have the following characteristics:

(c) The busbars and switching elements of each module shall be in a separate vacuum/gas tank. Each tank will be equipped with a meter showing vacuum/gas pressure values;

(d) Suitable for indoor/outdoor use;

(e) It must be possible to operate all the switch mechanisms from the front;

(f) Three manually selected positions (ON-OFF or EARTH) on all modules. The operating handle is to be such that it must be relocated from the ON – OFF position to the EARTH position before the earthing switch can be closed;

(g) Clearly visible ON – OFF and OFF – EARTH indicators shall be provided and provision shall be made for locking the mechanisms by means of selector levers, preventing the insertion of the operating handle in any position;

(h) A mechanical interlock will prevent the opening of the cable termination cubicle if the module is not in the EARTH position;

(i) Transparent inspection windows that display the position of the earthing contacts, allowing; a visually check that the earthing switch is in the closed position;

(j) A voltage presence-indicating device on all modules to check whether a voltage is present across the cables. (IEC 62271-206: Part 206: Voltage presence indicating systems for rated voltages above 1 kV and up to and including 52 kV);

(k) Cable test facility where the cable can be tested without disconnecting the cable from the switchgear bushings or opening the cable termination cubicle;

(l) The switchgear must be designed to withstand the impact of an internal arc caused by a fault current in order to provide the maximum protection to switching operators;

(m) All bushings shall be Type C rated at 630Amp according to BS EN 50181;

(n) A protection relay (self-powered from the CT units) on the circuit breakers connected to the ring circuit with:

i. Overcurrent and earth fault protection
ii. Thermal overload protection
iii. Current measurement functions
iv. No PC or specific tool required for setting or commissioning

(o) No oil-filled circuit breakers are accepted in the miniature substations.

### E19.3.1 11kV cable termination

The Contractor must ensure that suitable methods of 11kV cable termination are applied. Indoor terminations with screened separable connectors (SSC's) must be used to terminate 11kV cables on the RMU. This allows for the use of PILC cable for 11kV reticulation. Because of the short clearances in the switchgear cable termination box the flashover risk is minimised by ensuring that the terminations and SSC's are type tested in accordance with IEC 60055-1 and IEC 60502-4.

E19.3.2 Ratings

The continuous current rating of the Ring Main Unit shall not be less than 630A. The continuous current rating of the combined fuse-switch shall not be less than 90A with overload making capacity minimum 32.5kA. The short circuit rating shall be at least 350MVA at 11kV.

E19.3.3 Combined fuse-switch

The combined fuse-switch shall be in accordance with SANS 60282.

The operating mechanism of the combined fuse-switch shall be of the fixed trip type, which ensures the full closure of the switch and full clearance of fault by the fuses before tripping the switch.

(p) The fuse carriage must be so arranged that when the striker pin fuses are fitted, the operation of a fuse in any phase trips all the phases simultaneously. Conversely, if any one fuse is blown, then it shall not be possible to close the switch.

(q) Manual tripping is to be provided by means of a pushbutton and not by using the operating handle.

(r) Automatic shutters shall be provided, to safeguard against inadvertent contact with “live” parts when the fuse carriage is removed.

(s) The operating mechanism must be interlocked with the fuse carriage cover, to allow access to the fuse carriage only when the operating mechanism is in the OFF position.

(t) The fuses and carriage shall be housed vertically in a separate compartment on the front of the unit. The fuse carriage design is preferred which would accept both 336mm and 254mm long by 64mm diameter HRC fuses.

(u) One designation blank label shall be provided.

(v) Fuses shall be fitted before delivery.

E19.3.4 Ring Main Network Isolators

a) The triple pole contacts of the isolators shall be gang-operated by a spring assisted manual mechanism.

b) Integral cable test terminals shall be provided and shall only be accessible from the front of the unit when the switch is in the EARTH – TEST position. Interlocks shall be provided to ensure that the switch cannot be moved from the EARTH – TEST position when the test terminal cover is open. If alternative ring main units are offered, then one set of test prongs shall be supplied for each unit.

c) No cable end boxes are required. However, provision shall be made for the clamping of cross-linked polyethylene and PILC type cables by means of a split wooden block.

d) The size of cables used shall be 70mm2, 3 core and 185mm2 PILC. The clamps that must accept different sizes of cable shall be mounted approximately 600mm below the terminals.

e) Each isolator shall be provided with a designation white sandwich board label, which shall be left blank.

E19.3.5 Circuit breaker with overcurrent and earth fault relay

(a) It is required that these miniature substations be supplied with at least 630A

11kV circuit breaker ring main units with overcurrent and earth fault protection relay switches or protection relay that has the same tripping curves as normal HRC MV fuses.

(b) Manually operated mechanisms for cable and transformer switches are to be supplied as standard with an option that they can also be fitted with motor operation.

(c) The circuit breaker system of protection shall not require an external power supply.

(d) SF6 or vacuum circuit breakers shall be acceptable for this purpose although a virtually maintenance-free system with a high level of reliability is preferred.

(e) This RMU is required to be supplied with the following standard equipment:

i. Earthing switches
ii. Operating mechanisms with integral mechanical interlocking
iii. Operating handle
iv. Facilities for padlocks on all switches functions
v. Bushings for cable connection in front with cable covers.
vi. Manometer for SF6 pressure/density monitoring (where applicable).
vii. Lifting lug for easy handling.
viii. All units are designed for the subsequent fitting of an integral remote control and monitoring unit.
ix. Three-way configuration.

(f) All R.M.U. shall comply with SANS 1874.

(g) All R.M.U. operating, cable testing facilities cable terminating and indication devices must be fully accessible only from the front of the MV compartment.

(h) The R.M.U. configuration shall be Switch Disconnector, Circuit Breaker

(i) The cable boxes shall comply with SANS 876 and shall require type 2 terminating clearances.

The design of the switchgear shall take due consideration of the safety of personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, mechanical protection of equipment and interchangeability of equipment. The offered equipment should be capable of continuous operation under the indicated environmental conditions for the project. The panel must be able to withstand lifting and installation stresses without deforming. There must be consideration for corrosion prevention measures indicated elsewhere in this tender documentation. The panel finish must be epoxy coated and be able to sustain the UV impact of outdoor installation without peeling or discolouration.

## E19.4 ELECTRICAL DATA AND SERVICE CONDITIONS

| Item | Parameter | Unit | Value |
|---|---|---|---|
| 1 | Rated Voltage | kV | 12/13.8 |
| 2 | Power frequency withstand voltage | kV | 75/95 |
| 3 | Impulse withstand voltage | kV | 75/95 |
| 4 | Rated frequency | Hz | 50 |
| 5 | Rated current busbars | A | 630 |
| 6 | Rated current (cable switch) | A | 630 |

| | | | |
|---|---|---|---|
| 7 | Rated Current T-OFF | A | 200 |
| | **Breaking capacities** | | |
| 8 | Active Load | A | 630 |
| 9 | Closed loop (cable switch) | A | 630 |
| 10 | Off-load cable charging (Cable switch) | A | 135 |
| 11 | Earth fault (Cable switch) | A | 200 |
| 12 | Earth fault cable charging (cable switch) | | 115 |
| 13 | Short Circuit breaking current (T-OFF Circuit breaker) | kA | 20 |
| 14 | Rated making capacity | kA | 52 |
| 15 | Rated short time current 3 sec | kA | 20 |
| | **Ambient temperature** | | |
| 16 | Maximum value | °C | +50 |
| 17 | Maximum value of 24hr mean | °C | +35 |
| 18 | Minimum value | °C | 0 |
| 19 | Altitude for erection above sea level | m | 1500 |
| 20 | Relative humidity | | Max 95% |

## E19.5 RMU TECHNICAL DATA

| Item | General data, enclosure and dimensions | | |
|---|---|---|---|
| 1 | Standard to which switchgear complies | | IEC |
| 2 | Type of RMU | | Metal enclosed, Panel type, Compact module |
| 3 | Number of phases | | 3 |
| 4 | Whether RMU is type tested | | Yes |
| 5 | Whether facility is provided with pressure relief | | Yes |
| 6 | Insulating gas | | SF6/Vacuum |
| 7 | Nominal operating gas pressure | | 1.4 bar abs 20° C |
| 8 | Gas leakage rate/annum | % | 0.075 |
| 9 | Expected operating lifetime | | 30 years |
| 10 | Whether facilities are provided for gas monitoring | | Yes, temperature compensated manometer |
| 11 | Material used in tank construction | | Stainless steel sheet, 3mm/ metallised cast resin |
| | **Operations, Degree of protection and colours** | | |
| 1 | Means of switch operation | | Separate handle |
| 2 | Means of circuit breaker operation | | Separate handle and push buttons |
| 3 | Rated operating sequence of circuit breaker | | O 3min CO 3 min CO |
| 4 | Total opening time of circuit breaker | | Approx. 45 ms |
| 5 | Closing time of circuit breaker | | Approx. 40 ms |
| 6 | Mechanical operations of switch | CO | 1000 |
| 7 | Mechanical operations of CO earthing switch | | 1000 |
| 8 | Mechanical Operations of circuit breaker | CO | 2000 |

| | | | |
|---|---|---|---|
| 9 | Principal switch/earth switch | | 3 position combined switch/earth switch |
| | **Degrees of Protection** | | |
| 1 | High Voltage live parts, SF6/Vacuum tank | | IP 67 |
| 2 | Front cover mechanism | | IP 2X |
| 3 | Cable covers | | IP 3X |
| 4 | Outdoor enclosure | | IP 56 |

## E19.6 REQUIRED TESTS

All component parts of the equipment shall be subject to type tests and routine tests in accordance with the relevant SANS, BSI or IEC standard specifications.

Circuit breakers shall be subjected to the following tests in accordance with IEC 62271-1, adjusted for atmospheric correction:

(j) Type Tests

x. Mechanical endurance
xi. Temperature rise
xii. Dielectric strength and impulse voltage
xiii. Making and breaking capacity and short time current

(k) Routine tests

i. Power, frequency, voltage
ii. Resistance of the main circuit
iii. Mechanical operation.

(l) On site tests

The equipment shall be tested on site after erection and prior to commissioning. The following minimum tests shall be performed:

i. Pressure tests on the primary and secondary circuits in accordance with IEC 62271-1.
ii. Insulation resistance tests.
iii. Primary injection tests.
iv. Earth continuity and earth resistance tests.
v. Operating tests.
vi. Any other tests that may be required to ascertain the correct functioning of the equipment.

After putting the panel to service for a minimum 1 week, a thermal image must be scanned and analysed for any hot spots. The image should be presented as part of the Operations and Maintenance manual.

## E19.7 GUARANTEE

The equipment must be guaranteed against latent defects for a minimum of 18 months from date of delivery or 12 months from date of commissioning, whichever is later.

## E19.8 DOCUMENTATION

The following documentation will be required for the RMU at tender stage:

(a) Type test certificate

(b) Data sheet

(c) Workshop drawings – prior to manufacture, weights and dimensions included

The following documentation will be required for the RMU with delivery:

(a) Factory tests results

The following documentation will be required for the RMU at handover:

(a) Certificate of compliance (design, manufacture and installation)

(b) Operations and maintenance manual

(c) Recommended spare parts list

(d) Drawings – unit drawings and reticulation drawings – as built

## E19.9 NAMEPLATE INFORMATION

(a) Name of manufacturer

(b) Type, design and serial number

(c) Rated voltage and current

(d) Rated frequency

(e) Rated symmetrical breaking capacity

(f) Rated making capacity

(g) Rated short time current and its duration

(h) Purchase order number and date

(i) Month and year of supply

(j) Rated lightning impulse withstand voltage

## E19.10 MEASUREMENT AND PAYMENT

| Item | Unit |
|---|---|
| Supply and deliver 11kV RMU ..... | No |

The unit of measurement shall be the number of conductor terminals installed.

The tendered rate shall include full compensation for the design, supply, handling, inspection and installation of the the Ring main Unit.

# PARTICULAR SPECIFICATION: VOLUME E20: ELECTRICAL OVERHEAD LINES UP TO 22kV

## CONTENTS

## E20.2 SCOPE

This specification covers the design, supply, delivery, installation, testing and commissioning of overhead lines up to 22kV.

## E20.3 STANDARDS

E20.3.1 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 1200 : Standardized specification for civil engineering construction

(b) SANS 753 : Pine poles, cross-arms and spacers for power distribution, telephone systems and street lighting

(c) SANS 754 : Eucalyptus poles, cross-arms and spacers for power distribution and communications systems

(d) SANS 218 : Radio interference characteristics of overhead power lines and high-voltage equipment

(e) SANS 10280 : Overhead power lines for conditions prevailing in South Africa

(f) SANS 1507 : Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)

(g) SANS 1574 : Electric flexible cables with solid extruded dielectric insulation

(h) NRS 035 : Drop-out fuse-link assemblies or solid-link assemblies - Pole-mounted types - For nominal ac voltages up to and including 33 kV

(i) SANS 60269 : Low-voltage fuses

(j) SANS 60282 : High-voltage fuses

(k) SANS 182-3 : Conductors for overhead electrical transmission lines

Further to the standards listed above, the distribution line shall also comply with the Occupational Health and Safety Act (No. 85 of 1993).

All material shall adhere to the various ESKOM material specifications for the different assemblies as mentioned in the ESKOM Distribution Standards.

E20.3.2 Particular specifications to be read in conjunction with this specification

The following particular specifications shall be read in conjunction with the product specification:

(a) E15 : TRANSFORMERS

(b) E11 : ELECTRICAL EARTHING AND LIGHTNING PROTECTION

## E20.4 CONSTRUCTION AND OPERATION REQUIREMENTS

E20.4.1 General

(a) All overhead distribution lines will be designed with a minimum nominal voltage of 24kV (RMS phase to phase)

(b) Stay wire 7/4.00 stay wire 1100MPa UTS of 96kN

Stay rod to be 20mm diameter, 2.0m long

Stay plate to be a minimum of 350mm x 350mm x 6mm thick

Stays to be planted at 45 degrees to vertical.

(c) Factor of safety used on concrete poles is 2.5 as per the OHS Act

(d) Use the smallest applicable span length

(e) Electrical clearance span is the phase spacing to prevent electrical clashing

(f) For transformer poles, use 10m 8kN pole, max weight of transformer 900kg

(g) Where a line is tied off from another line, fuse protection must be installed on the t-off line (at the point of the t-off)

E20.4.2 Conductor types

| Conductor | Type | Diameter (mm) | Weight (kg/m) | Tensile strength (kN) | Strands |
|---|---|---|---|---|---|
| Fox | ACSR | 8.37 | 0.149 | 13.2 | 7 |
| Mink | ACSR | 10.98 | 0.255 | 21.8 | 7 |
| Hare | ACSR | 14.16 | 0.425 | 36 | 7 |

**Table 1:** Conductor types (ACSR: Aluminium conductor steel core)

The following conductor is preferred:

Aluminium Conductor Steel Reinforced (ACSR) conductor with typical data:

(a) Equivalent copper area : 64.52 mm²

(b) Stranding and wire diameter : 6 / 1 / 4.72 mm

(c) Diameter over steel : 4.72 mm

(d) Overall diameter : 14.16 mm

(e) Aluminium area : 104.98 mm²

(f) Steel area : 17.50 mm²

(g) Total area : 122.48 mm²

(h) Approximate cable mass :

i. Aluminium : 289 kg / km

ii. Steel : 138 kg / km

iii. Total : 427 kg / km

(i) Ultimate tensile strength : 36000 Newton

(j) Co-Efficient of linear expansion : 19.31 / C x $10^6$

(k) Initial modulus of elasticity : 48500 MPa

(l) Final modulus of elasticity : 80400 MPa

(m) DC resistance at 20°C : 0.2733 Ω / km

(n) Current rating : 360 A

E20.4.3 Span lengths, sag and tension

The span length from one structure to the next shall not exceed 100 meters. The design will adhere to the sag and tension characteristics issued by the manufacturer of the conductor.

E20.4.4 Vertical Clearance

All vertical clearance profiles will comply with the Occupational Health and Safety Act (No. 85 of 1993)

| | | |
|---|---|---|
| Nominal voltage (rms phase to phase) | 24 | kV |
| Minimum safety clearance | 0.32 | m |
| Above ground | 5.5 | m |
| Above roads | 6.4 | m |
| To buildings, poles and structures not forming part of power lines | 3 | m |

**Table 2:** Vertical Clearance profiles

E20.4.5 Excavations

The contractor will satisfy himself of the ground conditions and make provisions for any hard rock in his excavation prices.

The contractor will obtain the distribution standards as listed and in this specification and shall execute the entire project in accordance with these standards.

