



# PHOKWANE LOCAL MUNICIPALITY

BID No: PLM/TUPG01/1611 - 2025

## HARTSWATER BULK WATER SUPPLY UPGRADE

TENDER DOCUMENT

VOLUME 2 -  
PROJECT SPECIFICATION

**NOVEMBER 2025**

**PHOKWANE LOCAL MUNICIPALITY**  
24 HERTZOG STREET  
HARTSWATER  
8570

**NAME OF BIDDER** : .....

.....

*FULL NAME, i.e. (CC, (PTY) LTD, LTD, JV, SOLE PROPRIETOR etc.)*

**CONTACT NUMBER** .: .....

**EMAIL** : .....



## *Phokwane Local Municipality*

### HARTSWATER BULK WATER SUPPLY UPGRADE

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## *Phokwane Local Municipality*

### HARTSWATER BULK WATER SUPPLY UPGRADE

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### HARTSWATER BULK WATER SUPPLY UPGRADE

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## Phokwane Local Municipality

### HARTSWATER BULK WATER SUPPLY UPGRADE

#### **SECTION C3.4: CONSTRUCTION**

##### **C3.4.1 STANDARD SPECIFICATIONS**

The Standard Specifications on which this contract is based are the South African Bureau of Standard's Standardized Specifications for Civil Engineering Construction (SABS 1200). (Note: "SABS has been changed to "SANS"; the SABS 1200 specifications are due to be replaced in the foreseeable future by SANS 2001 amongst other specifications).

Although not bound in nor issued with this Document, the relevant sections of the standard specifications shall form part of this Contract. These documents are available at the Contractor's expense from the SA Bureau of Standards, Private Bag X191, PRETORIA, 0001.

The applicable SANS 1200 Standardised Specification for this Contract shall be the following

- |    |   |                                     |
|----|---|-------------------------------------|
| A  | - | General                             |
| AB | - | Engineers office                    |
| C  | - | Site clearance                      |
| D  | - | Earthworks                          |
| DA | - | Earthworks (Small Works)            |
| DB | - | Earthworks (Pipe Trenches)          |
| DK | - | Gabions and pitching                |
| DM | - | Earthworks (Roads, Subgrade)        |
| G  | - | Concrete (Structural)               |
| GA | - | Concrete (small works)              |
| GB | - | Concrete (Ordinary buildings)       |
| HA | - | Structural steelwork (sundry items) |
| HB | - | Cladding and sheeting               |
| L  | - | Medium pressure pipelines           |
| LB | - | Bedding (pipes)                     |



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## Phokwane Local Municipality

### HARTSWATER BULK WATER SUPPLY UPGRADE

#### **SECTION C3.4: CONSTRUCTION**

##### **C3.4.2 PROJECT SPECIFICATIONS**

The following variations and additions to the Standard and Particular Specifications will be applicable to this contract.

In the event of any discrepancy between a part or parts of the Standardized or Particular Specifications and the Project Specification, the Project Specification shall take precedence. In the event of a discrepancy between the Specifications, (including the Project Specifications) and the drawings and / or the Schedule of Quantities, the discrepancy shall be resolved by the Employer's Agent before the execution of the work under the relevant item.



## **PSA GENERAL**

### **PSA1 SPECIFICATION DRAWINGS (Clause 2.7)**

Specification Drawings may be included in this document as annexures to the Project and Particular Specifications. Where such Specification Drawings depict items and standard structures according to layouts and details differing from those shown in the Standardised Specifications, the layouts and details shown in the annexures to the Project and Particular Specifications shall be adopted.

### **PSA2 QUALITY (Clause 3.1)**

All material used in the Works shall, where such mark has been awarded for a specific type of material, bear the SABS mark. Alternatively, the Contractor shall furnish the Employer's Agent with certificates of compliance of materials, which bear the official mark of the appropriate standard.

#### **PSA2.1 DEFINITIONS**

##### **PSA2.1 Definitions**

Add the following :

|                         |                                                                 |
|-------------------------|-----------------------------------------------------------------|
| Task                    | - a quantified activity or operation.                           |
| Daily task              | - a task that is required to be completed within a working day. |
| Task remuneration       | - remuneration as paid for a completed task or job.             |
| Daily rate              | - the remuneration of a day's work.                             |
| Daily wage              | - See daily rate.                                               |
| Daily task remuneration | - the remuneration for a completed daily task.                  |

the economically efficient employment of as great a portion of labour as is technically feasible to produce as high a standard of construction as demanded by the specifications and allowed by the funding available, thus the effective substitution of labour for equipment. (Note: This definition is not Contract specific, but applies to the project as a whole. This Contract is a part of such a project.)

Labour-intensive construction

### **PSA3 MATERIALS**

#### **PSA3.1 Supply of Materials**

The Contractor will be responsible to supply all the materials necessary for the proper execution of the works. He shall also be fully responsible for quality of materials used and/or installed.

### **PSA4 PLANT (Clause 4.3)**



Except where the use of plant is essential in order to meet the specified requirements by the Due Completion Date, the Contractor shall use only hand tools and equipment in the construction of those portion(s) of the Works that are required in terms of the Project Specifications to be constructed using labour intensive construction methods.

## **PSA5 CONSTRUCTION**

### **PSA5.1 Setting Out of the Works**

Where labour-intensive work is specified, the Contractor shall also be responsible for the setting out of daily tasks.

## **PSA6 TESTING (Clause 7)**

- (a) All test results obtained by the Contractor in the course of his process control of the Works shall be submitted to the Employer's Agent or his Representative prior to requesting inspection of the relevant portions of the Works. Any request for inspection shall be submitted on the prescribed forms that are appended as annexures to the Specifications.
- b) The Contractor shall make suitable arrangements for process control prior to commencement with the Works. Should he intend using site personnel for this purpose he shall ensure that suitably trained and competent personnel take charge of the necessary test work, and that the necessary equipment is at their disposal prior to commencement of the Works. Failure to comply with these requirements shall be just cause for the Employer's Agent to order suspension of the Works without additional remuneration, or for him to recommend termination to the Employer in terms of the General Conditions of Contract.
- c) The Contractor shall deliver to the Employer's Agent, for his consideration, quality assurance programmes (as obtained from all the Contractor's proposed suppliers of pipes, valves and specials) prior to the Contractor's appointment of any suppliers.

## **PSA7 SITE CORRESPONDENCE**

### **PSA7.1 Instructions by the Employer's Agent**

Site instructions by the Employer's Agent, addressed to the Contractor at his office on the Site, will be numbered consecutively and will be deemed to have been received by the Contractor's Representative unless a break in the sequence of numbers is brought to the notice of the Employer's Agent in writing immediately.

### **PSA7.2 Site Diary**



A site diary, which will be supplied by the Employer's Agent, must be filled in on a daily basis and submitted to the Employer's Agent on a monthly basis. No claims will be considered without the site diary's schedule properly completed (on a daily basis) and submitted. A site diary will be kept one per site.

**PSA8 SITE MEETINGS**

Refer to Section C3.5.1.10.

**PSA9 PAYMENT** (Clause 8.2)

Refer to Section C3.5.1.11.

**PSA10 REPORTS**

The submission of each monthly payment certificate shall be accompanied by a completed Progress Report.

This report is a pre-requisite for the approval of each monthly payment certificate and shall be completed in full to illustrate all work completed the preceding month, as well as work in progress at the time of submission of the report.

Labour intensive activities must be reported separately. All Local Labour reports required by the Employer / Funder must be completed and submitted on a monthly basis. Templates will be provided on commencement of the project.

**PSA11 SUMS STATED PROVISIONALLY** (Clause 8.5)

**PSA11.1 Contingencies**

No provisional sum has been included for contingencies. A Provisional Sum shall be included in the Summary of Schedules for contingencies. No percentage mark-up will be applicable to any payments made using contingency money other than those included in prices for variations determined in terms of Clause 6.4 of the Conditions of Contract.

**PSA11.2 Contract Price Adjustment**

No provisional sum has been included for Contract Price Adjustment (CPA). A Provisional Sum shall be included in the Summary of Schedules for CPA. No percentage mark-up will be applicable to any payments made using CPA money other than as determined by the CPA Formula applicable to the Contract.