Soil types can be roughly classified into four groups based on the maximum soil bearing pressure (see table below)

| Soil Type | Maximum soil-bearing pressure |
|---|---|

| | kPa |
|---|---|
| Type “A” | 300 |
| Type “B" | 120 |
| Type “C” | 100 |
| Type “D” | 50 |

**Table 3:** Soil Types

(a) All soils to be checked by a professional engineer

(b) All stays in types “A” and “B” soil to have six pockets of cement added to excavated soil, which is then thoroughly mixed and compacted in 200mm layers with an 11kg hand-compactor. All stays for types “A” and “B” soil to be 1.5 x 0.8 x 2.0m deep as a minimum

(c) All poles in types “A” and “B” soil to have four pockets of cement added to excavated soil, which is then thoroughly mixed and compacted in 200mm layers with an 11kg hand compactor. All pole foundations for types “A” and “B” soil to be 0.7 x 0.7 x planting depth as a minimum

Poles shall be planted at the following depths:

i. 7m poles 1.3m
ii. 9m poles 1.5m
iii. 11m poles 1.8m
iv. 12m Poles 2.0 m

(d) For types “C” and “D” soil, the pole foundations and stay sizes must be designed by a professional engineer

E20.4.6 MV Network

The MV network shall be constructed, in general, to the following particular specification

(a) Configuration : Delta, horizontal installed
(b) Nominal Line Voltage : 24kV (RMS, phase to phase)
(c) Conductor : Aluminium Conductor Steel Reinforced (ACSR),
(d) Basic Insulation Level : According to Line Nominal Voltage (11kV: BIL 300kV)
(e) Poles : As specified (horizontal)
(f) Numbering pole number) : To Eskom requirements (transformer/feeder number with
(g) Transformers : As specified

E20.4.7 MV power line structures

The following medium voltage structures may be erected as part of this contract:

(a) MV Single Pole Intermediate (delta).
(b) MV Single Pole Strain - Vertical (0° - 30°).
(c) MV Single Pole Strain – Vertical (30° - 90°).

(d) MV H-Frame In-line Strain – Horizontal For road Crossings.

(e) MV H-Frame Termination Structure with Drop Out fuse assemblies and Station Class surge arrestors.

The contractor shall be responsible for specifying and supplying all materials required for the complete assembly of all structures. All equipment and components used in the construction of the line shall be rated for the nominal voltage and basic insulation level (BIL).

E20.4.8 Setting out of the Works

The contractor shall include the cost for the setting out of the Works in his bid.

An approved surveyor familiar with the erection of overhead lines, appointed by the contractor, shall capture all the positions of structures on a scaled drawing. The surveyor shall provide his services during negotiations for wayleaves etc. wherever and with whomever the client will need to negotiate.

The survey plan shall include

(a) Structure angles;

(b) Span lengths;

(c) Stay directions;

(d) Road and railroad crossings with profiles;

(e) Natural obstacles (rivers, graveyards etc.);

(f) Roads;

(g) Existing overhead electrical infrastructure;

(h) Envisaged use of flying stays.

The survey plan must be approved by the Engineer prior to construction

E20.4.9 Bush clearing

The contractor shall allow for all bush clearing in his pricing, and shall determine the extent of the bush clearing required prior to tendering. The contractor shall adhered to all recommendations as detailed in the environmental scoping document.

E20.4.10 Reinstating of roads and fences

The contractor will be responsible for reinstating and the repair of all damage or changes made to roads and fences during construction.

E20.4.11 Gates

The contractor will install gates to ensure construction vehicle access to servitude land where power lines are erected.

E20.4.12 Earthing

The equipment earthing shall comply with the particular specification E11: Electrical Earthing and Lighting Protection.

The contractor shall appoint a specialist engineer to do all soil resistivity tests, the earthing designs and compliance testing after installation. The earthing design shall be submitted

to the client for approval. All test results will be documented and submitted to the client for acceptance.

E20.4.13 Connections to existing infrastructure

The contractor will liaise with the client and obtain a certificate to commence work prior to connecting to any client owned infrastructure.

## E20.5 TESTING

On completion of the installation, the contractor shall perform all the necessary tests as prescribed by SANS, NRS or IEC as well as performing the manufacturer's routine tests and any other tests that the engineer may require.

In particular, the following tests shall be performed for the overhead line structures

(a) All type tests as prescribed elsewhere in this document for steel, galvanizing, insulators, poles, structures, conductors, stay assemblies, bolts, nuts and other paraphernalia. Where type tests were performed on similar equipment, test results can be presented at the tender stage;

(b) Soil bearing pressure tests at each foundation position where reinforced concrete foundations are to be used;

(c) Soil test where poles are buried to ensure pole stability;

(d) Pull out tests in all soil conditions for rock anchors for stays and foundations;

(e) Soil resistivity tests at each structure.

## E20.6 AS-BUILT DRAWINGS

The contractor will provide a complete set of fully marked up 'As Built" drawings.

The contractor will provide the following as a minimum in a hardbound cover to the Engineer for his approval:

(a) Dimensioned drawings for the layout of the equipment, structures and systems.

(b) Wiring diagrams cross referenced to the site drawings

(c) All test Certificates for both FAT and SAT.

(d) System and equipment descriptions.

(e) Operating manuals for all equipment.

(f) Maintenance manuals of all equipment, including all adjustment and calibration instructions, fault finding procedures and maintenance schedules.

## E20.7 DAMAGE TO PROPERTY

The contractor will take all precautions to prevent damage to property.

Where such damage cannot be avoided, a full report containing the following information will be submitted to the Engineer.

(a) Name and address of the property owner;

(b) Nature of the damage;

(c) Reason why damage cannot be avoided;

(d) Contractors estimate of compensation.

Construction work shall only be allowed to proceed once approved by the Engineer. The engineer will provide feedback within 14 days.

Accidental damage shall be reported to the Engineer immediately and repaired within 48 hours. All costs associated with the accidental damage shall be for the account of the contractor.

## E20.8 MEASUREMENT AND PAYMENT

The tendered rate shall include full compensation for the design, supply, handling, inspection, testing and delivery of the equipment to implement the overhead line. It will also include full compensation for the soil resistivity testing, design, supply, handling, inspection, testing and delivery of the material required for the equipment earthing

**Item**
**Unit**

Supply and deliver Overhead Line..... No

The unit of measurement shall include the total length of the conductors supplied, number of wooden poles, cross members with braces, line insulators, drop-down fuse assemblies and surge arrestors.

**Item**
**Unit**

Supply and deliver Earthing system..... No

The unit of measurement shall include soil resistivity testing, design, supply, handling, inspection, testing and delivery of the material required for the earthing (down conductors, earthing spikes and associated clamps, splices ext.)

**Item**
**Unit**

Install, commission and test Overhead Line..... No

The unit of measurement shall include all excavation works, civil works, crainage and scaffolding, installation of poles, cross members and conductors, testing and commissioning of the overhead line complete with equipment earthing.

## PARTICULAR SPECIFICATION: VOLUME E21: ELECTRICAL LIGHTING AND ILLUMINATION

## CONTENTS

## E21.1 SCOPE

This section covers the requirements for lighting and illumination. Lighting and illumination shall be supplied, delivered, installed and commissioned as specified.

## E21.2 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:

| | | |
|---|---|---|
| (l) SANS 475 | : | Luminaires for interior lighting, street lighting and floodlighting - Performance requirements |
| (m) SANS 10389-1 | | Exterior lighting Part 1: Artificial lighting of exterior areas for work and safety |
| (n) SANS 10114-1 | : | Interior lighting Part 1: Artificial lighting of interiors |
| (o) SANS 10114-2 | : | Interior lighting Part 2: Emergency lighting |
| (p) SANS 10142-1 | : | The wiring of premises Part 1 Low-voltage installations |
| (q) SANS 1019 | : | Standard voltages, currents and insulation levels for electricity supply |
| (r) SANS 60081 | : | Double-capped fluorescent lamps - Performance specifications |
| (s) SANS 60598-1 | : | Luminaires - Part 1: General requirements and tests |
| (t) SANS 60901 | : | Single-capped fluorescent lamps - Performance specifications |
| (u) SANS 60968 | : | Self-ballasted lamps for general lighting services - Safety requirements |
| (v) SANS 61547 | : | Equipment for general lighting purposes - EMC immunity requirements |
| (w) SANS 1777 | : | Photoelectric control units for lighting (PECUs) |
| (x) SANS 60947-4-1 | : | Low-voltage switchgear and controlgear Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters |
| (y) SANS 10225 | : | The design and construction of lighting masts |
| (z) IEC 62031 | : | LED modules for general lighting – Safety specifications |
| (aa) IEC 61347-2-13 | : | Lamp controlgear - Part 2-13: Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules |
| (bb) IEC 62560 | : | Self-ballasted LED-lamps for general lighting services by voltage > 50 V-Safety specifications |

## E21.3 SPECIFICATIONS

E21.3.1 Manufacture and Assembly of Luminaires

Body

(k) The bodies and relevant sheet metal parts of all fittings shall be manufactured from minimum 0,8mm sheet steel, to precise tolerances, with joints neatly formed and spot-welded.

(l) Metal parts shall be painted with a suitable primer utilized for epoxy or polyester powder coat finishes. The final finish shall be a high reflectance, white epoxy or polyester powder coating (other colours applicable as well).

(m) Bodies of lay-in fittings shall fit neatly into the specified ceiling grid, with no visible light leaks from below.

(n) Access for lamp replacement and maintenance shall be simple and easy.

Lamp holders

(a) Lamp holders shall be of a good quality, manufactured from polycarbonate, with heat resistant centres.

(b) Lamp holders for all fluorescent luminaries (recessed, surface, open channel) shall be good quality roto-lock type from a known manufacturer.

Control gear

(a) All luminaires, except the metal halide types, shall be equipped with electronic ballast/control gear. Metal halide/High pressure Sodium fittings shall use ballasts/chokes.

(b) Ignitors shall be digital in nature with time control pulse break for optimum control gear and lamp protection. (Ignitors will also allow enclosed rated lamps to be used in open luminaries).

(c) Only capacitors supplied by reputable manufacturers shall be offered. Power factor correction in luminaires shall be done to ≥0.90.

Wiring

(a) All internal wiring shall be done with high temperature PVC insulation (105°C).

(b) Wiring shall be neatly grouped and retained.

(c) The wiring shall terminate in a 3-way, 6A screw terminal block, with the earth conductor terminated onto a welded earth stud.

Cord Sets

(a) Cord sets shall be fitted on all indoor luminaires and as specified in the luminaire schedule.

(b) Cord sets will be 3m long as a minimum.

(c) Cord sets shall 3-core PVC cabtyre cable, 0.75mm² measured from the side of the fittings with a 6A, three pin moulded plug top. The cord shall terminate in the luminaire by means of compression gland.

Lamps

(a) All lamps shall be as specified in the lamp schedule.

(b) Only lamps from known manufacturers shall be offered.

(c) All fluorescent tubes shall be tri-phosphor.

E21.3.2 Manufacturing and assembly of Fluorescent luminaires

(a) Luminaires shall be supplied and delivered complete with lamps, control gear and flexible cords and plug tops as specified.

(b) Luminaires shall be designed to prevent excessive high temperatures and components and materials shall be selected so that they are not adversely affected by the operating temperature.

(c) The voltage and wattage ratings shall be clearly and indelibly marked on control gear and related control equipment and apparatus.

(d) Bodies of lay-in fittings shall fit neatly into the specified ceiling grid, with no visible light leaks from below.

(e) Access for lamp replacement and maintenance shall be simple and easy.

(f) Lamp holders shall be of a good quality, manufactured from polycarbonate, with heat resistant centres.

(g) Lamp holders for all fluorescent luminaries shall be good quality roto-lock type.

(h) All luminaires shall be equipped with quick start electronic ballast/control gear.

(i) All internal wiring shall be done with high temperature PVC insulation (105C).

(j) Wiring shall be neatly grouped and retained.

(k) The wiring shall terminate in a 3-way, 6A screw terminal block, with the earth conductor terminated onto a welded earth stud.

(l) Cord sets shall be fitted as specified in the luminaire schedule.

(m) Cord sets shall consist of 3 metre 0.75mm² 3-core PVC cabtyre cable with a 6A, three pin moulded plug top. The cord shall terminate in the fitting by means of compression glands.

(n) Integrated dimming and or switching control capability utilizing an external 0-10 VDC control signal, dry NO or NC contact.

E21.3.3 Manufacturing and assembly of LED luminaires

General

(a) The life of all led luminaires and lamps shall be >50 000 hours.

(b) Output beam angle shall be as specified.

Construction

(a) Preference shall be given to modular luminaires designed for ease of component replacement: LED luminaires shall be equipped with replaceable or upgradable LED modules.

(b) Ingress protection rating of the LED luminaire should be prescribed for the intended applications under specific environmental conditions.

(c) Housing to be manufactured from die cast or extruded aluminium.

(d) There should be additional room available in the wiring compartment for third-party adaptive controls to be retrofitted.

(e) Luminaires should be designed for ease of component replacement, including LED engines/modules, drivers, surge devices, and they should accommodate end-of-life disassembly.

(f) Power supply driver shall be specified as dimmable or non-dimmable in the

luminaire schedule and will operate as follows:

- Reliable operation up to ≥45°C ambient temperature;
- Will last >80,000 hours;
- Driver housing IP66 rated
- Integrated dimming and or switching control capability utilizing an external 0-10 VDC control signal, dry NO or NC contact, DALI shall be specified if required.

2ft/4ft/5ft Vapour Proof LED Light

| | | | |
|---|---|---|---|
| (a) | Body length | : | 660mm or 1277mm or 1572mm |
| (b) | Body construction | : | Polycarbonate with stainless steel latches and mounting hangers |
| (c) | Cover lens | : | UV stable Polycarbonate |
| (d) | Lumen | : | 660mm: 25W - 3200 lumen<br>1277mm: 50W - 6400 lumen<br>1573mm: 90W - 12000 lumen |
| (e) | CCT options | : | 4000K or 5000K |
| (f) | Supply voltage | : | 230V AC |
| (g) | IP rating | : | IP 65 |

LED Flood light

| | | | |
|---|---|---|---|
| (a) | Wattage | : | 220W, 440W, 880W |
| (b) | Body construction | : | Die cast LM6 aluminium - powder coated |
| (c) | Front glass cover | : | 5mm tempered safety glass |
| (d) | Lighting performance | : | 146 lumens per W at source |
| (e) | CCT | : | 4000K or 5000K |
| (f) | CRI | : | +80 minimum |
| (g) | Supply voltage | : | 230V AC/50hz |
| (h) | Additional protection | : | 10KV |
| (i) | IP rating | : | IP 65 |

LED Bulkhead/Street light

| | | | |
|---|---|---|---|
| (a) | Body construction | : | Glass filled Nylon / Yoke and Bulkhead bracket Stainless Steel 316 |
| (b) | Lens type | : | 3mm Polycarbonate (UV stabilised) toughened glass or impact modified Acrylic |
| (c) | Wattage | : | 20W/40W/50W |
| (d) | Lumen options | : | 20W – 3520 Lumens at source<br>40W – 7040 Lumens at source<br>50W – 8800 Lumens at source |
| (e) | CCT | : | 4000K or 5000K |

| | | | |
|---|---|---|---|
| (f) | CRI | : | +80 minimum |
| (g) | Supply voltage | : | 230V AC/50hz |
| (h) | IP Rating | : | IP65 |
| (i) | Power factor | : | 0.94 or better |

2ft/4ft/5ft Utility LED light

| | | | |
|---|---|---|---|
| (a) | Body Construction | : | Extruded aluminium - either anodized or powder coated |
| (b) | Lens and Reflector | : | 190-degree ultra wide distribution<br>Opal lens with 80% transmission. |
| (c) | Length/Lumen options | : | 600mm – 24W 3072 lumens at source<br>1200mm – 48W 6144 lumens at source<br>1800mm – 72W 9216 lumen as source |
| (d) | Supply Voltage | : | 230V AC 50HZ |
| (e) | CCT options | : | 4000K or 5000K |
| (f) | CRI | : | +80 minimum |
| (g) | IP Rating | : | IP 44 |
| (h) | Control Gear | | Internally mounted |

LED High bay

| | | | |
|---|---|---|---|
| (a) | Body construction | : | ABS end caps<br>Anodised aluminium reflectors<br>Powder coated or anodised aluminium body |
| (b) | Lens type | : | 4mm Polycarbonate or toughened glass |
| (c) | Supply voltage | : | 230V AC 50HZ |
| (d) | Load/lumen options | : | 75W – 13200 lumens at source<br>90W – 15750 lumens at source<br>150W – 26400 lumens at source<br>180W – 31500 lumens at source<br>300W – 52800 lumens at source<br>360W – 63000 lumens at source |
| (e) | CRI | : | +80 minimum |
| (f) | CCT | : | 4000K and 5000K |
| (g) | IP Rating | : | IP 65 |
| (h) | Power factor | : | Better than 0,97 |

Luminaire LED Performance

(a) Minimum Luminaire Efficacy : 75 lumens per watt
(b) Correlated Colour Temperature (CCT) : 4000K - 5000K
(c) Minimum Colour Rendering Index (CRI) : 80
(d) Lumen Output: - Initial lumen output shall be ≥ 10% higher than required for the luminaire to meet recommended values for the specific locations indicated, in

order for the luminaire to maintain compliance over its entire lifetime.

E21.3.4 Manufacturing and assembly of Emergency fittings

General

(a) The fittings shall be manufactured according to the standard fittings as described above.

(b) The fittings shall be self-contained emergency modules. I.e. The modules (emergency control units plus battery packs) can be fitted inside recessed and surface mounted luminaires including CFL bulkhead fittings.

(c) The emergency fittings should have a switched live for Normal ON/OFF operation and an unswitched live for Emergency light battery charging.

(d) The module should be able to maintain 50% light output for 1hour or alternatively 100% light output for ½ hour.

E21.3.5 High Masts Lighting

General

(a) All work on the high mast lighting must be done from ground level.

(b) All high mast poles will be of the hinging/tilting type. The hinging action allows the floodlights to be lowered to the ground for ease of access. Enough clearance space must be allowed to lower the pole.

Mast Shaft

(a) All poles must be designed to SABS 0225 by a registered Professional Engineer.

(b) The mast shall be constructed to form an enclosed tapered shaft. All steelwork must be hot dip galvanised, by an SABS approved galvaniser, to SABS ISO1461.

(a) The lower mast portion shall be fitted with a suitably designed base plate bolted onto the mast foundation. The bolts will be reusable security bolts (tamper proof bolts) where a special tool is required to remove the bolts.

(c) All mast foundations must be designed by a professional engineer, taking into account the mounting requirements of the pole baseplate.

(d) The upper portion will be counterbalanced and hinged at midpoint.

(e) The mast must be designed to safely withstand any loading (wind and own weight) in the upright and hinged position.

Floodlight Mounting Assembly

(a) The mast shall be fitted with a suitable luminaire mounting assembly fabricated from steel sections and capable of carrying the specified number and type of luminaires.

Electrical Equipment

(a) The Electrical distribution board shall be mounted in the base section of the mast and accessible only once the lid cover has been removed. The cover will be permanently fixed to the mast by means of a chain.

(b) The lid cover will be fitted with reusable security bolts (tamper proof bolts) where a special tool is required to remove the bolts.

(c) A multicore trailing cable shall be installed from the distribution board to a splitter box mounted on top of the mast.

(d) The cable supplying power to the floodlight luminaires need not be disconnected

during the lowering procedure thus allowing testing of the floodlights with the mast in the hinged down position.

E21.3.6 Sensors

Daylight Sensors

Daylight sensors must be provided to switch lights on at dusk and off at dawn by detecting natural light changes. All day light sensors shall have the following minimum requirements:-

(a) Conduit entry with wall bracket mounting.
(b) Efficient lighting solution.
(c) Ultra violet stabilized materials.
(d) Fail-safe position "ON".
(e) Capacity switching - Incandescent or fluorescent 2.2Kw HID 1,8W.
(f) Impact and hail resistant 0-4mm.
(g) IP Rating: 54.
(h) Amp Rating: 16A.
(i) Voltage: 200 - 250Vac (50Hz).

Occupancy Sensors

(a) Sensor shall activate the electrical load upon entry into the controlled area and deactivate it after the area is vacated.
(b) Sensor shall be able to detect moderate types of motion.
(c) Sensor shall maintain a constant level of sensitivity to motion regardless of changes in environmental conditions including airflow.
(d) Sensor shall utilize passive infrared sensing technology to activate lights and other equipment connected to it.
(e) Sensor shall contain timing circuitry to provide adjustable “time to lights off” delay of 15 seconds or less (for installer checkout) to 30 minutes. A 10-minute delay shall automatically default if the potentiometer is left at minimum.
(f) Sensor shall provide a ten-second “grace period” that allows lights to be turned on by motion anywhere in an area after they are turned off due to inactivity.
(g) Sensor shall self-adjust sensitivity (range) and time delay in real-time to optimize performance.
(h) Sensor shall provide a Building Automation system (BAS) option interface via (1) a built-in isolated Form C relay output, (2) an open collector output, with or without pull-up option, or (3) a direct BAS connection.
(i) Sensor shall be designed for parallel wiring to allow coverage of large areas.

## E21.4 LIGHTING DESIGN

(a) The contractor must do an area illuminance design in accordance with the applicable lux levels listed in SANS 10389-1 (Table 7 — Recommended values for illuminance, uniformity ratios and glare rating limits) and SANS 10114-1 (Table 1 — Minimum maintained illuminance values).
(b) All exit routes must be lit with emergency lights in accordance with the latest Occupational Health and Safety Act (Act 85 of 1993) and the Building Code.
(c) The contractor must submit the design to the Engineer for approval prior to the

procurement of any material.

(d) After installation, the contractor must do an illuminance study to confirm compliance to SANS 10389-1. The contractor must supply calibrated instruments to be used during the study. The compliance study must be witnessed by the Engineer.

(e) Should the illuminance study indicated insufficient lux levels, the contractor must take steps to increase the lux levels to the required level.

(f) Luminaire must be supplied as listed in the table below, specific to the area of installation (see paragraph E21.3.3 for minimum requirements)

| # | *AREA* | *LUMINAIRE (See E21.3.3)* |
|---|---|---|
| 1 | Analyser Rooms | 2ft/4ft/5ft Vapour Proof LED Light |
| 2 | Balancing Tanks | LED Flood Light on high mast |
| 3 | Belt Filter Press Sludge Dewatering | 2ft/4ft/5ft Vapour Proof LED Light or<br>LED Bulkhead/Street light |
| 4 | Biogas Collection and Storage (Gas Holder) | LED Flood Light on high mast |
| 5 | Bioreactors | LED Flood Light on high mast |
| 6 | Boiler Rooms | 2ft/4ft/5ft Vapour Proof LED Light<br>Ex-Rated fittings (Zone 2) |
| 7 | Chemical Dosing areas (Ferric Chloride and Hypochlorite) | LED Flood Light on high mast or<br>2ft/4ft/5ft Vapour Proof LED Light |
| 8 | Control Rooms | 2ft/4ft/5ft Vapour Proof LED Light |
| 9 | Degritters | LED Flood Light on high mast<br>In case of shed, use LED High bay |
| 10 | Digester Area | LED Flood Light on high mast |
| 11 | Fermenters | LED Flood Light on high mast |
| 12 | Final Clarifiers | LED Flood Light on high mast |
| 13 | Head Of Works (Buildings) | 2ft/4ft/5ft Vapour Proof LED Light<br>(LED High bay for areas under Sheds) |
| 14 | Head Of Works (Open area) | LED Flood Light on high mast<br>(LED High bay for areas under Sheds) |
| 15 | Lime Preparation and Dosing (Open Area) | LED Flood Light on high mast |
| 16 | Liquor treatment (Open Area) | LED Flood Light on high mast |
| 17 | MCC/PLC Rooms | Utility LED |
| 18 | Open channels | LED Flood Light on high mast |
| 19 | Poly make-up, storage and transfer (Buildings) | 2ft/4ft/5ft Vapour Proof LED Light |
| 20 | Poly make-up, storage and transfer (Open area) | LED Flood Light on high mast |
| 21 | PSTs | LED Flood Light on high mast |
| 22 | Screening and Washing areas (Buildings) | 2ft/4ft/5ft Vapour Proof LED Light |

| # | *AREA* | *LUMINAIRE (See E21.3.3)* |
|---|---|---|
| 23 | Screening and Washing areas (Open area) | LED Flood Light on high mast |
| 24 | Screw Pump Station | 2ft/4ft/5ft Vapour Proof LED Light or LED Flood Light on high mast |
| 25 | Skip areas for grit or screenings removal | 2ft/4ft/5ft Vapour Proof LED Light |
| 26 | Sludge Pumping Station | 2ft/4ft/5ft Vapour Proof LED Light |
| 27 | Sludge storage sumps or tanks (Open area) | LED Flood Light on high mast |
| 28 | Solar Sludge Drying Slabs (Drying Beds) | LED Flood Light on high mast |
| 29 | Thickeners | LED Flood Light on high mast |
| 30 | Perimeter of the sites | LED Bulkhead/Street light |
| 31 | Cable tunnels (Inside/Underground) | LED Bulkhead/Street light |
| 32 | Drying Bed Conveyors | 2ft/4ft/5ft Vapour Proof LED Light |
| 33 | Perimeter of the sites (outside) | LED Flood Light on high mast |
| 34 | Access gates (Outside) | LED Bulkhead/Street light |
| 35 | Cable Pipe Bridge/Gantry (with walkway) | 2ft/4ft/5ft Vapour Proof LED Light |
| 36 | Blower House (Inside) | 2ft/4ft/5ft Vapour Proof LED Light |
| 37 | Digester Feed Sump | LED Flood Light on high mast |
| 38 | GTL pump station | LED Bulkhead/Street light or 2ft/4ft/5ft Vapour Proof LED Light |
| 39 | BPU (Belt Press Underflow) pump station (Inside and outside) | LED Bulkhead/Street light or 2ft/4ft/5ft Vapour Proof LED Light |
| 40 | Biogas Generator plant (Inside and outside) | LED Bulkhead/Street light |
| 41 | Elutriation (Inside) | 2ft/4ft/5ft Vapour Proof LED Light |
| 42 | Compost Shed (Inside) | LED High bay |
| 43 | Flammable Stores | 2ft/4ft/5ft Vapour Proof LED Light Zone 2 Ex Rated |
| 44 | Workshops | 2ft/4ft/5ft Utility LED light |
| 45 | Admin Buildings | Architect to specify: For refurbished offices - check and propose to Joburg Water |
| 46 | Change Rooms (showers) | 2ft/4ft/5ft Vapour Proof LED Light |
| 47 | Laboratory | 2ft/4ft/5ft Vapour Proof LED Light |

## E21.5 INSPECTION AND TESTING

E21.5.1 General

All tests in accordance with the test requirements of this specification shall be performed prior to shipment.

Test certificates will be submitted with tender submission for all the units that are proposed.

All fittings shall be tested in accordance with SANS 475 and shall bear the performance mark. The fittings shall also comply with ISO 9000 certification and the testing requirements of IEC 60598-1 publication.

## E21.6 COMMISSIONING

The datasheet shall indicate whether the contractor is to allow a site technician to be present when the lighting system is to be commissioned. In such a case, the contractor shall quote a separate price for the provision of all personnel, materials and equipment for the site commissioning of the lighting.

Contractors shall provide a commissioning procedure, stating the tests that shall be performed with the results forecast.

The commissioning tests carried out on site shall be tests stipulated in the contractor's commissioning procedure.

## E21.7 GUARANTEE

All equipment shall be guaranteed against defect for a period of twelve months, from the date of mutually agreed successful hot commissioning, fair wear and tear accepted.

Tenderers shall submit a written undertaking at the time of tender that a complete range of spares for the equipment offered will be held by the manufacturer for a minimum period of 10 years from the date of tender.

## E21.8 TRANSPORTATION/SHIPPING

The costs of preparation for shipping will be included in the contractor's price.
The contractor is responsible to ensure that no damage will be sustained while shipping and he will prepare the appropriate packaging to ensure this.

The specification sheet shall indicate whether the contractor is to deliver the luminaires to site and whether the contractor is to offload the luminaires on site or if the delivery and offloading on site shall be carried out by a third party.

Where delivery and/or offloading by the contractor are specified on the specification sheet, the costs thereof shall be included in the contractor's price.

## E21.9 DRAWINGS & DOCUMENTATION

The contractor shall supply all drawings and documentation as indicated in the Specification sheet.

## E21.10 MEASUREMENT AND PAYMENT

| Item | Unit |
|---|---|
| Supply and delivery of luminaire ..... | No |

The unit of measure shall be the number of luminaire supplied and delivered.

The tendered rate shall include all costs related to the manufacture, supply and delivery of the luminaire (as detailed in the schedule of quantities), including the additional requirements detailed in the detail specification.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the type of luminaire.

| **Item** | **Unit** |
|---|---|
| Install luminaire | No |

The unit of measure shall be the number of luminaire installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the luminaire as specified. The rate shall further include for an illuminance study.

Separate items will be scheduled in the schedule of quantities for different types of luminaire.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by type of luminaire.

| **Item** | **Unit** |
|---|---|
| Supply and delivery of high mast lighting | No |

The unit of measure shall be the number of high masts supplied and delivered.

The tendered rate shall include all costs related to the manufacture, supply and delivery of the high mast (as detailed in the schedule of quantities), including the additional requirements detailed in the detail specification.

Separate items will be scheduled in the schedule of quantities for different types and lengths, defined by the type of high mast.

| **Item** | **Unit** |
|---|---|
| Install high mast lighting | No |

The unit of measure shall be the number of high masts installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the high mast lighting as specified. The rate shall further include for the pole plinth, crainage and other services required completing the installation.

Separate items will be scheduled in the schedule of quantities for different types of high masts.

# PARTICULAR SPECIFICATION: VOLUME E23: ELECTRICAL POWER FACTOR CORRECTION

## CONTENTS

## E23.1 SCOPE

This section covers the requirements applicable to low-voltage AC shunt capacitor banks intended to be used for power factor correction purposes, equipped with a built-in switchgear and controlgear apparatus capable of connecting to or disconnecting from the Main Distribution Board part(s) of the bank with the aim to correct its power factor.

## E23.2 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 10142-1 : The wiring of premises Part 1 Low-voltage installations

(b) SANS 60831-1 : Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1 000 V - Part 1: General - Performance, testing and rating - Safety requirements - Guide for installation and operation

(c) SANS 60931-1 : Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000 V - Part 1: General - Performance, testing and rating - Safety requirements - Guide for installation and operation

(d) SANS 61439-1 : Low-voltage switchgear and controlgear assemblies Part 1: General rules

(e) SANS 60947-2 : Low-voltage switchgear and controlgear Part 2: Circuit-breakers

(f) SANS 60947-4 : Low-voltage switchgear and controlgear Part 4: Contactors

(g) SANS 60076-6 : Power transformers Part 6: Reactors

(h) SANS 61439-2 : Low-voltage switchgear and controlgear assemblies Part 2: Power switchgear and controlgear assemblies

(i) SANS 61921 : Power capacitors - Low-voltage power factor correction banks

E23.2.1 Particular specifications to be read in conjunction with this specification

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

(a) E08 : WIRING

(b) E26 : ELECTRICAL SPECIFICATION FOR COLOUR CODES

## E23.3 GENERAL REQUIREMENTS

Power Factor Correction (PFC) will only be applied at Low Voltage level. Medium Voltage PFC will only be accepted on MV motors.

All PFC equipment will be installed in separate enclosures to minimise secondary damage to adjacent equipment in the event of PFC failure. The electrical connection to the PFC enclosure will be cable or busbar trunking. Installation of PFC equipment in a MCC, DB or

motor terminal box is not acceptable. PFC enclosures will not be positioned within 2m from MCC or DB's.

## E23.4 METHODS FOR POWER FACTOR CORRECTION

On selecting a method of power factor correction, the following steps must be followed:

a) Determine the required reactive energy (calculation or physical measurement)
b) Selection of the compensation mode:
   i. Central, for the complete installation;
   ii. By sector;
   iii. For individual loads, such as large motors.
c) Selection of the compensation type:
   i. Fixed, by connection of a fixed-value capacitor bank;
   ii. Automatic, by connection of a different number of steps, allowing adjustment of the reactive energy to the required value;
d) Allowance for operating conditions and harmonics.

**Note:** As a guideline: where the kvar rating of the capacitors is less than or equal to 15 % of the power supply transformer rating, a fixed compensation system will be installed. Above the 15 % level, an automatic compensation system will be installed.

### E23.4.1 Fixed compensation

This arrangement uses one or more capacitor(s) to provide a constant level of compensation.

The capacitors shall be installed at the terminals of large inductive loads (mainly induction motors) where the load factor is reasonably constant. No control is possible as this is a direct connection to a load and switched with it. The contractor will adjust the protection settings to the equipment after the installation of fixed compensation capacitors.

Motors with Forward/Reverse control will not be compensated. Motors on VSD control will not be compensated.

### E23.4.2 Automatic compensation

This kind of compensation provides automatic control and adapts the quantity of reactive power to the variations of the installation in order to maintain the targeted cos φ by switching capacitor banks in and out.

The PFC equipment shall be installed at points in an installation where the active-power and/or reactive-power variations are relatively large, for example: on the busbars of main distribution switchboards.

Control will be provided by an electronic device (Power Factor Controller) which monitors the actual power factor and controls the connection or disconnection of capacitor banks in order to obtain the targeted power factor. Accurate PF control must be provided by designing the individual capacitor banks in a combination of larger and smaller kvar sizes. Capacitor bank connection is provided by contactors.

### E23.4.3 Dynamic compensation

Dynamic compensation is achieved by the combination of a fixed capacitor bank and an electronic var compensator, providing either leading or lagging reactive currents. The result is a continuously varying and fast compensation.

Dynamic power factor compensation will not be acceptable.

## E23.5 OPERATING CONDITIONS AND HARMONICS

E23.5.1 Operating conditions

The operating conditions have a great influence on the life expectancy of capacitors. The following parameters should be taken into account:

a) Ambient temperature (°C);
b) Expected current and voltage fluctuations.

E23.5.2 Harmonics

Harmonic rated capacitors must be used with detuned reactors. Reactors are necessary in order to prevent the amplification of harmonic currents and avoid resonance.

## E23.6 SELECTION OF PFC COMPONENTS

The contractor must supply a safe, reliable and high-performance solution for power factor correction in the most severe application conditions.