**PSA11.3 Materials for Dayworks**

A Provisional Sum has been included in Schedule 2 for materials to be used during the execution of dayworks. In addition to the abovementioned amount, provision is made in Schedule 2 for a mark-up on the materials used during the execution of the dayworks by the



Contractor. Payment made shall be regarded as full compensation for overheads, charges and profit on the materials that are used when executing dayworks.

#### **PSA11.4 Royalties for Borrow Materials**

A Provisional Sum has been included in Schedule 2 for any royalties that may become payable by the Contractor in obtaining suitable borrow materials from sources designated by the Engineer. Payment will be based on the royalties actually and necessarily paid. In addition to the above amounts, provision is made in Schedule 2 for a mark-up on any payments made by the Contractor in this regard. The mark-up shall be regarded as full compensation for overheads, charges and profits as provided for in clause 6.6 of the Conditions of Contract.

#### **PSA11.5 Vegetation and Site Keeping**

A Provisional Sum has been included in Schedule 2 for cutting and removal of grass, weeds, and other vegetation within the site boundaries, access roads, and working areas, including cleaning and disposal of waste and debris to an approved spoil area, as and when instructed by the Engineer. Payment under this item shall be made for actual work carried out upon written instruction from the Engineer and supported by approved records or measurement.

#### **PSA11.6 Up-keeping of Plant Operations**

A Provisional Sum has been included in Schedule 2 for maintaining and supporting the continued operation of the existing water treatment plant during the construction period. Work to include cleaning of work areas, maintaining access and safety around operational units, assisting with temporary diversions or shutdowns, preventing disruption to ongoing treatment processes, and ensuring proper housekeeping within the plant as and when instructed by the Engineer. This Item shall also include the careful handling, protection, and temporary support of existing mechanical, electrical, and civil infrastructure within the water treatment plant during construction activities. Work to include safeguarding of pipelines, cables, valves, pumps, tanks, and structures against damage; covering or isolating sensitive equipment; reinstating disturbed areas; and performing related works as and when required. Payment under this item shall be made for actual work carried out upon written instruction from the Engineer and supported by approved records or measurement.

#### **PSA11.7 Operation Support During Tie-ins and Commissioning**

A Provisional Sum has been included in Schedule 2 for assistance and support to the Employer's operations staff during tie-ins, plant shutdowns, changeovers, and commissioning activities. Work to include coordination with operational personnel, provision of labour, tools, and equipment where required, maintaining temporary bypasses or connections, and ensuring continuity of water supply and treatment processes as and when such activities are scheduled or instructed by the Engineer. Payment under this item shall be made for actual work carried out upon written instruction from the Engineer and supported by approved records or measurement.



## **PSA12 PRIME COST ITEMS (Clause 8.6)**

### **PSA12.1 Acceptance Control Testing of Earthworks**

A Prime Cost Item has been included in Schedule 2 for acceptance control testing of earthworks ordered by the Employer's Agent to be undertaken by a commercial laboratory. Payment will be based on the actual invoicing by the laboratory to the Contractor. In addition to the above-mentioned amount, provision is made in Schedule 2 for a mark-up on any payments made by the Contractor in this regard. The mark-up shall be regarded as full compensation for overheads, charges and profits as provided for in Clause 6.6 of the Conditions of Contract.

### **PSA12.2 Labour Desk Officers**

A prime cost item has been included in Schedule 2 for the compensation of the Labour Desk Officer. Payments will be done to the Labour Desk Officer on instruction of the Employer's Agent, in writing. In addition to the abovementioned amount, provision is made in Schedule 2 for a mark-up on the payments made to Labour Desk Officers. This mark-up shall be regarded as a full compensation for overheads, charges and profits as provided for Clause 6.6 of the Conditions of Contract.

### **PSA12.3 Artisan and Skills Training**

A Prime Cost Item has been included in Schedule 2 for payments to be made to specialists for the training of unskilled or semi-skilled persons in industry accredited management and generic skills. Payment to the Contractor will be based on invoices certified by the Employer's Agent and issued by training specialists to the Contractor for work undertaken in terms of this item.

In addition to the above amounts, provision is made in Schedule 2 for a mark-up on any payments made by the Contractor in this regard. The mark-up shall be regarded as full compensation for overheads, charges and profits as provided for in Clause 6.6 of the Conditions of Contract.

### **PSA12.4 Office Consumables for Engineer's Site Facility**

A Prime Cost Item has been included in Schedule 2 for office consumables as well as rental and maintenance associated with the telephone(s) to be supplied to the Employer's Agent's Representative(s) for the duration of the Contract as specified in section PSAB below. Payment will be based on call and rental costs, but excluding any deposits and installation costs which shall be priced under the Preliminary and General item Engineer's site facility.



In addition to the above amount, provision is made in Schedule 2 for a mark-up on any payments made by the Contractor. This mark-up shall be regarded as full compensation for overheads, charges and profits as provided for in Clause 6.6 of the Conditions of Contract.

#### **PSA12.5 Electrical Connection Fees**

A Prime Cost Item has been included in Schedule 2 for payments to Eskom in respect of electrical connection fees for borehole and pump station equipment.

In addition to the above-mentioned amount, provision is made in Schedule 2 for a mark-up on the connection fees paid. This mark-up shall be regarded as full compensation for overheads, charges, administration and profits as provided for in Clause 6.6 of the Conditions of Contract.

#### **PSA12.6 Specialist Contractors**

A Prime Cost Item has been included in Schedule 2 for payments made to Specialist Contractors, which will be executed specialist work.

In addition to the above-mentioned amount provision is made in Schedule 2 for a mark-up on the Specialist Contractors paid. This mark-up shall be regarded as full compensation for overheads, charges, administration and profits as provided for in Clause 6.6 of the Conditions of Contract.

#### **PSA12.7 Specialized Services**

A Prime Cost Item has been included in Schedule 2 for the appointment and payment for specialized services if and when required. These may include all work required by the following specialists:

- Acceptance control testing of pipe manufacturing, coatings and linings.

In addition to the abovementioned amount, provision is made in Schedule 2 for a mark-up for paying such specialized services. This mark-up shall be regarded as full compensation for overheads, charges and profits provided for Clause 6.6 of the Conditions of Contract.

#### **PSA12.8 Relocation of Existing Services**

A Prime Cost Item has been included in Section 2 for the relocation of existing services by specialists if and when required and ordered by the Employer's Agent.

In addition to the abovementioned amount, provision is made in Schedule 2 for a mark-up for paying for the relocation of existing services. This mark-up shall be regarded as full



compensation for overheads, charges and profits provided for clause 6.6 of the conditions of Contract.

**PSA12.9 Accommodation for Employer's Agent's Representative**

A Prime Cost Item has been included in Schedule 2 for accommodation to be supplied to the Employer's Agent's Representative(s) for the duration of the Contract as specified in section PSAB below. Payment will be based rental costs and include any deposits and /or booking costs.

In addition to the above amount, provision is made in Schedule 2 for a mark-up on any payments made by the Contractor. This mark-up shall be regarded as full compensation for overheads, charges and profits as provided for in Clause 6.6 of the Conditions of Contract.

**PSA12.10 Management of approved emerging local sub-contractors**

A prime cost has been included in Schedule 2 for management of approved emerging local sub-contractors, which will be executed during works.

In addition to the above-mentioned amount provision is made in Schedule 2 for a mark-up on amounts paid to the approved emerging local sub-contractors. This mark-up shall be regarded as full compensation for overheads, charges, administration and profits as provided for in Clause 6.6 of the Conditions of Contract

**PSA13 ADJUSTMENT OF PRELIMINARY AND GENERAL ITEMS DUE TO RAIN**

Should the period for completion be automatically extended due to abnormal weather conditions occurring during execution of the Contract as provided for in the Project Specifications, no adjustment to the total for time-related preliminary and general items will be applicable.

**PSA14 ADJUSTMENT OF PRELIMINARY AND GENERAL TIME-RELATED ITEMS**

An approved extension of time will qualify the Contractor to receive additional payment for each relevant time related item at a unit rate based on the sum originally tendered for such item, and which shall be fair and reasonable as contemplated in Clause 6.4 of the General Conditions of Contract.

**PSA15 ADJUSTMENT OF PRELIMINARY AND GENERAL ITEMS DUE TO INTERRUPTION IN WORK SCHEDULE**

Should the period of completion be automatically extended in terms of clause PS5.6 as a result of interruption in the contractor's work schedule during execution of the contract, no adjustment to the total for time related preliminary and general items would be applicable.