E23.6.1 Capacitors with detuned reactors

The use of detuned reactors prevents harmonic resonance problems, avoids the risk of overloading the capacitors and helps reduce voltage harmonic distortion in the network. Capacitors banks must be configured with reactors in a series resonant circuit, tuned so that the series resonant frequency is below the lowest harmonic frequency present in the system.

### a) Detuned Capacitor Banks

The tuning frequency for a capacitor bank with detuned reactors can be expressed by the relative impedance of the reactor (in %), or by the tuning order, or directly in Hz. The value of relative impedance must be designed to filter the highest harmonic voltage at the specific installation. Standard tuned reactors are available for the following harmonic current spectrum:

i. Impedance 5.5 % (3rd Harmonic)
ii. Impedance 10.7 % (5th Harmonic)
iii. Impedance 5.3 % (7th Harmonic)
iv. Impedance 2.1 % (11th Harmonic)

### b) Capacitors

Capacitors must be supplied with the following as the minimum requirement:

a) Self-healing, which is a process by which the capacitor restores itself in the event of a fault in the dielectric, which can happen during high overloads, voltage transients etc.;
b) Pressure-sensitive disconnector (also called ‘tear-off fuse’) in each phase of the capacitor to enable safe disconnection and electrical isolation at the end of the life of the capacitor;
c) Discharge resistors fitted.

The rated voltage ($U_N$) of a capacitor is defined as the continuously allowable operating voltage. In order to accept system voltage fluctuations, capacitors must be selected to sustain over-voltages equal to 1.1 times $U_N$ for a period of 8 hours per 24 hours. (SANS 60681-1). In a detuned filter application, the voltage across the capacitors is higher than the network service voltage ($U_S$). Then, capacitors must be designed to withstand higher voltages.

The rated current ($I_N$) of a capacitor is the current flowing through the capacitor when the rated voltage ($U_N$) is applied at its terminals, supposing a purely sinusoidal voltage and the exact value of reactive power (kvar) generated. Capacitor units shall be suitable for continuous operation at a rms current of (1.3 x $I_N$) (SANS 60681-1). Depending on the selected tuning frequency, part of the harmonic currents are absorbed by the detuned capacitor bank. Then, capacitors must be designed to withstand higher currents, combining fundamental and harmonic currents.

**c) Detuned reactors**

Detuned reactors must be supplied with thermal protection (a normally closed dry contact). The thermal protection contact must be connected to trip the supply circuit breaker in case of overheating.

Force ventilation is mandatory when installing detuned reactors. The operating temperature of the panel should be maintained < 50 degrees through proper ventilation. The sizing must consider ambient conditions.

**Power Factor controllers**

Control will be provided by an electronic device (Power Factor Controller) which monitors the actual power factor and controls the connection or disconnection of capacitor banks in order to obtain the targeted power factor.

The Power Factor Controller must

a) Permanently monitoring the network and equipment;
b) Equipped with a large on-board display;
c) Allows controller self-configuration;
d) Provide information about equipment status;
e) Activate Alarm signals in case of PFC malfunction.

**d) Contactors**

Special contactors designed for switching 3-phase, single or multiple-step capacitor banks shall be supplied. The contactors must be fitted with a block of early make poles and damping resistors, limiting the value of the current on closing to 60 $I_n$ max. This current limitation increases the life of all the components of the installation, in particular that of the fuses and capacitors. The contactors must conform to SANS 60070 and 60831.

Short-circuit protection must be provided by gI type fuses rated at 1.7…2 In.

## E23.7 FIXED COMPENSATION PFC PANELS

E23.7.1 Enclosure

Fixed Compensation PFC enclosures will be:

a) Manufactured from 3CR12 stainless steel (min 2.0mm thickness);
b) Painted electric orange (B26);
c) Rated IP65 to SANS 60529 and shall be fitted with a canopy when installed

outdoors;

d) Wall mounted or pedestal mounted at least 1000mm above floor level. The pedestal base plate shall be installed on 10mm of epoxy grout to prevent crack corrosion. The pedestal material shall be stainless steel (3CR12) and have minimum thickness of 6mm. The pedestal shall be painted electric orange (B26);

e) Mounted as close as possible within a radius of 1000mm from the supply terminals of the main equipment (motor);

f) Clearly labelled with an identity label. The label will be engraved with 30mm high black on white characters, and shall be mounted on the top of the enclosure. The name of the associated drive will be shown.

E23.7.2 Equipment

The PFC circuit will consist of:

a) Incomer CB (MCCB) with overload and thermal protection;

b) Capacitors with detuned reactors. The kvar rating of the capacitor bank will be in the order of 25% of the kW rating of the motor.

## E23.8 AUTOMATIC COMPENSATION PFC PANEL

E23.8.1 Enclosure

Automatic Compensation PFC enclosures will be:

a) Manufactured from 3CR12 stainless steel (min 2.0mm thickness);

b) Painted electric orange (B26);

c) A freestanding panel, floor standing with front access doors. Cable entry will be from a cable trench below the panel;

d) Installed in an electrical substation building 2m away from the main MCC or DB;

e) Clearly labelled with an identity label. The label will be engraved with 30mm high black on white characters, and shall be mounted on the top of the enclosure. The name of the associated MCC or DB will be shown.

E23.8.2 Equipment

a) Incomer CB (ACB or MCCB) with overload and thermal protection;

b) Capacitors banks with detuned reactors complete with CB's or fuses and contactors. The kvar rating of the capacitor banks will be based on the transformer size feeding the MCC or DB;

c) Power Factor controller.

E23.8.3 Protection Devices

The following protection devices must be included in the PFC system as a minimum:

a) **Over voltage**

In the event of an over voltage, electrical stress on the capacitor dielectric and the current drawn by the capacitors will increase. The PFC equipment must be switched off in the event of over voltage with a suitable over voltage relay / surge suppressor.

b) **Over Current**

Over current condition is harmful to all current carrying components. The capacitor bank components must be rated based on the maximum current capacity. A suitable over current relay with an alarm function must be used for over current protection.

c) **Short circuit protection**

Short circuit protection at the incomer of the capacitor bank must be provided by devices such as MCCB's and ACB's. MCB or MCCB must be installed at every step for short circuit protection.

d) **Thermal Overload**

A thermal overload relay must be used for over load protection and must be set at 1.3 times the rated current of capacitors (as per SANS 60831).

In case of de tuned capacitor banks, the over load setting is determined by the maximum over load capacity of the detuning reactor (kvar rating).

e) **Over Temperature protection**

The PFC controller must be tripped with the help of thermostats in cases the internal ambient temperature of the capacitor bank exceeds the temperature withstand characteristics of the capacitor bank components. Reactors are provided with thermal switches and can be isolated in the case of over temperature conditions.

## E23.9 TESTS

At the end of the manufacturing process, the LV PFC switchboard must undergo various routine inspections and tests in the factory, following an established programme.

The switchboard must comply with :

a) The appropriate standards (listed above);

b) The design file (drawings, diagrams and specific requirements);

c) Manufacturer mounting instructions;

d) Joburg Water In-house instructions (this specification).

## E23.10 MAINTENANCE

For the first year after commissioning (defects liability period), the contractor is responsible to maintain and test the PFC installation. Thereafter, maintenance must be done every year. The following annual checks must be performed:

a) General cleanliness of the equipment;

b) Filters and ventilation system;

c) Terminal tightening torques;

d) Proper working order of switching and protective devices;

e) Temperature in the premises: -5 °C to +40 °C max - for normal designs;

f) Capacitance: It is recommended to change the capacitor if the capacitance value has reduced more than 10%.

## E23.11 MEASUREMENT AND PAYMENT

**Item** **Unit**

Supply and delivery of Fixed Compensation PFC Panels..... No

The unit of measure shall be the number of Fixed Compensation PFC panels supplied and delivered.

The tendered rate shall include all costs related to the manufacture, supply and delivery of the Fixed Compensation PFC panels (as detailed in the schedule of quantities), including support pedestal in accordance with this specification and the additional requirements detailed in the detail specification complete with all mounting brackets.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the kvar rating of the Fixed Compensation PFC panels.

**Item** **Unit**

Install Fixed Compensation PFC Panels .....No

The unit of measure shall be the number of Fixed Compensation PFC Panels installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the Fixed Compensation PFC Panels as specified. The rate shall further include for pedestal support securing and sealing preventing crevice corrosion.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the kvar rating of the Fixed Compensation PFC panels.

**Item** **Unit**

Supply and delivery of Automatic Compensation PFC Panels .....No

The unit of measure shall be the number of Automatic Compensation PFC panels supplied and delivered.

The tendered rate shall include all costs related to the manufacture, supply and delivery of the Automatic Compensation PFC panels (as detailed in the schedule of quantities), including additional requirements detailed in the detail specification.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the kvar rating of the Automatic Compensation PFC panels.

**Item** **Unit**

Install Automatic Compensation PFC Panels.....No

The unit of measure shall be the number of Automatic Compensation PFC Panels installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the Automatic Compensation PFC Panels as specified.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the kvar rating of the Automatic Compensation PFC panels.

# PARTICULAR SPECIFICATION: VOLUME E24: ELECTRICAL BATTERY TRIPPING UNIT

## CONTENTS

## E24.1 SCOPE

This section covers the design, manufacture, test, pack and deliver, install and commissioning requirements for a Battery Tripping Unit (BTU) to be used in conjunction with MV switchgear.

## E24.2 STANDARDS AND SPECIFICATIONS

E24.2.1 Particular standards to be read in conjunction with this specification

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:

1) SANS 60146 : Semiconductor converters.
2) SANS 1652 : Battery chargers - Industrial type.
3) SANS 60896-22 : Stationary lead-acid batteries Part 22: Valve regulated types - Requirements
4) SANS 62485 : Safety requirements for secondary batteries and battery installations
5) SANS 60076 : Power transformers.
6) SANS 60529 : Degrees of protection provided by enclosures (IP code).
7) SANS 60947-2 : Low-voltage Switchgear and Control gear Part 2 Circuit breakers
8) SANS 1091 : National colour standard.

E24.2.2 Particular specifications to be read in conjunction with this specification

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

1) G01 : PARTICULAR SPECIFICATION FOR COLOUR CODES.
2) G02 : PARTICULAR SPECIFICATION FOR CORROSION PROTECTION.
3) E08 : WIRING

## E24.3 GENERAL REQUIREMENTS

1) The BTU will be an indoor, free standing, floor-mounted unit;
2) The BTU will be a naturally air-cooled, designed for continuous operation in the specified ambient temperature. Ventilation louvers shall be installed in the in the casing;
3) The BTU shall be housed in mechanically reinforced sheet steel cubical. The thickness of sheet steel shall be 2.0 mm for load bearing members and 1.6 mm for other sides;
4) The cubical shall be dust and vermin proof;
5) The degree of protection will be IP42;

6) All doors on the cubical shall be hinged and shall have a locking agreement;
7) All door mounted parts/items as well as parts/items mounted inside the cabinet shall be provided with individual labels with their designation engraved;
8) A cable gland plate shall be provided for incoming / outgoing cables;
9) Electrical indicating instruments shall be mounted flush on the door with only the flange projecting. The instrument dial shall be white with black numbers and lettering;
10) The BTU will be complete with internal wiring, including input and output terminals. The components shall be liberally sated. Standard colour code practice shall be followed, with the use of ferrules for numbering and identification of wires. Copper conductor of suitable size shall be used;
11) Each cubicle will undergo a through process of derusting cleaning, application of red oxide primer paint followed by two coats of BS 631 Light Grey synthetic enamel paint.

## E24.4 BTU PARAMETERS

If not otherwise stated in the specific specification, the BTU will be specified as follow:

### E24.4.1 Rating

The charger shall be provided with load limiting feature for protection against overload.

1) Permanent Load : 4A
2) Ripple Content : 1% or lower
3) Battery : Ni-Cad (22Ah)

### E24.4.2 Incoming supply

The BTU shall be protected against voltage surges by voltage suppressor devices.

1) Input Voltage : 110, 230, 260 VAC Single phase
2) Frequency : 45 to 65 Hz
3) Maximum Supply Demand : 250VA

### E24.4.3 Duty

The BTU shall employ two battery-charging states i.e. Float charge and the Boost charge.

1) The Float mode of the charger shall be fully automatic type during operation on auto mode. However, necessary provision of manual operation control shall also be provided in addition to auto control with required auto/manual selector switch etc. in the event of failure of auto control. The Float charge shall supply the DC load of the substation and trickle charge the batteries up to full capacity. For this condition, the float charge mode shall be designed to float charge the batteries and supply DC load of the substation at constant voltage.
2) When the AC supply fails, the batteries will supply the substation DC load and will discharge gradually. The batteries will be charged in the Boost mode. Boost

mode shall have adequate rating to quick charge the battery fully within 10 hours after an AC failure. While boost charging the batteries, the charger will also supply the DC load of the substation.

E24.4.4 Output

Suitable ripple filtering circuits shall be provided to give a smooth DC output. The DC output shall be free from switching surges, transients etc.

1) Steady State Output Voltage : 34.08V
2) Steady State Output Current : 5A (current limit)
3) Ripple Content : 1% or lower

## E24.5 GENERAL PROVISION

1) AC input ON/OFF main switch (double pole);
2) Neon indicating lamp for AC supply 'ON' indication (After main AC fuse).
3) Double wound impregnated naturally air cooled single phase transformer with taps at 110V, 230V and 360V on primary side;
4) Full wave half controlled rectifier bridge comprising of silicon diodes and silicon controlled rectifiers (SCR) with R/C surge suppressor network;
5) Ammeter for measuring DC output current of charger;
6) Auto/ manual mode selector switch;
7) Battery test function;
8) Volt meter for measuring DC output voltage (battery voltage);
9) DC output ON/OFF switch;

## E24.6 PROTECTION AND ANNUNCIATION:

Following protection with LED alarm indicating lamp and a NO/NC potential free contact shall be included.

1) Float charging;
2) Boost charging;
3) Charge Failed;
4) Battery Volts Low.

## E24.7 DOCUMENTATION AND DRAWINGS

Necessary product information, booklets, drawings circuit diagram operating and maintenance manuals, etc. should be submitted. One set of each of detailed dimensional drawings, commissioning and operating instructions manual, literature, write up and test certificates of bought out items shall be supplied with the each BTU.

## E24.8 ACCEPTANCE / ROUTINE TESTS

The following test shall be carried out by the manufacturer on each BTU prior to delivery

1. Visual inspection and dimensions;

2. Checking of wiring and continuity of circuits;
3. Ripple content measurement;
4. No load test;
5. Load test;
6. Operational tests for protection, alarm, indication;
7. Auto/Manual operation test.

## E24.9 MEASUREMENT AND PAYMENT

| Item | Unit |
|---|---|
| Supply and delivery of Battery Tripping Unit ..... | No |

The unit of measure shall be the number of BTU's supplied and delivered.

The tendered rate shall include all costs related to the manufacture, supply and delivery of the BTU's (as detailed in the schedule of quantities), including additional requirements detailed in the detail specification.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the Ah rating of the BTU's.

| Item | Unit |
|---|---|
| Install BTU's ..... | No |

The unit of measure shall be the number of BTU's installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the BTU's as specified.

Separate items will be scheduled in the schedule of quantities for different types and sizes, defined by the Ah rating of the BTU's.

## ELECTRICAL SPECIFICATION: VOLUME E26: COLOUR CODING OF EQUIPMENT

### CONTENTS

## E26.1 SCOPE

This Specification has been adopted by Johannesburg Water to ensure the colour coding of electrical equipment located on Johannesburg Water's Wastewater Treatment Works shall conform to the ruling Occupational Health and Safety Act.

Table 1 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 1091, National colour standard (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.

| PSY2<br>tem | PSY3<br>olour | PSY4<br>emarks | PSY5<br>ode 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 |

Table 1: Colour Coding of Electrical Equipment

### E26.1.1 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.

### E26.1.2 Records

The contractor shall maintain records of the application environment, dates of applications, conditions of surfaces before preparation, blast profiles, wet and dry film thicknesses, over-coating 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.

## E26.2 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 and the surface preparation, transporting of equipment to and fore from the

applicator shall be included. No separate measurement item shall be included for the application of these coatings.

# PORTION 8: PARTICULARS SPECIFICATIONS FOR CONTROL WORK

| Volume | Description |
|---|---|
| 3 | PLC PANELS |
| 5 | CLEAN POWER AND SURGE PROTECTION |
| 6 | CABLING |
| 7 | NETWORKING |
| 8 | FLOW MEASUREMENT |
| 9 | LEVEL MEASUREMENT |
| 19 | FIELD JUNCTION BOXES |
| 23 | PRESSURE MEASUREMENT |
| 25 | LABELLING |

# VOLUME 3 : PROGRAMMABLE LOGIC CONTROLLER (PLC) PANELS

## INDEX

# 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.

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

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

3.4.9 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.

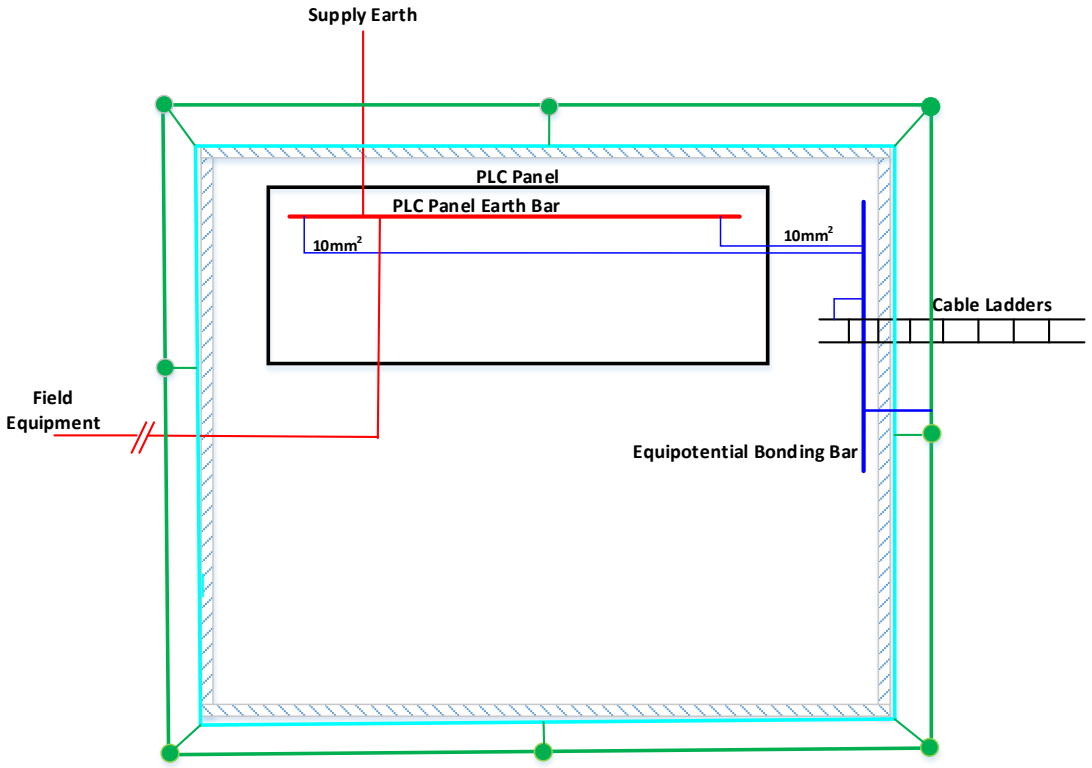
3.5.1.7 No holes may be drilled for tapping, riveting, bolts & nuts, etc. in any section of the panel where it will compromise the protection rating of the panel. I.e. only in the backing plate or in the glanding plate may holes be drilled. Where drilling is unavoidable, e.g. to affix labels, the holes 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.

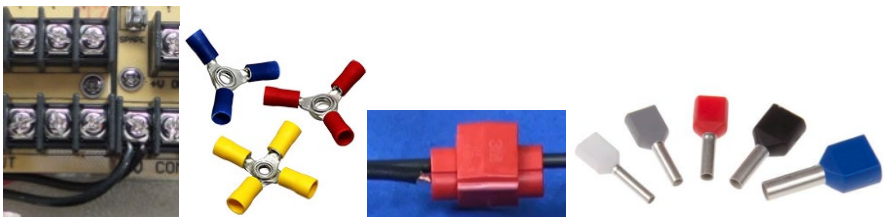
3.5.1.14 Where stopper plugs are used to seal holes that are not used, no plastic stopper plugs will be acceptable. All stopper plugs must be threaded, non-corrodible, metal plugs with rubber washers on both sides of the panel to ensure at least an IP65 seal (see examples below).

## 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.

# VOLUME 5 : CLEAN POWER AND SURGE PROTECTION

## INDEX

# 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.

## 5.8 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 | |

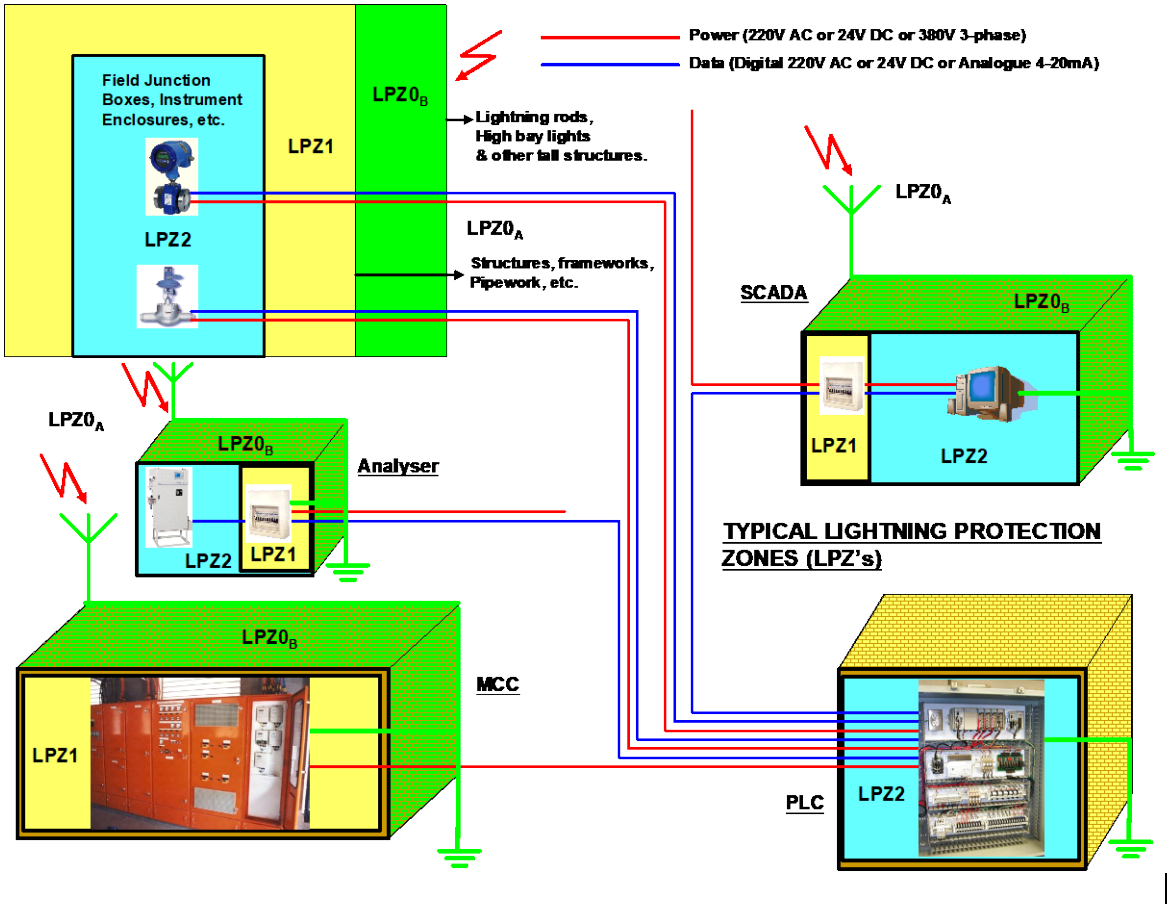
## 5.9 Surge Protection General

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:<br>$I_{imp}$ = 50kA (10/350 µs) for SPDs between PHASE and NEUTRAL<br>$I_{imp}$ = 100kA (10/350 µs) for SPDs between NEUTRAL and PE and<br>For Combination Units:<br>$I_{imp}$ = 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<br>$I_{sn}$ = 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.

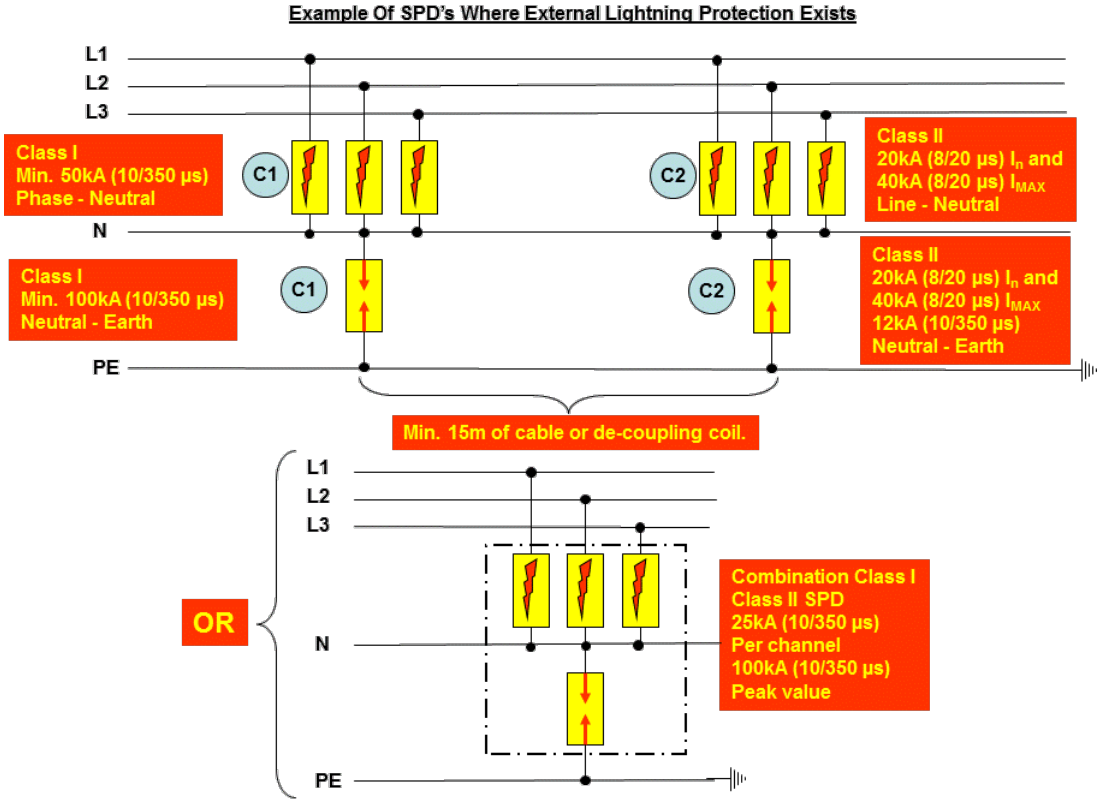
5.9.7 In order to ensure that individual protective devices are selectively effective, i.e. each protection stage only takes on the amount of interference energy which it is designed for, if one protection stage is faced with the threat of an energy overload, the upstream, more powerful arrester must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

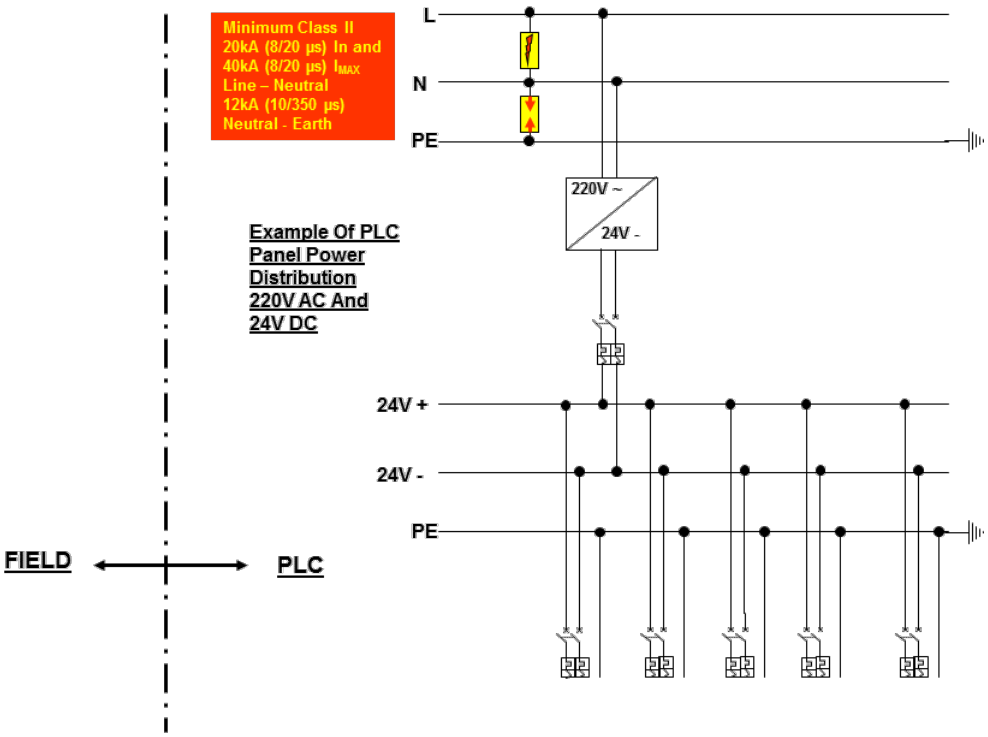
5.9.13 For Class II the minimum conductor size is 6mm$^2$ and pre-fusing of 125 Amps is required if the upstream protection is greater than 250 Amps. Fuses must be connected in series with the SPDs and must have the same fault current level or higher than that of the panel or board where they are installed.

## 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.

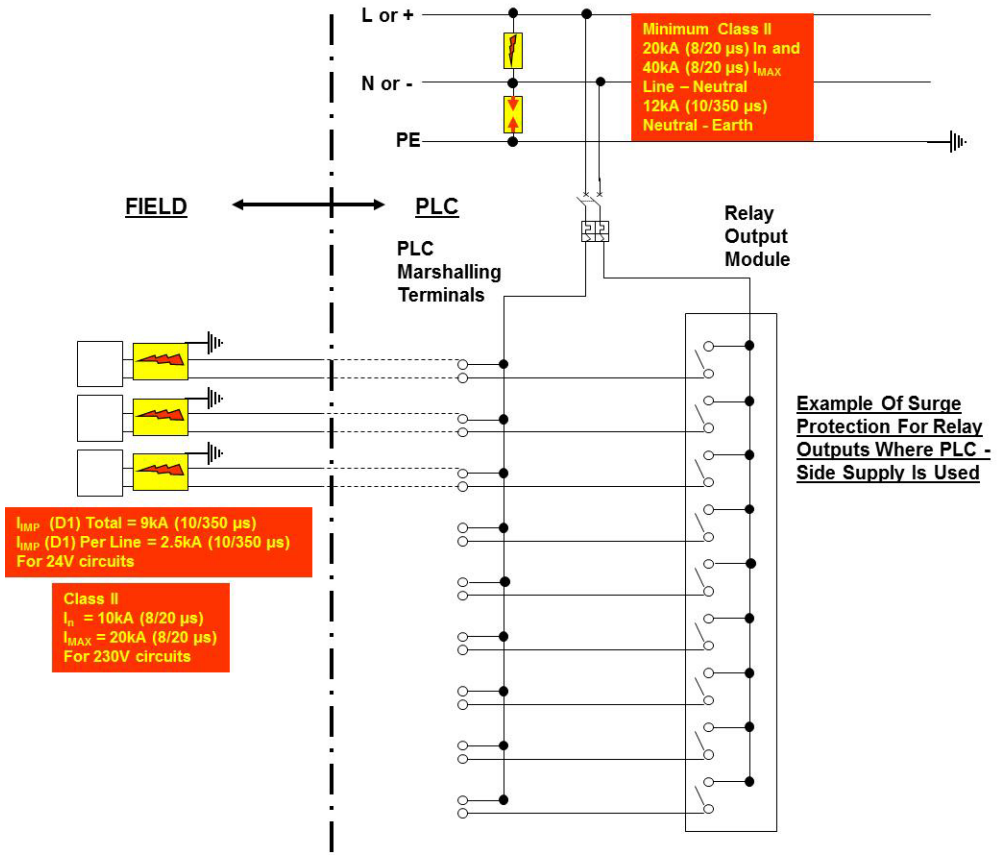
5.11.2 SPDs must be installed at both ends of each cable (i.e. at the PLC and at the field

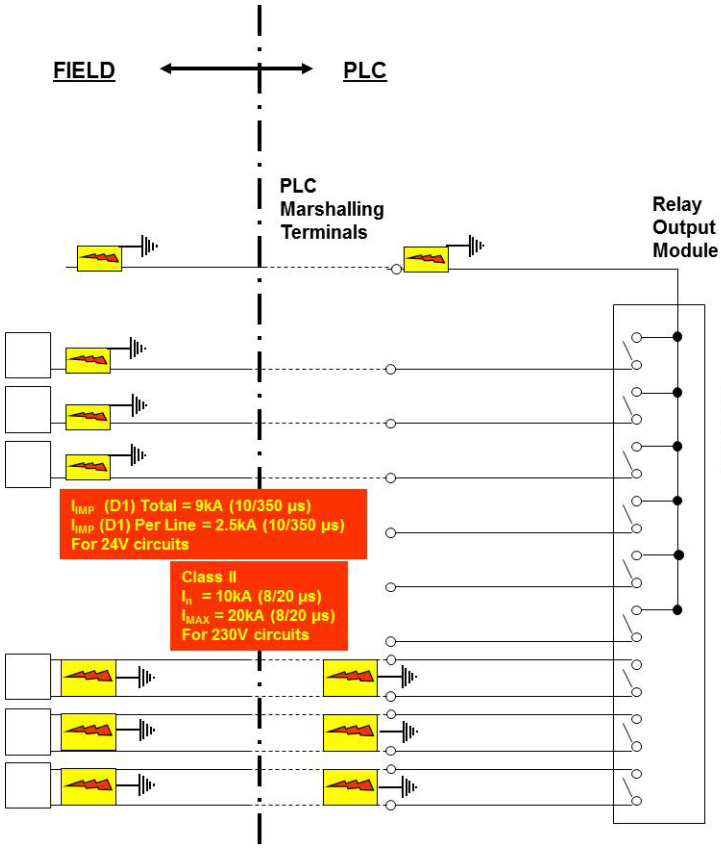
instrument, MCC, control panel, junction box, etc).