Time related preliminary and general items will be paid only if the Contractor has been established on site during a specific period. Therefore, if the Contractor was not established on site, time related P & G-items will not be paid.

If he was on site for only a limited period during a specific month, time related P&G items are to be paid in full for such a month.

#### **PSA17 Contractor's Re-establishment**

Amend clause 8.3.4 of SANS 1200A as follows:

PSA17.1 Change the heading of clause 8.3.4 to:

"Remove Contractor's site establishment for an interim de-establishment (on instruction of the Engineer)."

The purpose of this clause is to remunerate the contractor for all interim de-establishment costs and shall provide for the making good and restoring of the site to the satisfaction of the Engineer.

..... **Unit : Sum**

PSA17.2 Include the following clause 8.3.6

"Additional establishment cost payable to the Contractor on re-establishment."

- This item must cover all costs incurred by the Contractor when re-establishing after a de-establishment on instruction of the Employer's Agent. Such re-establishment cost must not be confused with the initial establishment costs ..... **Unit: Sum**

#### **PSA18 HEALTH AND SAFETY**

The maintenance of safe work practice at all times and in all sections of the execution of the works is embedded in the day-to-day site activities of all the Contractor's management, staff and workforce on the contract.

However, the introduction of the Construction Regulations in 2014 requires from the Employer to ensure that the Contractor has made adequate provision for the execution of the works within the specifications of said regulations. The following items have been identified as critical towards ensuring the minimum standards of safe work practice:

It must be noted that the lists below are not exhaustive and that many items have been traditionally priced by the Contractor as an integral part of his Preliminary and General items or as part of the overhead costs of other items. The tender document, although not detailed with regards the Construction Regulations, requires that the Contractor ensures adherence to the Occupational Health and Safety Act (Act 85 of 1993) the Construction Regulations, 2003.



## PSA18.1 Fixed-charge Items

Add the following new Clause (Clause 8.3.5):

|                                                                                                                                                                 |                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| Compliance with the Occupational Health and Safety Act<br>(Act 85 of 1993) and its regulations and with the Employer's<br>Health and Safety Specification. .... | <u>Unit</u><br><br>Sum |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|

The fixed charge item shall include but shall not be limited to the following:

- Preparation of Health and Safety Plan,
- Establishment of Health and Safety File,
- Health and Safety Training
- Personal Protective Clothing and Equipment
- Erecting Fences, Signs and Barricades
- Establishment of Safety Administration
- Other Health and Safety Fixed-charge Obligations

## PSA18.2 Time-related Items

Add the following new Clause (Clause 8.4.6):

|                                                                                                                                                                  |                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|
| Compliance with the Occupational Health and Safety Act.<br>(Act 85 of 1993) and its regulations and with the Employer's<br>Health and Safety Specification. .... | <u>Unit</u><br><br>Month |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|

The time related item shall include but shall not be limited to the following:

- The employment cost of all health and safety personnel including consultants, health and safety officers, inspectors, supervisors and issuers required in terms of the Contractor's Health and Safety Plan,
- Updating the Health and Safety Plan as needed,
- Carrying out of periodic own audits and follow-up audits,
- Compiling ongoing risk assessments and risk assessment reports as required by the Works,
- Convening of regular safety meetings with the Safety Representatives,
- Accompanying and supporting the Employer or his Safety Agent during ad hoc audits,
- Compilation of monthly safety reports and statistics for the Employer or his Safety Agent,
- Implementation and maintenance of Training
- Maintenance of personal protective clothing and equipment
- Maintenance and/or removing and re-erecting of fences, signs and barricades
- Implementation and maintenance of safety administration



- Other Health and Safety Time-related Obligations

## **PSA19 ENVIRONMENTAL MANAGEMENT PLAN**

The Contractor shall compile and comply with approved Environmental Management Plan.

### **PSA19.1 Fixed-Charge Items**

Add the following Clause (Clause 8.3.6):

Unit

Compile approved Environmental Management Plan and Record of Decision ..... Sum

The sum tendered shall cover all costs, overheads, profits and charges incurred in compiling of the Environmental Management Plan and Record of Decision.

### **PSA19.2 Time-related Items**

Add the following Clause (Clause 8.4.7):

Unit

Compliance with Environmental Management Plan and Record of Decision.....Month

The sum tendered shall cover all costs, overheads, profits and charges incurred in complying with all the conditions of the approved Environmental Management Plan and Record of Decision bound.



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**PSAB EMPLOYER'S AGENT'S OFFICE**

**PSAB1 NAME BOARDS** (Clause 3.1)

Two name boards confirming to the standard requirements of the Regional Bulk Infrastructure Programme (RBIG) and as shown on drawing 2024-08/G/D/002 must be provided and erected at points to be designated by the Employer's Agent during the duration of the Contract for this purpose.

**PSAB2 OFFICE BUILDING** (Clause 3.2)

An office building as shown on drawing 2024-08/G/E/001 shall be provided and maintained for the duration of the Contract. The following variations and additions to the requirements of SANS 1200AB shall apply:

- a) The office shall have a floor area of at least 36 m<sup>2</sup>.  
The office to be divided into two equal sections with access between offices.
- b) The minimum glazed area shall be 6 m<sup>2</sup>.
- c) The minimum window opening shall be 4.0 m<sup>2</sup>.
- d) Fourteen (14) boardroom chairs with table/s to suite and 2 office chairs and one (1) desk of 1.5 m<sup>2</sup> are required in addition to those furnishings specified in SANS 1200AB.
- e) Rack for hanging contract drawings shall be provided.
- f) One 15 amp plug point is to be installed within each of the offices.
- g) A 0,75kW air conditioner with suitable power supply (reverse cycle/compressor type) is to be installed in each of the offices.

**PSAB3 TELEPHONE** (Clause 5.4)

A Cellular telephone(s) of an approved type shall be provided for the exclusive use of the Employer's Agent's Representative(s) for the duration of the Contract.

The Contractor shall make all arrangements necessary for the provision of the cell phone, and shall pay all necessary deposits and installation costs that may be applicable. A prime cost item has been allowed in Schedule 2 to cover all call and rental costs that are associated with the provision of this facility for the Employer's Agent's Representative(s).

**PSAB4 PERSONAL COMPUTER**

The Contractor shall provide and maintain in good working order two personal computers and printers on site for the exclusive use of the Employer's Agent's Representatives with the following specifications:

- (a) Computer:
  - Dell Vostro 5568
  - I7-7500U Processor
  - 15.6-inch FHD (1920 x 1080)
  - 8GB, 2400MHz, DDR4



- 1TB 5400rpm Hard Drive
- Windows 10 Pro (64bit) English
- NVIDIA(R) GeForce(R) 940MX 4GB GDDR5
- 3Yr Basic Warranty

(b) Printer

- HP Laserjet Pro 400
- M477fdn
- Colour Printer or Similar Approved

**PSAB5 SURVEY ASSISTANTS** (Clause 5.5)

Two suitably educated and trained survey assistant shall be made available for the sole use of the Employer's Agent's Representative(s) for the duration of the construction.

**PSAB6 SURVEY EQUIPMENT**

The survey equipment listed hereunder shall be made available for the exclusive use of the Employer's Agent for the duration of the Contract. Equipment shall be insured and maintained for the full duration of the Contract.

|                                                                                                             |         |
|-------------------------------------------------------------------------------------------------------------|---------|
| (a) Automatic surveyor's level complete with tripod and leather carry case such as Zeiss N1-2 or equivalent | 1 No    |
| (b) Nylon-coated steel surveyor's tape 100m long and 10mm wide                                              | 1 No.   |
| (c) 5m long steel tape                                                                                      | 1 No.   |
| (d) 5m long three-piece telescopic survey staves (metric double-face) complete with angle bracket level     | 1 No.   |
| (e) 2kg hammer with rubber handle                                                                           | 1 No.   |
| (f) Steel pegs, 300mm long and 12mm dia.                                                                    | 100 No. |
| (g) Measuring wheel                                                                                         | 1 No    |
| (h) 100m long 50 kg strength fish line                                                                      | 1 No.   |
| (i) One-metre-long spirit level                                                                             | 1 No.   |
| (j) DCP                                                                                                     | 1 No.   |
| (k) 100m Dip meter (water level meter)                                                                      | 1 No.   |

**PSAB7 CARPORTS**

The Contractor shall provide two carports of at least 30 m<sup>2</sup> each, which is so constructed as to provide shelter for the vehicles from the rain and the direct rays of the sun. The floor shall consist of crushed aggregate to alleviate dusty and muddy conditions.