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.

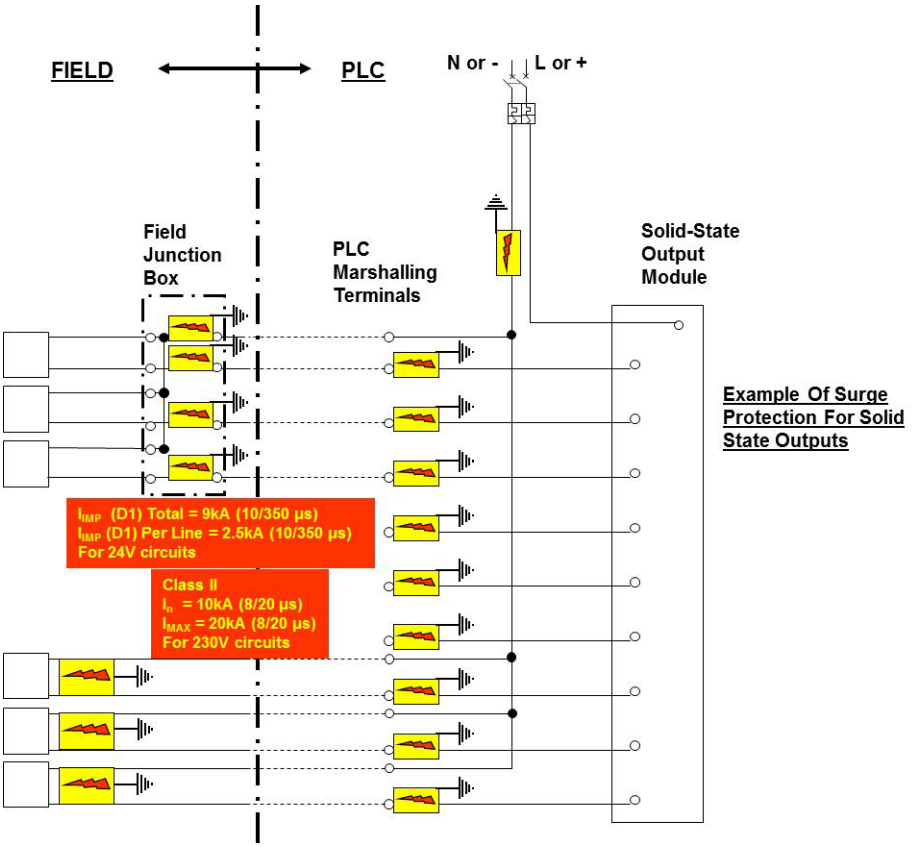
5.11.4 The rated operating current for SPDs used for protection of I/O systems must not be less than 0.75Amp.

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

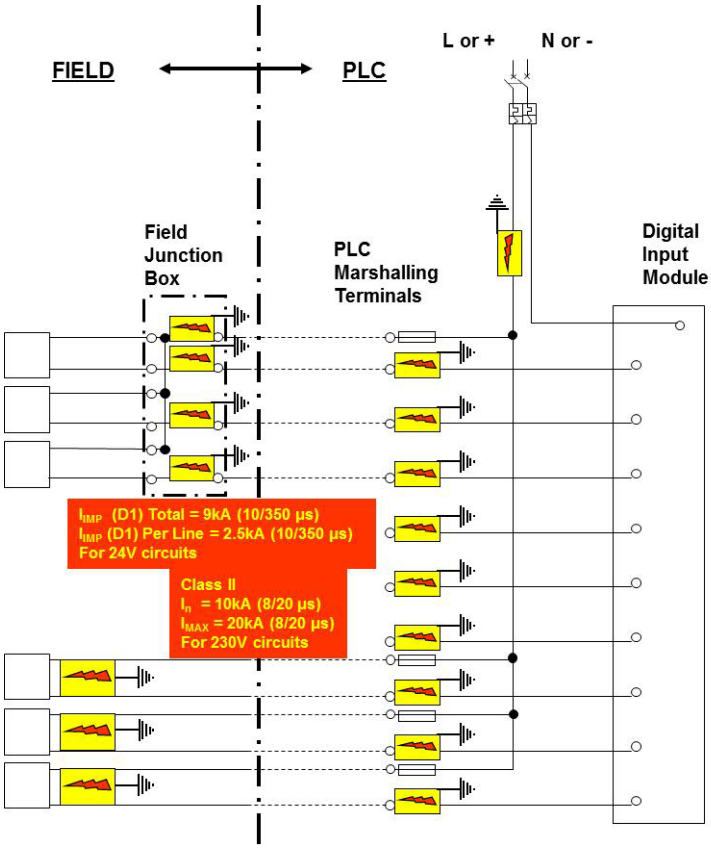




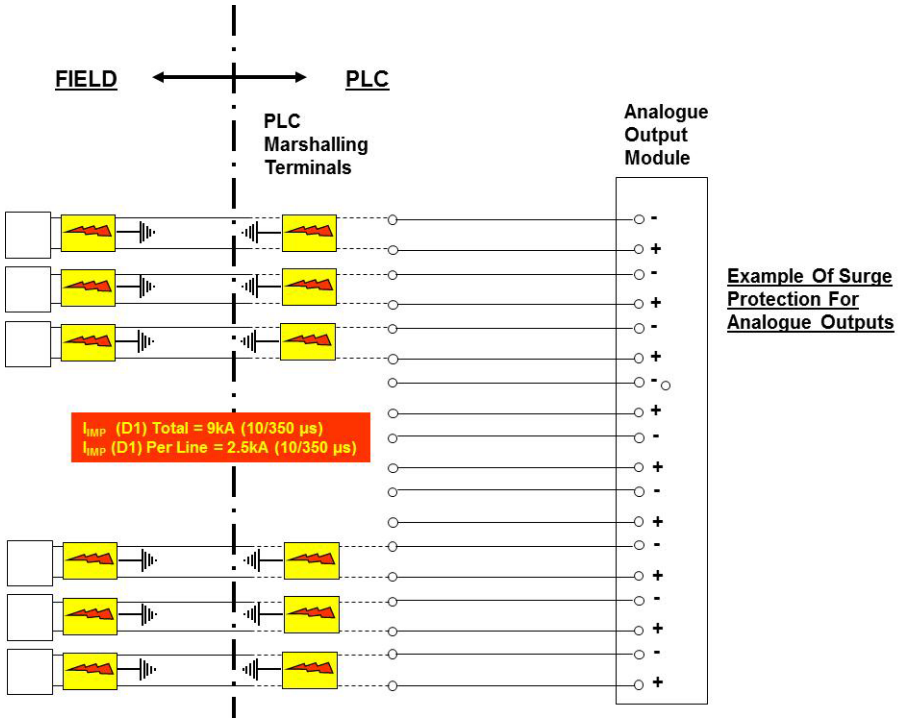

Example Of Surge Protection For Relay Outputs Where External Supply Is Used

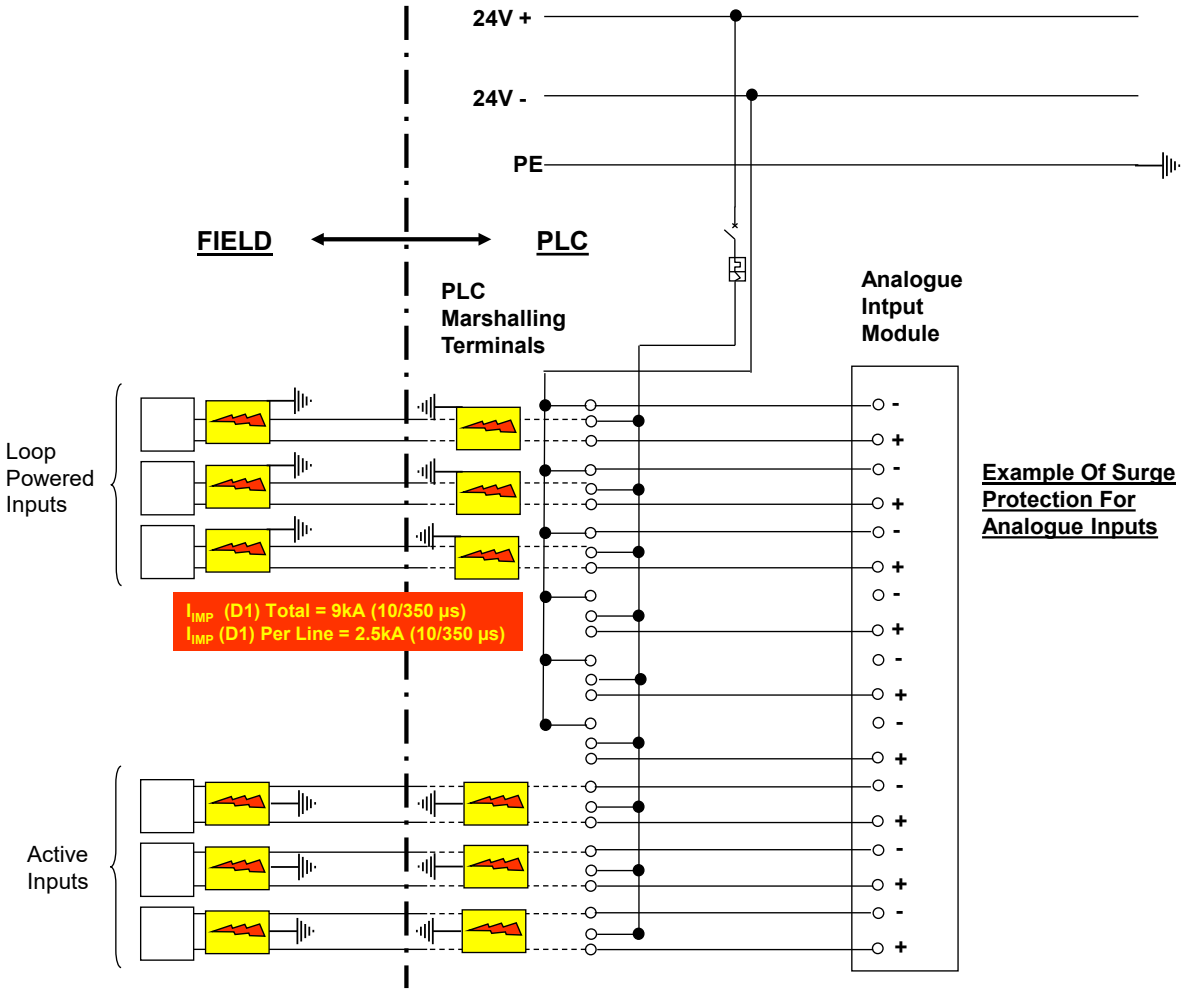



Example Of Surge Protection For Solid State Outputs




Example Of Surge Protection For Digital Inputs


FIELD
PLC
PLC Marshalling Terminals
Analogue Output Module
$I_{IMP}$ (D1) Total = 9kA (10/350 µs)
$I_{IMP}$ (D1) Per Line = 2.5kA (10/350 µs)
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

# VOLUME 6 : CABLING

## INDEX

# 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:

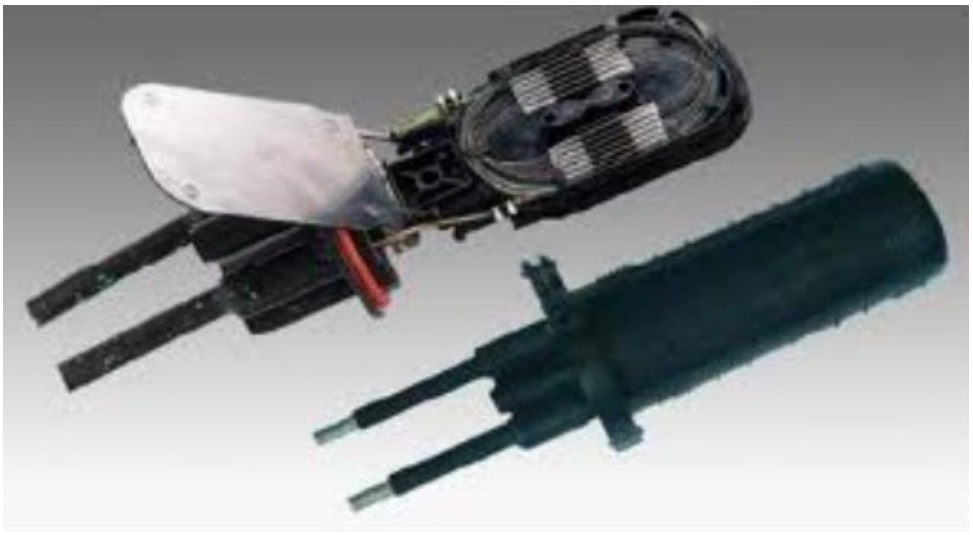
| Installation Condition | Blown Fibre Microduct Assembly Requirements |
|---|---|
| In ceiling of a building | Rodent-proof, low-smoke, fire retardant, halogen-free. |
| On a cable support against the side of the building | Steel wire or steel tape armoured, UV protected. |
| Buried in a trench | Suitable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

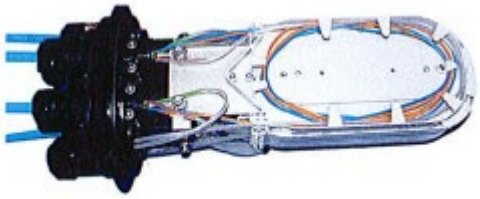
6.4.30 All cables on racks, in trenches, in tunnels, in wire ways, on cable supports, etc. must be vermin-proof. I.e. such cables must be equipped with suitable armouring to prevent rodents or other vermin from chewing through core conductors or their insulation.

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.

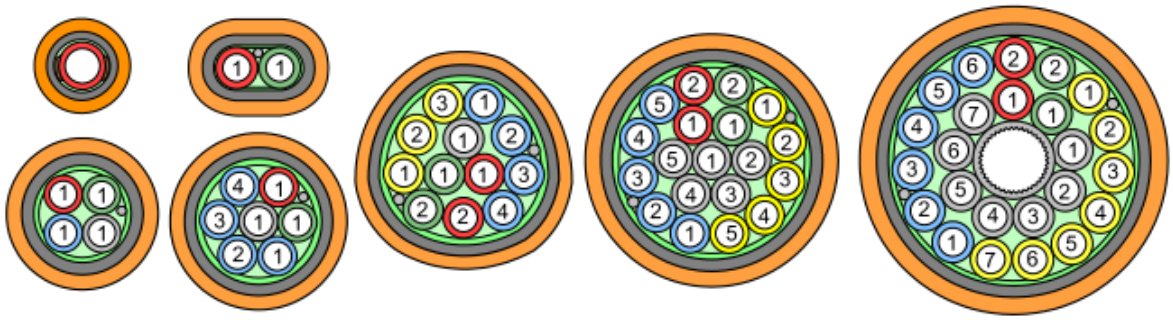
6.4.39 The jacket or buffer tubes of fibre bundles used in blown fibre installations must be colour coded and terminated in the following sequence:

| 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) |

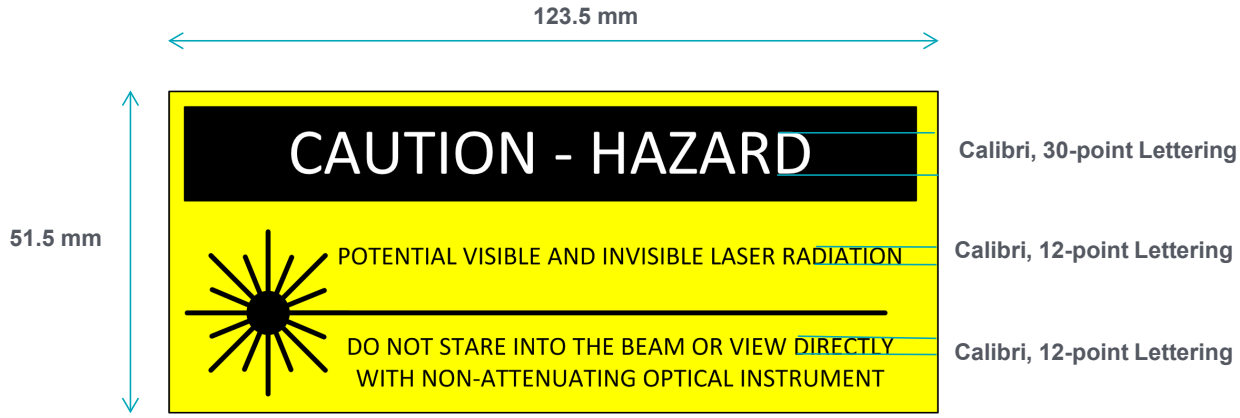
6.4.40 The microducts (or inner tubes) of microduct assemblies used for blown fibre installations must be constructed from low-friction Poly Ethylene (PE). These microducts must be 5/3.5 in size (i.e. 5mm OD and 3.5mm ID). Surrounding the group of microducts, must be a layer of waterswell tape. Where 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).