**PSAB8 DIGITAL CAMERA**

The Contractor shall provide, insure and maintain for the full duration of the contract an approved digital camera complete with data zoom features.



## PSAB9 LABORATORY

No laboratory buildings or fittings are required by the Engineer. The Employer's Agent will arrange separately with a commercial laboratory or designate specialists to carry out all acceptance control testing including cube testing, but excepting for density control tests. See clause PSA12 for detail of the Prime Cost item provided for this purpose. The Contractor shall remain responsible for carrying out the process control testing that is required by the Standardised, Particular and Project Specifications.

The Contractor shall supply the following equipment and maintain same for the duration of the Contract:

- (a) Twelve concrete cube moulds, 150mm nominal size.
- (b) Cubes shall be taken on-site in the prescribed procedure. A minimum of one (1) test per 12m<sup>2</sup> concrete placed. Each test shall consist of 6 cubes, to be tested at 7 and 28 days respectively.
- (c) All necessary equipment required for adequate sampling **and curing** of concrete so to ensure contractor's process control.
- (d) Concrete slump cone (2 No).



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**PSC SITE CLEARANCE**

**PSC1 DISPOSAL OF MATERIAL** (Sub-Clauses 3.1 and 8.2.1)

Materials arising from clearing and grubbing shall be disposed of at a site to be arranged by the Contractor, in accordance with the provisions of Clause PSD4. Trees and stumps necessarily removed shall not be burnt unless authorised by the Employer's Agent, but shall be cut and stacked at areas designated by the Engineer.

**PSC2 AREAS TO BE CLEARED AND GRUBBED** (Clause 5.1)

The areas to be cleared and grubbed will be indicated by the Engineer. Should a portion or the whole of the site have been cleared and grubbed by nature or by others prior to the start of construction, then no clearing and grubbing will be ordered or payment made with respect to the applicable portion of the site.

**PSC3 PRESERVATION OF TREES AND SHRUBS** (Sub-Clause 5.2.3)

The penalty in respect of each individual tree and shrub designated as a tree or shrub to be preserved that is damaged or removed unnecessarily by the Contractor, shall be R5 000. Trees that fall within areas upon which the Works are to be constructed or within areas that the Contractor must occupy for the proper construction of the Works will not be designated for preservation.

**PSC4 OVERHAUL** (New Sub-Clause)

No overhaul will be payable on the disposal of material arising from clearing and grubbing.



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**PSDA EARTHWORKS (SMALL WORKS)**

**PSDA1 FREEHAUL AND OVERHAUL** (Clause 5.2.5.1)

The freehaul distance for all material to be imported or spoiled shall be considered as 5 km from the outer ring of the project area.

**PSDA2 BORROW PITS** (Clause 5.2.2.2)

The Contractor shall be responsible for making his own arrangement regarding the provision of pipe bedding material, if required, from commercial borrow pits. The Contractor shall provide in his tender prices for all royalties payable and for the transport of the material to site. Borrow materials obtained from designated borrow pits shall be approved by the Employer's Agent.

The Contractor shall be responsible for the opening up and closing down of designated borrow pits. The Contractor shall in all respect comply with the various requirements of SABS 1200D and of the Minerals Act (No 50 of 1991 in relation to the opening up, closing down and utilisation of borrow pits. Except for the crushing or screening of materials in accordance with the written instructions of the Employer's Agent, no additional payment will be made for excavating or processing material from designated borrow pits, regardless of the hardness or other properties of the material.

**PSDA3 DISPOSAL OF SURPLUS MATERIAL (Sub-Clause 5.1.4.3 and 5.2.2.3)**

Add the following to the sub-clause:

"All surplus or unsuitable materials arising from trench excavations shall be spoiled and neatly spread and levelled along the route of the pipeline so as not to interfere with future works nor to disrupt the natural overland flow of storm runoff. Rocks, trees, debris and other unsightly material from trench excavations shall be disposed of at a suitable spoil site. Where the pipeline is laid within a road reserve the route of the pipeline shall be finished neatly to be flush with the natural ground level or finished sidewalk level as may be applicable.

The Contractor shall be responsible to make his own arrangements for a suitable spoil site".

**PSDA4 HAUL AND SPOIL ROADS**

The contractor shall be responsible for the provision of all haul and spoil roads that he may require for the construction of the works and that the Employer's Agent may approve. No additional payment will be made in this regard.



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**PSDB EARTHWORKS (PIPE TRENCHES)**

**PSDB1 MATERIALS** (Clause 3)

**PSDB1.1 Methods of classifying** (Clause 3.1)

Replace the contents of this sub-clause with the following:

**PSDB1.1.1** Save and except in respect of those portions of the Works which are specified in Portion 1 of the Project Specifications to be executed utilising Labour-Intensive Construction Methods, the Contractor may use any method he chooses to excavate any class material, but his chosen method of excavation shall not determine the classification of the excavation. The Employer's Agent will determine the classification of the materials.

**PSDB1.1.2** The classification will be based on the specified construction methods, inspection of the material to be excavated and on the criteria given in PSDB1.2 below, as applicable.

**PSDB1.1.3** Where the utilisation of Labour-Intensive Construction Methods is specified in Portion 1 of the Project Specification for certain classes of excavation only, the material for those classes of material to be excavated using Labour Intensive Construction Methods will be classified in terms of PSDB1.2.2 and for those classes of excavation which are not required to be executed by Labour Intensive methods, classification will be based on the criteria given in PSDB1.2.1

(i.e. Where it is specified that the excavation of soft materials only shall be executed using Labour Intensive Construction Methods, the classification of the soft material to be so excavated will be based on the criteria given in PSDB1.2.2(a) and the Contractor will be required to excavate all such soft material by Labour Intensive methods. However, when the material is classified in terms of PSDB1.2.2(b) to be "intermediate" and is thus no longer required to be excavated by Labour Intensive methods, the classification of the material not required to be excavated using Labour Intensive methods will be based on the criteria given in PSDB1.2.1 (thus a material classified as "intermediate" in terms of PSDB1.2.2(b) may in terms of PSDB1.2.1 be deemed to be "soft" and will be measured and paid as such under such circumstances.).

**PSDB1.1.4** All tools and equipment referred to in PSDB1.2 shall be in good mechanical and operational condition.

**PSDB1.1.5** "Efficiently" as used in PSDB1.2.2(a) - (c) shall be taken to mean "in a manner that can be reasonably expected of a Contractor, having regard to the production achieved".

**PSDB1.1.6** The classification of material other than "soft excavation" shall be agreed upon before excavation may commence.

**PSDB1.1.7** The Contractor shall immediately inform the Employer's Agent if and when the nature of the material being excavated changes to such an extent that a new classification



is warranted for further excavation. Failure on the part of the Contractor to advise the Employer's Agent in good time shall entitle the Employer's Agent to reclassify, at his discretion, such excavated material.

**PSDB1.2      Classes of Excavation** (Sub-Clause 3.1)

Add the following new sub-clause:

**PSDB1.2.1      Classes of excavation where Labour Intensive Construction Methods are NOT specified**

The excavation of material will, in the case of work which is NOT required in terms of the Contract to be executed utilising Labour-Intensive Construction Methods, be classified according to SANS 1200D for the purpose of measurement and payment.

Add the following new sub-clause:

**PSDB1.2.2      Classes of excavation where Labour Intensive Construction Methods are specified**

Classes of excavation where Labour Intensive Construction Methods are specified.

The excavation of material will, in the case of work which is required in terms of the Contract to be executed utilising Labour Intensive Construction Methods, be classified in accordance with Table B.1 and Table B.2 in Annex B of SANS 1921-5:2004, i.e. based on the number of blows which causes a dynamic cone penetrometer (DCP) to drop by 100mm. Failing such classification, the excavation of material will be classified in accordance with Table B.3 of the same document (pro-rated to an 8 hour task). The said appendix makes provision for the following material classifications:

- a)    Soft excavation, Class 1,
- b)    Soft excavation, Class 2,
- c)    Soft excavation Class 3,
- d)    Intermediate excavation, and
- e)    Rock excavation.

For soft excavation classes 1, 2 or 3, the excavation of isolated boulders not exceeding 0,04 m<sup>3</sup>, will be considered to be included in their respective category. The excavation rates are those of an average able-bodied labourer or group of such labourers.

The following definitions will in addition to those provided in Table B.1 apply:

- a)    Intermediate excavation

Intermediate excavation shall be excavation in material which requires ripping or loosening by mechanical means prior to removal of the loosened material utilising the methods described for Soft material.



b) Hard rock excavation

Hard rock excavation shall be excavation of undecomposed boulders exceeding 0,04 m<sup>3</sup> and excavation in solid rock occurring in bulk or in banks or ledges, which requires loosening or breaking up by drilling, wedging, splitting or blasting or by other approved quarrying methods, prior to being excavated and removed from the excavation utilising only picks, crowbars, shovels and similar hand tools.

(NOTE : Such excavation generally includes materials such as formations of un-weathered rock that can be removed only after blasting.)

The Employer's Agent will instruct which portions of the Works, based on evidence provided from trial holes excavated at approximately 200 m spacing by the Contractor for this purpose, will be executed utilising Labour-Intensive Construction methods. The Trial hole shall be excavated to trench depth utilising a Cat 416 Backactor or similar."

## **PSDB2 PLANT**

### **PSDB2.1 Excavation Equipment (Sub-Clause 4.1)**

Replace the contents of this sub-clause with the following:

- a) To the extent that the provisions of the Specifications permit the use of mechanical plant and equipment in the excavation of trenches, the Contractor may use trenching plant that will excavate to a width such that the side allowance does not exceed the appropriate value specified in 5.2 by more than 50%, except that where in terms of the Project Specifications or of the Drawings, the base width of a trench for a pipeline or a portion of a pipeline is not to exceed the minimum base width or a stated value, the Contractor may use trenching plant which will produce the required trench width or he shall accept the responsibility for all costs incurred in strengthening the relevant pipeline.

### **PSDB2.2 Compaction Equipment (Sub-clause 4.2)**

Replace the contents of this sub-clause with the following:

#### **PSDB2.2.1 Machine Compaction**

- (a) Where the compaction is not required to be executed utilising Labour-Intensive Construction methods, or where the utilisation of mechanical compaction plant and equipment is allowable in terms of the contract, the contractor may use mechanical compaction equipment, but he shall select such equipment and operate it in such a manner that the pipeline, duct or cable is not stressed or damaged during the compaction operation.



- (b) Machine compaction shall not be used directly above the pipe until sufficient backfill has been placed to ensure that machine compaction loads transmitted to the top of the pipe are no greater than would be imposed by normal traffic loads over a pipeline with cover of 600mm.

#### **PSDB2.2.2 Labour Intensive Construction Methods**

- (a) Unless and to the extent as may be otherwise provided in Portion 1 of the Project Specifications, the contractor shall, in the compaction of materials by Labour Intensive Construction methods, utilise only hand held manually powered tampers, rollers and similar compacting hand tools and equipment.
- (b) Compaction shall be carried out in such a manner as to ensure that the pipeline cable or duct is not stressed or damaged. The material above the pipe shall not be compacted until sufficient backfill has been placed to ensure that the compaction loads transmitted to the top of the pipe are no greater than would be imposed by normal traffic loads over a pipeline with cover of 600mm.

#### **PSDB3 ACCOMMODATION OF TRAFFIC (Sub-Clause 5.1.3)**

Traffic must be accommodated along construction works which falls within or adjacent to any road reserve.

The Contractor shall tender a lump sum in applicable Schedule for accommodating traffic during the duration of the Contract, which sum shall cover all his obligations in this regard, including but not limited to temporary barricades; the erection and re-erection of existing and/or temporary traffic signs; lights and flagmen for the guarding and protection of the Works; and for making all necessary arrangements with the applicable traffic authorities. Payment shall be made monthly pro-rata to the overall progress of the Works.

If crossing of the road in half widths is allowed, the road shall remain continuously open to traffic. The Contractor shall make provision to ensure the safe passage of traffic using this public road whilst installing the pipe through the road, and to ensure that any disruption to the public is kept to a minimum providing safe detours when so instructed by the Engineer. Each half width shall be completed in one day. No open trenches will be allowed overnight. If the half width is not completed by 16:00 the trench shall be backfilled, in which case the Contractor shall re-excavate the trench at a later stage to complete the work at his own expense. All detours and signs shall be erected and maintained in accordance with the latest issue of Road Signs Note 13 as issued by CSRA and CUTA.

#### **PSDB4 EXISTING SERVICES (Sub-Clauses 5.1.4)**

Where any existing service occurs within the specified trench excavation, and the presence of such service is known before being uncovered, then the protection of the service will be scheduled and measured as provided for in Clause 8.3.5 of 1200DB. Only known services (as defined in Clause 5.4 of 1200A) shall be measured for payment.



Where an unknown existing service is damaged during construction, and the Employer's Agent orders that the Contractor should undertake the repair of such service, then such repair will either be measured and paid as dayworks or alternatively as a contractual variation in terms of Clause 6.4 of the General Conditions of Contract.

No construction activity which may affect the integrity of telephone or electrical poles or stays may be carried out without the prior written approval of the Employer's Agent, which approval shall only be given subject to the acceptance of a *modus operandi* that will ensure the integrity of such structures during construction.

**PSDB5 TRENCH WIDTHS** (Sub-Clauses 4.1 and 5.2)

Trenches in general shall not exceed the widths laid down in Sub-Clause 8.2.3. If trenches exceed the specified width the Contractor shall be liable for the cost of any thicker pipes or more expensive bedding which may be required as a result of the additional trench width.

**PSDB6 TRENCH BOTTOMS** (Sub-Clause 5.5)

*Replace the first paragraph of this sub-clause "Material that ..... compacted as directed" with the following :-*

Where a firm foundation cannot be obtained at the grade indicated due to soft or unsuitable material, the Employer's Agent may instruct the Contractor to remove such unsuitable material and to backfill the excess depth with approved selected material or concrete, as directed by the Employer's Agent in each particular case, at the cost of the Employer. Backfill other than concrete, shall be placed in layers of 100mm un-compacted thickness, each layer thoroughly compacted to the entire satisfaction of the Employer's Agent, to provide adequate support for the pipe bedding to be placed on top of it.

Should the Contractor remove more ground than is required to secure the proper grade of the pipeline, the Contractor must, at his own cost, backfill the excess excavation with approved selected material or concrete, as directed by the Employer's Agent in each particular case.

**PSDB7 DISPOSAL OF EXCAVATED MATERIAL** (Sub-Clauses 5.6.3 and 5.6.4)

All surplus or unsuitable materials arising from excavation shall be disposed of in accordance with Clause PSDA3.

**PSDB9 FREEHAUL AND OVERHAUL (Sub-Clause 5.6.8)**

The provisions of Clause PSDA1 shall apply.

**PSDB10 AREAS SUBJECTED TO TRAFFIC LOADS** (Clause 5.7.2)



The requirements of Clause 5.7.2 shall apply to all pipes crossing roads and streets whether the roads and streets are to be constructed under this Contract or to be constructed at some time in the future.

The measurement and payment will apply to the full trench width. Pipes and sleeves crossing streets or paved areas will be measured and paid for to a length equal to the width of road or length of pavement crossed plus 1,4 m either side of the travelled edges.

Compaction of pipe trenches running parallel less than 1,4m away from the edge of the roadway shall be considered areas subject to traffic loads or where instructed by the Employer's Agent.

#### **PSDB11 REINSTATEMENT OF EXISTING BITUMEN SURFACED ROADS** (Clause 3.6 and 5.9.4)

Pipe trenches through the existing bitumen surfaced roads shall be reinstated with a 150mm upper selected subgrade layer compacted to 93 % mod AASHTO density, followed by a 150mm sub base layer compacted to 95 % mod AASHTO density and a 150mm graded crushed stone base compacted to 98 % of mod AASHTO density. The road shall be provided with a 40mm thick asphalt seal.

The upper selected subgrade layer shall have a CBR of at least 15, a grading modulus of at least 0.75 and a maximum PI of 12. The sub base shall conform to SANS 1200 ME and the base to SANS 1200 MF.