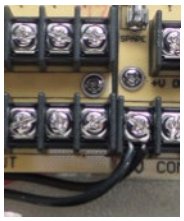
## 6.6 Electric Cable Terminations

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.

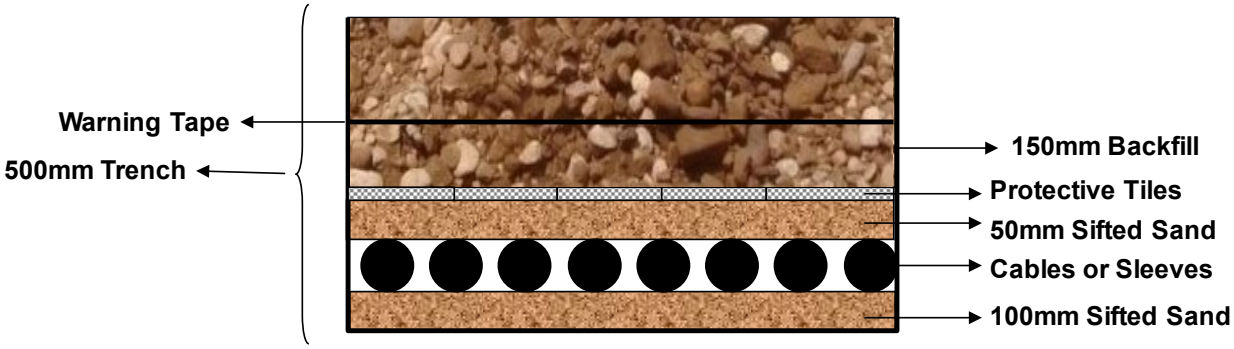
6.6.7 Where cable junction boxes, terminal boxes or terminations in instruments or any other panels in the field take place it must be ensured that such a junction box, termination box, instrument, etc. is not exposed to fire hazards from burning grass or other vegetation. If such a termination point 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.

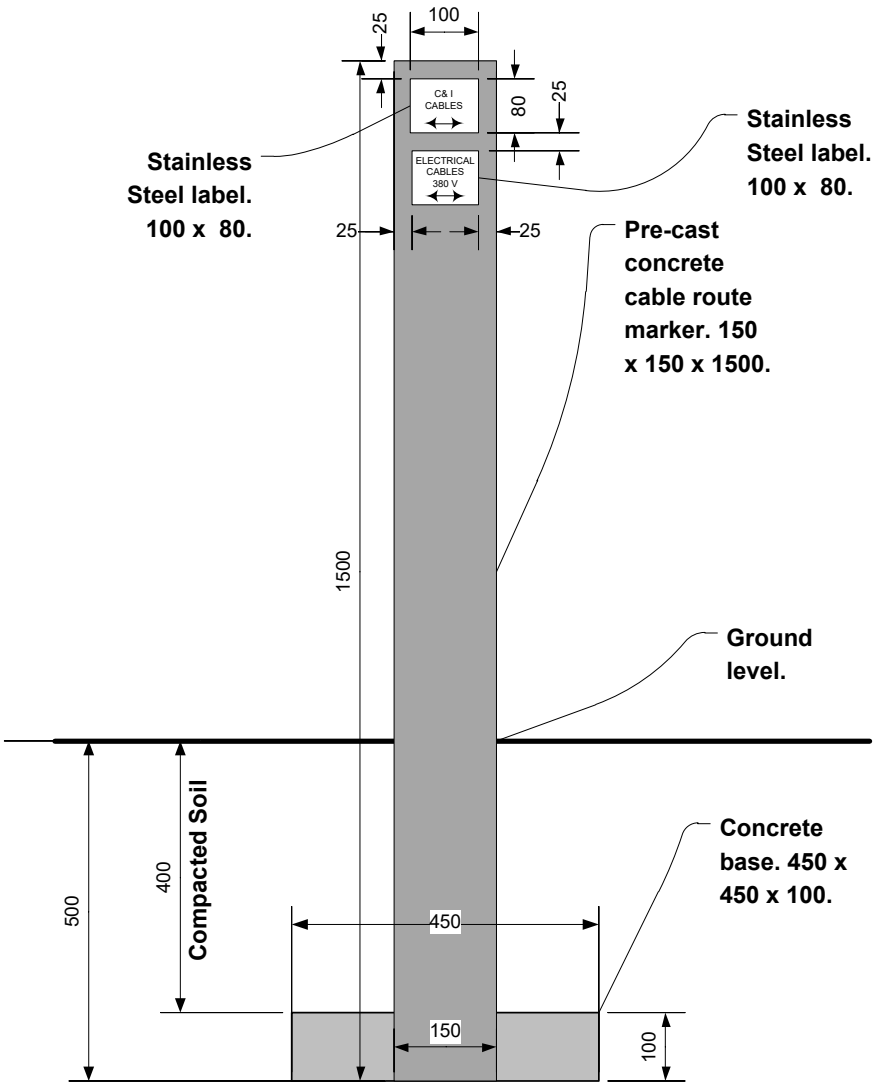
6.7.7 Cable route markers, in the form of concrete pre-cast posts, which stand 1.0m above ground level, secured in the ground, must be installed every 50m on straight runs and at every change in direction of the trench. Movable route markers will not be acceptable. The post must be equipped with a stainless 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).

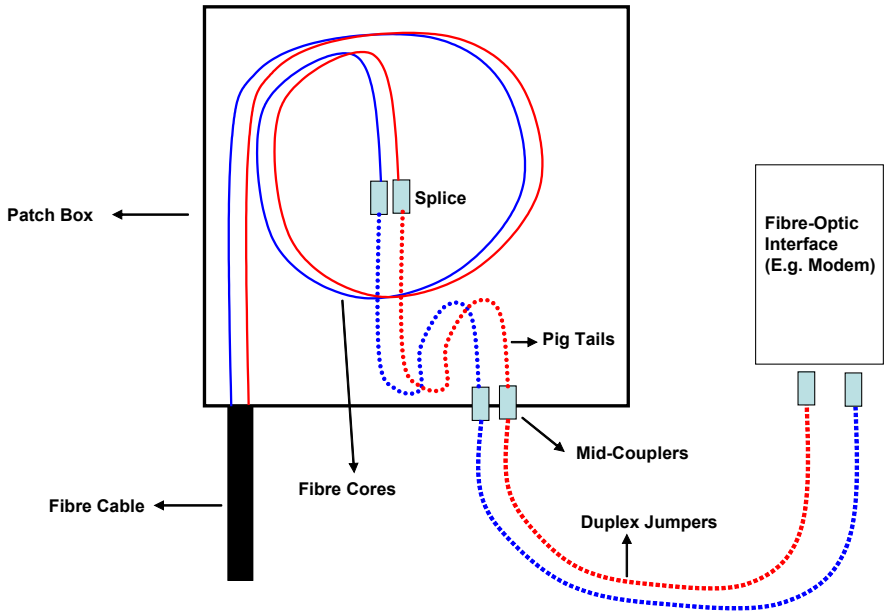
6.7.20 The base of the chamber must be made up of a dry mix of stone and cement so that it forms a hard but porous surface which is free draining for any water which enters the chamber.

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.

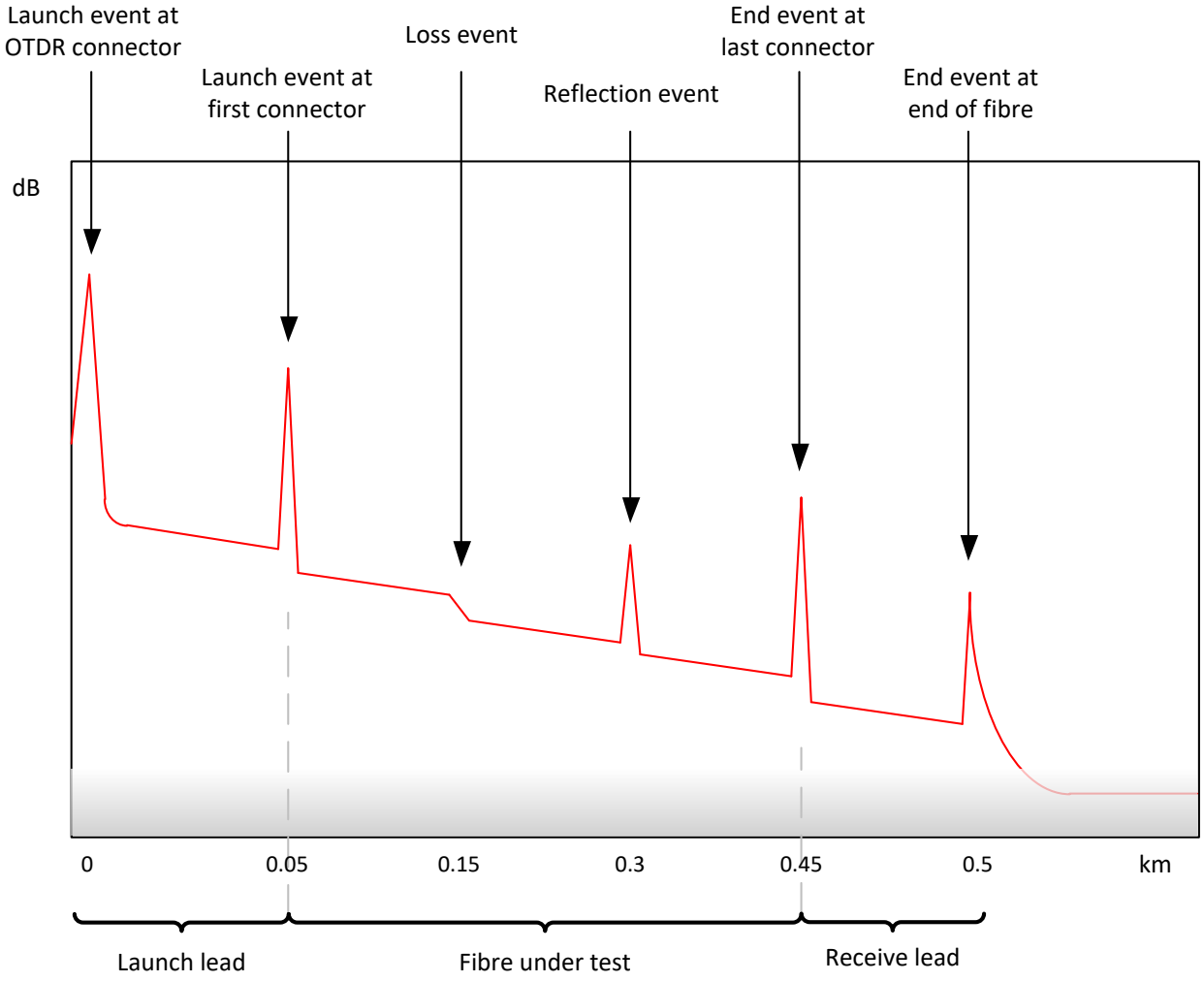
6.8.7 All fibre-optic cables supplied must comply with the relevant parts of SANS 60793/ IEC 60793 and SANS 60794/ IEC 60794 in terms of construction, installation and testing.

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

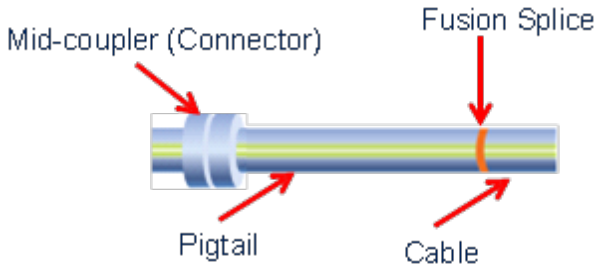



6.8.8.3 OLTS (optical loss test set) analysis with a power source and power meter must be done for all fibres after the installation has been completed. These tests must be done in both directions and the results have to be captured in MS Excel. A typical test report for one fibre is shown below. (P/Loss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

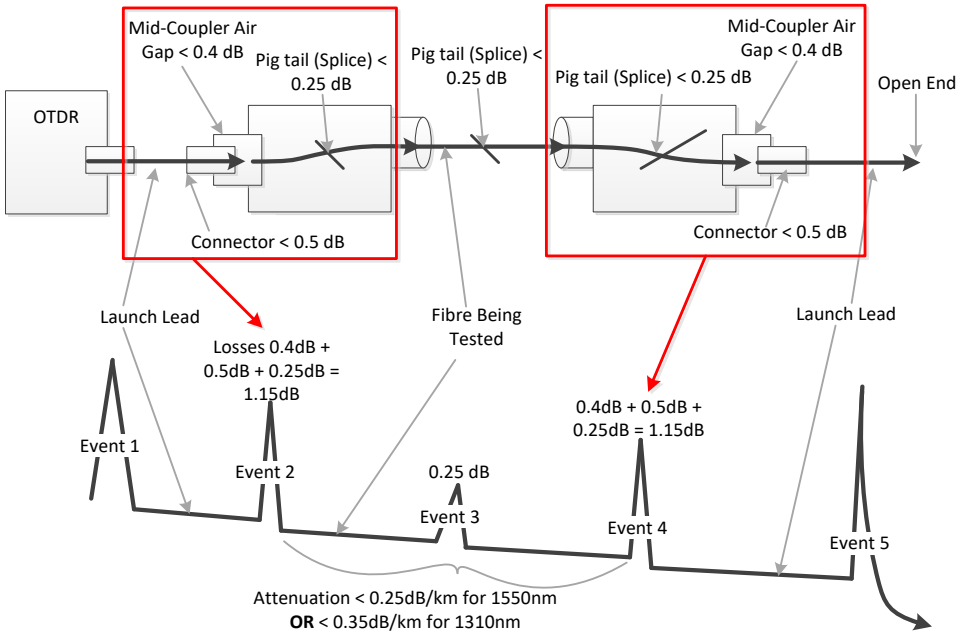
| Fibre ID | Wavelength | P/Loss | P/Loss | Average | ORL A | ORL B | Length |
|---|---|---|---|---|---|---|---|
| | | A->B | B->A | | | | |
| | (nm) | (dB) | (dB) | (dB) | (dB) | (dB) | (km) |

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.

# VOLUME 7 : NETWORKING

## INDEX

# 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 |

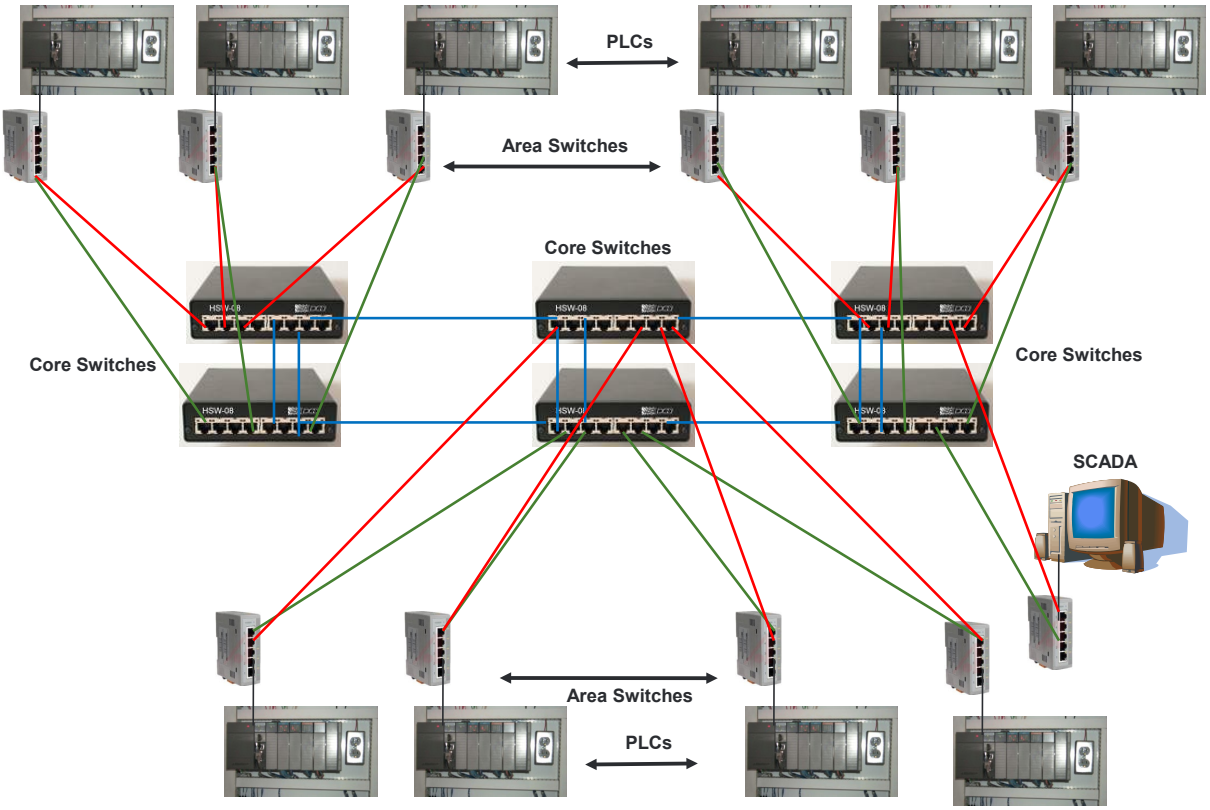
| | | |
|---|---|---|
| IEEE 802.1d | : | MAC Bridges |
| IEEE 802.1p | : | Quality of service |
| IEEE 802.1Q | : | VLAN Tagging |
| IEEE 802.1w | : | Rapid Spanning Tree Protocol |
| IEEE 802.1X | : | Port Based Network Access Control |
| IEC 60068-2-6 | : | Environmental Testing - Vibration |
| IEC 60068-2-27 Shock | : | Environmental Testing – Test Ea and guidance: |
| 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 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 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 7.10.1 All labelling must comply with the requirements as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

# VOLUME 8 : FLOW MEASUREMENT

## INDEX

# 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.

8.4.1 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.