#### **PSDB12 MEASUREMENT AND PAYMENT** (Clause 8.3.2)

##### **PSDB12.1 Basic Principles** (Clause 8.1)

Add the following to the sub-clause 8.1.2(a):

Payment for the excavation and backfilling of trenches shall be made at the tendered rates and at the following stages of the construction:

- |                                                                         |                  |
|-------------------------------------------------------------------------|------------------|
| i) upon completion and approval of the trench bottom, prior to bedding: | 40 %             |
| i) upon completion and approval of top of selected backfill:            | 70% (cumulative) |
| ii) upon completion and approval of the mainfill:                       | remaining 30 %.  |

##### **PSDB12.2 Excavation** (Sub-Clause 8.3.2)

Excavate, in all materials for trenches 0 – 1.0 m wide, backfill, compact and dispose of surplus material utilising Conventional Construction methods:

- |     |                      |                |
|-----|----------------------|----------------|
| (a) | up to 1.5 m in depth | m <sup>3</sup> |
|-----|----------------------|----------------|

Extra over the above for:



|     |                                                                                                                                                  |                |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| (1) | Intermediate material                                                                                                                            | m <sup>3</sup> |
| (2) | Hard rock excavation                                                                                                                             | m <sup>3</sup> |
| (3) | Backfill and compact by means of Labour Intensive Construction methods                                                                           | m <sup>3</sup> |
| (4) | Disposal of surplus material by means of Labour Intensive Construction methods within 20 m from the source of spoil material using wheel barrows | m <sup>3</sup> |

Backfill should be in 200 mm thick layers compacted to 90% Mod AASHTO.

### **PSDB12.3 Excavation of Trial Holes**

Excavation of trial holes as described in PSDB1.2.2 will be measured by number and shall include for backfilling after inspection.

### **PSDB12.4 Stone Bedding**

Stone bedding will be measured per cubic metre under the appropriate item in SANS 1200LB. Type A bedding (crushed stone wrapped in a geotextile blanket) shall be measured per linear metre along the centreline of the trench. The provision, operation and removal of (a) de-watering pump where authorised by the Employer's Agent will be measured as day works under the appropriate item in Schedule 3.



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**PSDM EARTHWORKS (Roads, subgrade)**

**PSDM1 OVERHAUL**

No overhaul will be payable on earthworks. Only long overhaul will be payable on gravel from designated borrow pits. The freehaul distance from designated borrow pits shall be 1 km.

**PSDM2 ACCOMMODATION OF TRAFFIC**

Refer to clause PSD4 in this regard.

**PSDM3 DISPOSAL OF SURPLUS MATERIAL**

All topsoil removed from the road reserve shall be spoiled in the existing borrow pit and neatly spread and levelled so as not to interfere with future works nor to disrupt the natural overland flow of stormwater. All other surplus material from the road excavation as well as rocks, trees debris and other unsightly material shall be removed to a suitable spoil area.

or

The Contractor shall make his own arrangements for a spoil area.

**PSDM4 BORROW PITS**

Refer to clause PSD5 in this regard.

**PSDM5 ROLLING BY SPECIFIED NUMBER OF PASSES (Subclause 5.2.3.3)**

**PSDM5.1 General**

Where shown on the drawings or ordered by the Engineer, the road-bed shall be subjected to a specified number of passes using a designated type of roller.

**PSDM5.1.1 Pneumatic-tyred roller**

A pneumatic-tyred roller shall consist of pneumatic-tyred wheels mounted on a rigid frame with a loading platform or body suitable for ballast loading to produce a load of at least 70kN on each wheel and arranged in a manner that allows all wheels to bear equally while operating on uneven surfaces.

The total load on any axle line shall not exceed 300kN. Tyres shall be uniformly inflated under operating conditions to a pressure within the range 500-800 kPa.

**PSDM5.1.2 Vibratory roller**



The vibratory roller shall be capable of exerting a combined static and dynamic force of not less than 120 kN/m width for every metre of loose-layer thickness at an operating frequency not exceeding 25 Hz and shall move at a speed not exceeding 4 km/h.

#### **PSDM5.1.3 Grid roller**

A grid roller shall have a mass of at least 13 t when ballasted, and shall be operated at this mass.

#### **PSDM5.1.4 Impact roller**

◇ Type 1

Impact roller type 1 shall be a single multifaced roller having a maximum of five flat or nearly flat faces and a mass of over 8 t. The roller shall be of the free fall type, and the roller and towing mechanism shall be so designed that all the energy applied in lifting the roller to the position in which it is supported on an edge between consecutive faces, is dissipated on impact when the roller drops again. The roller shall be towed by a tractor of engine power not less than 160kW and towed within 20 % of its optimum towing speed.

◇ Type 2

Impact roller type 2 shall be an impact compactor or roller delivering impact energy per blow of not less than 25 kilojoules, of the HEIC Series 600 type supplied by Compaction Technology (Pty) Limited or equal approved. The roller shall be towed by a tractor of engine power not less than 160kW and towed within 20 % of its optimum towing speed.

#### **PSDM5.2 Roller Compaction**

Any layer which is shown on the drawings or is specified or is prescribed by the Engineer to be rolled by a specified number of passes shall be prepared by shaping if necessary and then be compacted with a specified roller which complies with the requirements specified in subclause PSDM5.1.

A pass for a double drum roller is hereby defined as two passes of the roller over a suitable lane width such that one drum of the roller during its second passage travels in the interdrum space created by the first passage of the roller. Adjacent lanes shall not overlap or have a gap exceeding 250mm.

Except where otherwise authorised by the Engineer, compaction shall comprise not less than the required number of complete coverages by the wheels of the roller, specified or ordered, over every portion of the area being compacted. Although it is not the intention that water be applied to the roadbed by the Contractor under this class of compaction and no rigid control of the moisture content will be exercised during



compaction, the Contractor shall nevertheless satisfy the Engineer that every possible endeavour is being made to take advantage of favourable soil- moisture conditions and to carry out such compaction in so far as is possible during periods when the roadbed is neither excessively dry not excessively wet. The Engineer shall instruct the Contractor to water the roadbed at the Contractor's expense where, in the opinion of the Engineer, the Contractor has failed to comply with these requirements.

### **PSDM5.3 Payment**

Payments for roller compaction shall be measured as follows:

|     |                              |                           |
|-----|------------------------------|---------------------------|
| (a) | Heavy pneumatic-tyred roller | .....m <sup>2</sup> .pass |
| (b) | Vibratory roller             | .....m <sup>2</sup> .pass |
| (c) | Grid roller                  | .....m <sup>2</sup> .pass |
| (d) | Tamping roller               | .....m <sup>2</sup> .pass |
| (e) | Impact roller                | .....m <sup>2</sup> .pass |

### **PSDM7 TEMPORARY STOCKPILING OF MATERIALS (sub-clause 5.2.2.4 and 8.3.11)**

Add the following to the subclauses:

"All relevant rates shall include for temporary stockpiling where this operation is utilised by the Contractor to ease his own construction operations. It will be accepted that the Contractor has provided for the maintenance of all such temporary stockpiles in his tendered rates.

However, when measured in the Bill of Quantities, such temporary stockpiling will only be executed and paid for upon written instruction from the Engineer".

### **PSDM6 Graded Roads**

Add the following new payment clause:

"Graded roads ..... Unit: m<sup>2</sup>

Where ordered by the Engineer, roads which are not provided with bituminous or gravel surfacing shall be graded. The roads shall be graded to follow the slope of the natural ground so that stormwater is not concentrated.

The grading of roads will be measured per square meter.



If required, additional compaction in terms of clause PSDM 5 may be specified. The compaction will be measured separately".



**PSDK GABIONS AND PITCHING**

**PSDK1 GEOTEXTILE** (Sub clause 3.1.4)

Shall be Kaytech Geotechnical Fabric U24, or similar approved.

**PSDK2 PITCHING** (Sub clause 3.2.1.2)

Type of pitching shall be grouted Ordinary Stone Pitching, unless otherwise instructed by the Engineer.



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**PSG CONCRETE (Structural)**

**PSG1 SCOPE**

This specification covers the requirements for water retaining structural concrete for civil engineering work.

**PSG2 INTERPRETATIONS**

**PSG2.1 Definition**

For purpose of this Contract, all structures will be regarded as water retaining structures unless stated otherwise in the Project Specification.

**PSG2.2 Exposure Conditions**

For the purpose of this Specification, Water retaining structures shall be deemed to be classified under clause 2.4.1.3 (severe conditions) as specified in SABS 1200 G unless specified otherwise in the project specification.

**PSG3 CEMENTITIOUS MATERIALS**

**PSG3.1 Applicable standards**

All cementitious material used in concrete shall comply with the following standards, as relevant:

**Common cements**

SABS ENV 197-1:1992 *Cement B composition, specifications and conformity criteria B Part 1: Common cements*

**Cement extenders**

SABS 1491: Part I-1989 *Ground granulated blast furnace slag*

SABS 1491: Part II-1989 *Fly ash*

SABS 1491: Part III-1989 *Condensed silica fume*

**PSG3.2 Type**

Only CEM II B-V shall be used in water retaining structures.

Other types of cementitious material may be used only if specifically approved by the Engineer.

**PSG4 AGGREGATES (Sub-clause 3.4)**



The following additional requirements shall be applicable to water retaining structures:

#### **PSG4.1 Fine Aggregate**

Samples of the proposed fine aggregate shall be submitted to the Engineer for his approval before use.

The Contractor shall submit a sieve grading analysis to the Engineer for approval and if unacceptable, the Contractor shall offer another sample and grading for approval, or may blend aggregate from different sources and submit the blend for approval.

The water demand of the fine aggregate shall not exceed 195 l/m<sup>3</sup>.

Fine aggregate shall be stored on a concrete surface and washed sand shall be allowed to drain for at least 24 (twenty-four) hours before use. The Engineer may require the Contractor to test the sand daily (or more frequently if necessary) for moisture content, impurities and grading before use.

#### **PSG4.2 Coarse Aggregate**

The voids ratio of the coarse aggregate shall not exceed 47 % (forty-seven per cent). Single sized aggregates shall be stored on a concrete surface in separate stock piles, according to size. The proportions of the various single sized aggregates required for the various portions of the work shall be submitted by the Contractor for the Engineer's approval.

### **PSG5 CONSTRUCTION**

#### **PSG5.1 Reinforcement**

The following additional requirements shall be applicable to water retaining structures:

##### **PSG5.1.1 Fixing (Subclause 5.1.2)**

The use of plastic spacer blocks will not be allowed.

##### **PSG5.1.2 Cover (Subclause 5.1.3)**

In water retaining structures the exposure condition of a reinforcing bar closest to the face in direct contact with water or soil backfilling, shall be classified as severe.

It should be noted that in some water retaining structures only one face of the structural elements will be in contact with water.

Unless detailed to the contrary, the minimum cover on the waterside shall be as stated on the drawings and the cover on the other face as specified for mild exposure conditions.



The soffit of a slab suspended above the water (e.g. a reservoir roof) will be treated as being a contact with the water for the purpose of determining the cover.

#### **PSG5.2 Strength concrete (Subclause 5.5.1.7)**

It is a requirement that the Contractor employ the services of an approved specialist to obtain design mixes compatible with the specification.

No concrete shall be placed until the Contractor's concrete mix design has been approved by the Engineer. The Contractor shall submit to the Engineer a statement of the mix proportion proposed, together with a report from an approved testing laboratory, showing the 28 day concrete strength obtained when using the materials proposed for the work.

The strength determinations shall be based on not less than three concrete test specimens. Cubes shall be taken on-site in the prescribed procedure. A minimum of one (1) test per 12m<sup>2</sup> concrete placed. Each test shall consist of 6 cubes, to be tested at 7 and 28 days respectively.

When the Contractor can furnish reliable test records of concrete of a quality at least equal to that specified, having been made with materials from the same sources and of the same qualities as he proposes to use, the Engineer may waive all or part of the strength tests required in the above paragraph.

The preparation of the 150 mm test cube specimens and the sampling techniques shall be in accordance with the relevant SABS specification.

Concrete for water retaining structures shall be class 35MPa/19mm concrete and shall have a cement/water ratio not less than 2.2 and a cement content of 420 kg/m<sup>3</sup>.

Admixtures may be used to increase the workability of the concrete but only with the express approval of the Engineer and when the details of the active ingredients of the admixture and their effects are supplied to the Engineer for approval before use. No additives likely to impair low permeability of the concrete will be approved. Calcium chloride or admixtures containing chlorides may not be used in concrete for water retaining structures. Other admixtures and constituents may only be used with the approval of, or as specified by the Engineer.

#### **PSG5.3 Placing (Subclause 5.5.5)**

Panels between construction joints shall be cast alternatively.

#### **PSG5.4 Construction Joints (Subclause 5.5.7)**

The following additional requirements shall be applicable to water retaining structures:



The Engineer may allow the Contractor to cut an additional straight construction joint if it is possible without prejudicing the water tightness of the structure. The additional construction joint shall be sealed with the same seal that is specified for planned construction joints at the expense of the Contractor.

Construction joints in reinforced concrete walls, embankments, etc. shall consist only of horizontal joints. If under abnormal conditions a vertical construction joint is unavoidable it may only be constructed with the approval of the Engineer.

Construction joints shall only be placed at intervals shown on the drawings or as directed by the Engineer. The exact position of construction joints shall be marked on the formwork in order to obtain truly horizontal joints.

#### **PSG5.4.1 Preparation of Surface**

Prior to placing any further concrete the joint must be clean, damp and free of laitance. During the period when the concrete is still green, all loose material shall be removed, without disturbing the aggregates, by light brushing. Where this is not possible, or if the concrete has already set, the surface film shall be removed by mechanical means appropriate to the degree of hardness of concrete so as to expose the aggregate over the entire surface and leave a sound, irregular surface.

#### **PSG5.4.2 Before Placing Concrete**

Where the concrete of the previous lift is more than 3 days old, it shall be kept continuously wet before the mortar and fresh concrete is placed.

On all construction joints the following steps shall be taken after the surface has been prepared and at the most, 30 minutes before placing the concrete:

- (i) Remove all surface water with an air hose and dry sprinkle waterproofing additive (Vandex Premix or similar approved) at 9,8 kg per m<sup>2</sup>.
- (ii) Place a layer of approximately 10 mm thickness consisting of cement, sand and water mixed in the same proportions as used in the concrete.
- (iii) Place concrete within 30 minutes.

#### **PSG5.5 Curing and Protection (Subclause 5.5.8)**

SABS 1200 G Clause 5.5.8 will be deleted for the purpose of this Specification and replaced with the following:

“All concrete other than blinding concrete shall be maintained continuously saturated for at least ten days or as directed on the drawings immediately after placement or after stripping formwork in the case of walls, by methods which shall receive the prior written approval of the Engineer if different from the following:

- a) For floors



Ponded water with a minimum depth of 30 mm.

b) For Columns and Walls

Continuously saturated heavy jute sacking or other approved absorbent material maintained in contact with the concrete surface by fastenings spaced at not more than 2 m centres.

c) For Floors and Columns

Covering the previously saturated surfaces with approved plastic sheets maintained in contact with the concrete surface and with all edges and joints sealed by methods approved by the Engineer.

Where the ambient temperature is below 4 ° C the curing period of 10 days or as directed on the drawings, will be extended by 72 hours.

Newly cast concrete sections shall not be used for supporting loaded wheel-barrows, monorails, material or scaffolding, etc., until permission is obtained from the Engineer."

#### **PSG5.6 Adverse Weather Conditions**

##### **PSG5.6.1 Concreting in cold weather**

During cold weather no material having a temperature below 5 ° C shall be used for making concrete.

No concrete shall be placed when the ground or air temperature is below 2° C or if the ground or air temperature is likely to fall below 2° C within 6 (six) hours of placing the concrete.

The temperature of placed concrete shall not be allowed to fall below 5 ° C until the concrete has attained a strength of at least 5 Mpa, and the Contractor shall be responsible for all the necessary protective measures to ensure this. All concrete that has been damaged by frost or by the formation of ice in the concrete shall be removed and replaced by the Contractor at his own expense.

##### **PSG5.6.2 Concreting in hot weather**

During hot weather, the temperature of the concrete, as placed, shall not exceed 30°C. The Contractor shall ensure that the placing of the fresh concrete does not exceed the ambient temperature by more than 5°C. Where necessary this shall be accomplished by shading aggregate stockpiles, shading or insulating water pipes and water storage tanks.