8.4.12 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.

8.4.13 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.

## 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.

# VOLUME 9 : LEVEL MEASUREMENT

## INDEX

# 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

23.4.1 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).

# VOLUME 19 : FIELD JUNCTION BOXES AND PANELS

## INDEX

# 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.

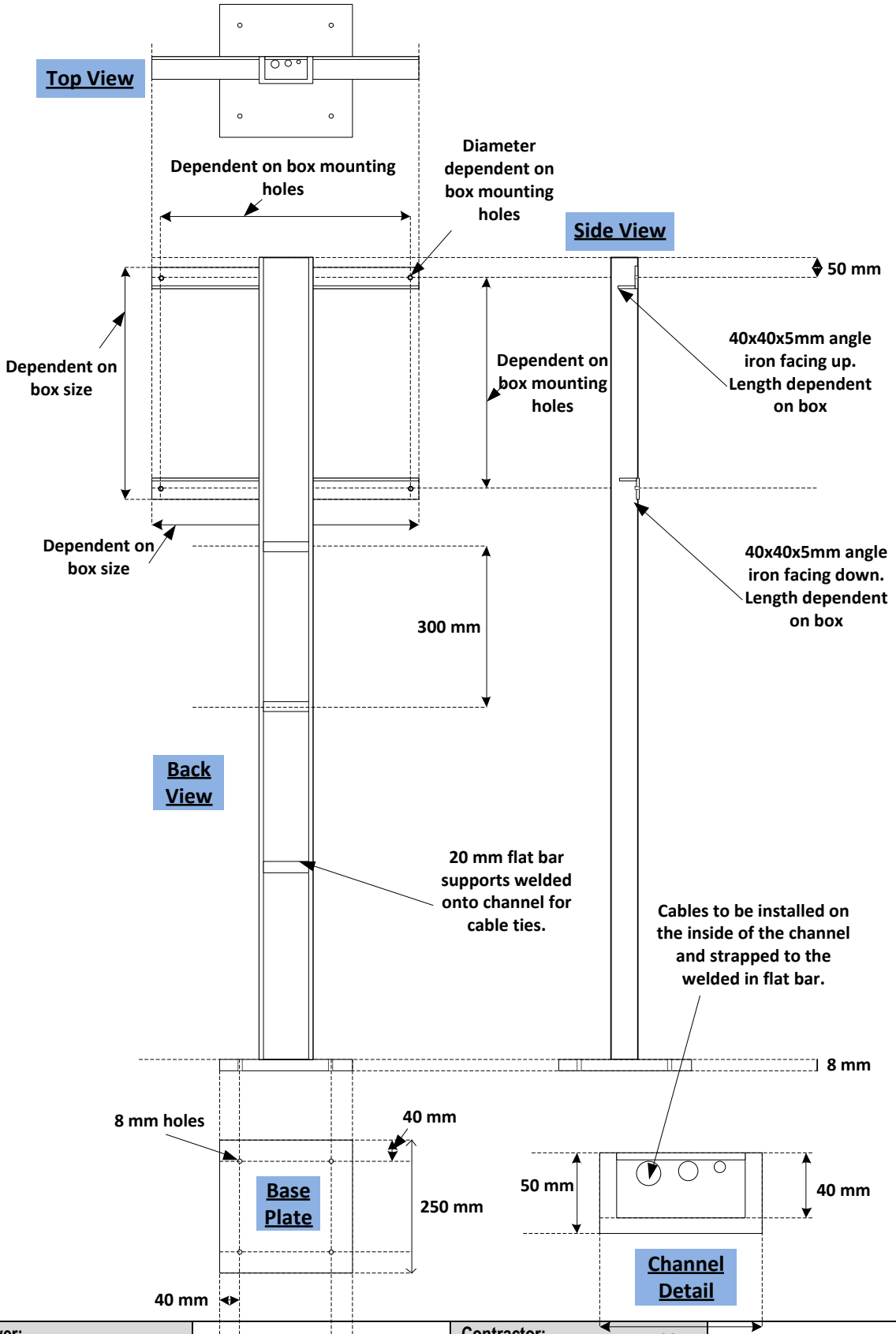
19.4.7 All IJBs should be clearly labelled with labels as specified in the Labelling Specification (Volume 25 of the Automation And Control Standards).

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.

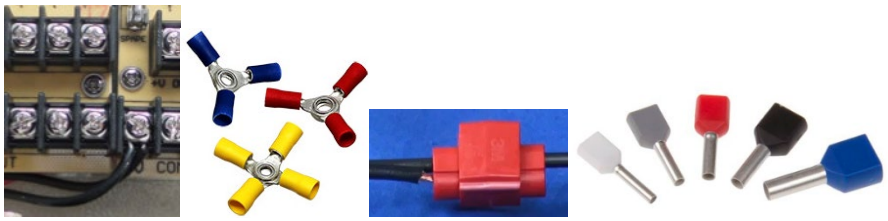
19.5.1.9 Where stopper plugs are used to seal holes that are not used, no plastic stopper plugs will be acceptable. All stopper plugs must be threaded, non-corrodible, metal plugs with rubber washers on both sides of the panel to ensure at least an IP65 seal (see examples below).

## 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:

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

b) Layout, numbering and labelling of equipment.

c) Wiring – sizes, numbering, colours, termination, etc.

d) 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. | |

# VOLUME 23 : PRESSURE MEASUREMENT

## INDEX

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# 23 PRESSURE MEASUREMENT

## 23.1 Scope

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

## 23.2 Abbreviations

23.2.1 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

## 23.3 Standards

23.3.1 The supply and installation of all Pressure 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.

## 23.4 General Requirements

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

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

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

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

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

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

23.4.2 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.

23.4.3 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).

23.4.4 FJBs 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.

23.4.5 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.).

23.4.6 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), or where it is not practically possible (for example where a transmitter is screwed directly into a socket in a pipe or vessel), can the transmitter be mounted outside the FJB.

23.4.7 FJBs 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.

23.4.8 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.

23.4.9 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.

23.4.10 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.

23.4.11 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.

23.4.12 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.

23.4.13 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.

## 23.5 Surge Protection

**PS 1.6**

23.5.1 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).

23.5.2 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).

23.5.3 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).

## 23.6 Pressure Measurement – Controller/Transmitter

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

23.6.2 The instrument must be equipped with a 4 – 20mA output which will be connected to a maximum 500 ohm load. If a pressure switch is required, the instrument must be equipped with two digital outputs of which the pressure operating value can be adjusted.

23.6.3 The transmitter must be equipped with an LCD or LED display to show the instantaneous pressure (for analogue or digital (pressure switch) instruments).

23.6.4 The transmitter must be mounted inside and IJB (Instrument Junction Box) which will be located in a suitable area for viewing, maintenance, etc. I.e. instruments with a transmitter local to the sensor will not be accepted.

23.6.5 The transmitter must have an error of not more than 0.2% of the full scale value for analogue instruments. This error must include non-linearity, hysteresis, repeatability plus zero-point and full scale deviations. If the error is defined by the maximum deviation of the transmitter output from a best fit straight line (B.F.S.L) in any one calibration cycle, this error must not be greater than 0.1% of the span (or full scale value). For digital instruments (pressure switch) the combined error (including non-linearity, hysteresis, zero point and full scale error) must not be greater than 1%.

23.6.6 The transmitter must be suitable for an ambient operating temperature range of -10ºC to +50ºC.

## 23.7 Pressure Measurement – Sensor/Transducer

23.7.1 All pressure measurements must be done by using a threaded instrument with a flush diaphragm sensor to ensure that there are no parts protruding into a pipe or vessel and which can lead to snagging of material in the medium being measured.

23.7.2 The range of the sensor must be suitable for the application (see items 23.4.8 and 23.4.9 of this specification).

23.7.3 The sensor must be suitable for an operating temperature range of -10ºC to +100ºC.

23.7.4 The sensor must be equipped with automatic temperature compensation.

23.7.5 The sensor must have an overpressure safety of not less than 1.33 times the measuring range.

23.7.6 The sensor diaphragm material must be ceramic.

## 23.8 Spares

23.8.1 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.

## 23.9 Data Sheets

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

# VOLUME 25 : LABELLING

## INDEX

# 25. LABELLING

## 25.1 Scope

25.1.1 The purpose of this document is to cover the requirements for the supply and installation of labels on all C&I equipment, cables, wires, and panels.

25.1.2 If there is a discrepancy between the requirements of this specification and the requirements in the tender Scope of Work, the Scope of Work will take precedence.

## 25.2 Abbreviations

25.2.1 In this specification the following abbreviations will apply :-

| | | |
|---|---|---|
| Contractor | : | The persons/s named as a contractor in the letter of tender accepted by the employer. |
| Employer | : | The person/entity named as Employer in the tender, and the legal successors in title to this person. |
| Engineer | : | The person appointed by the Employer to act as Engineer for the purposes of this contract. |
| BS | : | British Standards |
| ICP | : | Instrument Control Panel |
| IJB | : | Instrument Junction Box |
| PLC | : | Programmable Logic Controller |
| SPDT | : | Single Pole Double Throw (refers to relay or switch contact arrangements). |
| LCD | : | Liquid Crystal Display |
| LED | : | Light Emitting Diode |
| PTFE | : | Mixed Liquor Suspended Solids |
| O&M | : | Operating And Maintenance |
| UV | : | Ultraviolet |

## 25.3 Standards

25.3.1 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. |
| SANS 1186 | : | Information and Safety Signs. |
| SANS 1040 | : | National Building Regulations |

## 25.4 Performance and Installation Requirements

25.4.1 The attachment of labels must not at any time compromise the IP protection rating of any panel or enclosure.

25.4.2 Glue-on labels will only be permitted if industrial type glue or industrial type double-sided adhesive tape is used. Normal commercial or household glue or double-sided adhesive tape will not be accepted. This glue or tape must also not be used where environmental conditions such as wind, rain, UV, etc. can lead to the deterioration of the adhesive tape.

25.4.3 Any deviations from this specification need to be approved in writing by the engineer.

25.4.4 Where glue or adhesive tape is not used, signs and labels shall be affixed using corrosion resistant, mechanical fixings.

25.4.5 Not more than one item will be labelled with one label**, i.e. there will not be a continuous strip of labels for multiple items.** Each item shall have a separate, unique label assigned to it**.**

25.4.6 Allowed label materials are as follows:

25.4.6.1 Traffolyte or equal, or hard plastic sandwich board. (black lettering on white background) (not applicable to cables).

25.4.6.2 Reverse engraved acrylic material, with filled letters and reverse sprayed. (not applicable to cables).

25.4.6.3 Engraved or embossed stainless steel (for cable labels).

25.4.7 Labels that will be outside and frequently exposed to wind, rain and UV radiation must be either Traffolyte or equal, stainless steel, brass or aluminium, with engraved letters filled with black, or embossed lettering.

25.4.8 At the engineer's request the contractor shall provide proof that materials used for labels are corrosion proof or UV resistant. The cost of this needs to be allowed for in the tender.

25.4.9 The font used for all printed and engraved labels shall be Arial.

25.4.10 Specific requirements for labels listed in the tender specification supersede any general requirements listed in this specification.

25.4.11 Bolts with nuts shall not be used to attach labels to any mounting plate at any point. On mounting plates only bolts in tapped holes will be acceptable (if glue or double sided tape as mentioned in item 25.4.2 above is not used). Bolts with nuts will be allowed on enclosure doors however, where the bolts and nuts are easily accessible.

25.4.12 The use of pop rivets to attach labels will not be allowed.

25.4.13 The preferred method of attaching labels is to use corrosion resistant screws in tapped holes.

25.4.14 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.

25.4.15 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.

## 25.5 Safety

25.5.1 Where hazardous or dangerous equipment, conditions or materials are present, safety signs and labels shall be attached in such a way that it is clear what the hazard or danger is.

25.5.2 Any hazard, for which there is not a standard symbol defined in the standards mentioned in item 25.3.1 of this document, will be identified by simple wording and symbols approved or specified by the engineer.

25.5.3 Self-adhesive safety signs on vinyl will be permitted on enclosures if the safety signs are standard or approved by the engineer.

25.5.4 Where approved by the engineer, internally mounted, project specific safety labels and charts may be printed on plastic or laminated thin card, protected behind Perspex.

25.5.5 The contractor will supply safety signs for all hazardous components, including, but not limited to:

25.5.5.1 Busbar covers.

25.5.5.2 Fibre Optic patch panels and switches where laser light could be harmful to one's sight.

25.5.5.3 Power inside a panel that does not originate inside the panel itself i.e. it may not be powered do isolated.

25.5.6 The text size for Information/warning labels inside enclosures shall be 6mm high (16pt).

25.5.7 The text size for Information/warning labels outside enclosures shall be 10mm high (26pt).

## 25.6 Enclosures

25.6.1 Labels with the name of the enclosure shall be attached to the outside of the enclosure, on the front at eye height, or as close to eye height as is practical.

25.6.2 The label will be attached with corrosive resistant bolts or screws either into a tapped hole, or via a corrosion resistant washer and nut at the back. Nuts and bolts can only be used on enclosures where such nuts and bolts are readily accessible (e.g. on the enclosure door).

25.6.3 Every PLC panel, ICP, or IJB, shall have an engraved stainless steel label attached with the following information clearly visible inside the panel, ICP, or IJB:

25.6.3.1 Contractor name.

25.6.3.2 Contractor contact information.

25.6.3.3 Enclosure serial/identification number and manufacture date.

25.6.4 The text size for Enclosure name labels shall be 10mm high (26pt).

## 25.7 Cables

25.7.1 Identical labels shall be attached at both ends of each cable.

25.7.2 Labels for cables in a PLC panel/MCC panel/IJB/ICP shall be located at the entry to the panel, on the inside and outside of the panel, where the cable numbers inside and outside the panel are not visible from one location (e.g. cables at the PLC panel entry, where cable numbers are either visible inside the PLC panel or inside the cable trench).

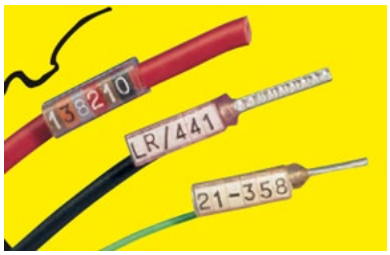
25.7.3 Labels for cables of instrument sensors and other field mounted components shall be located within 100mm of the termination point.

25.7.4 Labels for cables must be attached via either stainless steel straps or cable ties that are certified as UV stabilized.

25.7.5 The text size for cable identification labels shall be at least 6mm (16pt).

## 25.8 Wires

25.8.1 No separate wire numbers slid onto wires will be accepted. A wire number holder must be attached to the wire and the wire numbers must then be inserted into the wire holder (see the examples below).


These wire number holders must surround the wire completely. I.e. they must slide onto the wire. Clip-on holders will not be accepted.

25.8.2 Wires shall be labelled at both ends with the numbers indicated on construction drawings.

## 25.9 Components

25.9.1 Each component inside IJBs, ICPs, and PLC panels shall be clearly identified with a unique label as indicated on the construction drawings.

25.9.2 Labels will not be attached to trunking or any other item that can be removed for maintenance, including the component itself. Removal of trunking or replacement of components must not affect the component labelling.

25.9.3 Pushbuttons and other controls must be labelled with their function on a separate label (E.g. Stop, Start, Open, Close, etc.).

25.9.4 Labels for components are allowed to be inserted in a rail on the mounting plate, if this rail is specifically made for the relevant labels. The rail shall not obscure any part of any lettering.

25.9.5 Labels shall be located directly below, above or adjacent to the relevant equipment, as long as the label is clearly visible and it is clear and unambiguous as to which item of equipment the label refers to.

25.9.6 All terminal strips, and terminals must be labelled with labels that attach to the relevant terminal strip marker or terminal respectively.

25.9.7 The text size for component identification labels shall be 4mm high (10pt).