#### **PSG6 CONCRETE SURFACES (Subclause 5.5.10)**



#### **PSG6.1 Wood-Floated Finish**

Where wood floating is specified or scheduled, the surface shall first be given a finish as specified in Sub-Clause 5.5.10.1 of SABS 1200 G after the concrete has hardened sufficiently, it shall be floated to a uniform surface free of trowel marks. The screeded surface shall be wood-floated, either by hand or machine, only sufficiently to produce a uniform surface free from screed marks.

#### **PSG6.2 Steel-Floated Finish**

Where steel is specified or scheduled, the surface shall be treated as specified in PSG6.1 except that, when the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, the screeded surface shall be steel trowelled under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

#### **PSG6.3 Power-Floated Finish**

Where power floating is specified or scheduled, the surface shall be treated as specified in PSG6.1 except that the screeded surface shall be power-floated to produce a high quality dense, smooth, uniform surface free from trowel marks.

### **PSG7 CONCRETE JOINTS (Subclause 5.5.11)**

#### **PSG7.1 Construction Joints (Subclause 5.5.7)**

Joints at which special measures are taken to achieve subsequent continuity are termed construction joints. Construction joints will be permitted only where shown on the drawings or approved by the Engineer and shall be formed true to line on all formed or exposed surfaces. Horizontal joints shall be formed by casting against a timber or metal former. Recesses shall be formed as detailed on the drawings. Where detailed on the drawings, galvanized metal strips or waterbars shall be cast into the joints. No unplanned construction joints will be allowed. If a breakdown occurs, the contractor shall strip the shuttering as soon as possible and break out all concrete up to the previous planned construction joint.

Except in the case where movement joints are required, the entire joint contact area of the concrete already placed shall be thoroughly roughened by chipping with sharp chipping picks before placing concrete against the surface. This surface will not be accepted unless the coarse aggregate projects 5 mm beyond the surrounding matrix. In this connection approved light pneumatic or electric tools are preferred provided that no structural damage is done to the concrete being chipped: otherwise hand tools are to be used. Chipping shall not be commenced until at least 48 (forty-eight) hours after the concrete was placed.



Alternative methods of preparing the surfaces of construction joints to those given above will be considered. The Contractor shall submit proposed alternative methods of achieving the roughened surface required to the Engineer for approval.

Should the Engineer at any time withhold or withdraw permission for alternative methods to be used then the Contractor shall prepare the surfaces of construction joints in accordance with the above specification.

Immediately before the adjoining concrete is placed, the chipped surface shall be thoroughly cleaned by brushing and washing and then thoroughly wetted.

At the discretion of the Engineer the percentage of coarse aggregate of the mix may be slightly reduced in a layer not exceeding 200 mm in depth immediately above the chipped surface of a horizontal construction joint. Suitable temporary openings shall be left in the shuttering to allow for the removal of sawdust, shavings, nails, debris, etc.

The application of compounds to the surfaces of stop ends at vertical joints to retard the setting of a film of concrete in contact with the stop end will be permitted subject to the Engineer's approval of the compound to be utilised and the Contractor's methods for the application of the same.

#### **PSG7.2 Movement Joints**

Movement joints shall be formed where shown on the drawings.

Movement joints shall be formed true to line and shall be thoroughly cleaned of all accretions of concrete or other foreign matter by scraping or other approved means. The surfaces in contact with joint sealing material shall be prepared strictly in accordance with the manufacturer's Specification.

Care shall be taken to ensure that the waterbars are in perfect contact with well compacted void-free concrete throughout, particularly on horizontal joints where special procedures shall be adopted for placing and compacting concrete under the waterbars, to the approval of the Engineer.

#### **PSG8 WATERPROOFING OF CONCRETE JOINTS**

Three different systems of waterproofing (or construction of systems) exist and the appropriate system (or combination) will be applied as specified on the drawings: The three systems are:

- a) Waterproofing with hypalon bandage system
- b) Waterproofing with waterbars
- c) Waterproofing with surface sealants

##### **PSG8.1 Hypalon system**



Hypalon bandage joint sealing system shall be the Sikadur-Combiflex Hypalon bandage system as supplied by Sika (Pty) Ltd.

The joint shall consist of 2 mm thick Combiflex Hypalon sheeting, 200 mm and 250 mm wide, as shown on the drawings. The Hypalon sheeting shall have a tensile strength of 6N/mm<sup>2</sup> and an elongation at failure of not less than 400%.

The Hypalon sheeting shall be bonded to the concrete with Sikadur 31 two component, solvent free, moisture intensive, high viscosity, epoxy paste adhesive.

## **PSG8.2 Waterbars**

Except where otherwise specified waterbars shall be manufactured from virgin polyvinyl chloride complying with BS 2571 : latest amendment (Class 3 compounds) and the Tenderer shall provide full details of the composition and properties of the material in the relevant annexure where applicable.

Samples of waterbars shall be submitted for approval and all material subsequently supplied shall be identical in size, shape, colour and quality to the approved sample. The waterbar shall be of uniform cross-section and size and shall have lugs welded at 1 m centres on both edges of the waterbar to hold it securely in position during concreting operations.

It shall be possible for all sizes of waterbar to be turned through a 75 mm radius without damage or permanent set to the waterbar.

Joints in waterbars shall be kept to a minimum by the use of the longest possible lengths.

Waterbars shall be held to the required shape, lines, etc, in suitable formwork: site joints shall be bonded as directed by the manufacturer in such a way as to form a continuous watertight seal free from pin holes at any point of the length or width of the strip.

Formwork shall be designed to accommodate the waterbars without subsequent bending and the waterbars shall be adequately supported and protected from damage and sunlight until finally encased in concrete.

Waterbars shall be tested in accordance with BS 2782 and ISO R527.

## **PSG8.3 Waterproofing with surface sealants**

### **a) General**

A groove of dimensions specified shall be formed, where indicated, and sealed by an approved sealant. The sealant shall be non-toxic and shall be either a hand applied bitumen putty sealant or a polysulphide sealant. The type of sealant to be specified on the drawings and the product to be used shall be approved by the Engineer.



b) Bitumen Putty Sealant

All joints shall be clean, dry and free of laitance. The concrete shall be at least four weeks old. The joint surfaces shall then be primed by an ancillary product and the sealant applied as per the supplier's specification. Special precautionary measures shall be taken to acquire a neat finish by covering the face edges of the joint with masking tape before priming. Any excess material will be cut away and finished flush.

c) Polysulphide Sealant

All joints shall be clean, dry and free of laitance. Prime joint face if required – following the suppliers specification. Apply the sealant and finish off flush with the concrete surface.

**PSG9 MISCELLANEOUS**

**PSG9.1 Porous concrete**

Porous concrete shall be laid under foundations and floor slabs and behind walls, etc, where shown on the drawings and where directed by the Engineer. Porous concrete shall be placed behind shuttering to form a vertical layer against the external face of foundations etc where shown on drawings and where directed by the Engineer. The thickness of the horizontal, sloping and vertical layers shall not be less than that shown on the drawings.

The exposed faces, both horizontal and vertical, of the porous concrete shall be finished with a cement mortar seal where reinforced concrete is to be cast against it. The porous concrete shall be sealed with a 5 mm thick layer of mortar composed of one part normal portland cement to two parts of fine aggregate by mass, trowelled on before the porous concrete has hardened, and finished with a screed to provide a smooth, uniform plane surface without filling any of the internal voids of the porous concrete. The surface of the seal shall have a steel or power float surface.

The schedule rates for porous concrete shall include the cost of mortar seal and steel float finish.

Porous concrete shall comprise water, cement, coarse aggregate and not more than 5 % (five percent) by mass of fine sand. The voids ratio of porous concrete shall not be less than 27.5 % (twenty-seven and one half) percent. Testing of porous concrete shall be carried out in accordance with test method 3 of BS 1881 Part 3 – 1970.

**PSG9.2 Bond breaker**

Where indicated on the drawings, site or porous concrete under floor slabs and wall footings etc. shall be covered with a bond breaker consisting of 100 micron tear resistant



damp proof membrane to SABS 952 (1969) C having 150 mm laps and pierced at 1 m intervals to allow the passage of water.

### **PSG9.3 Pipe work**

All pipe specials shall be cast in by the Contractor. Special care shall be taken to maintain them in the exact position shown on the drawings and also to render the joints watertight.

### **PSG9.4 Holding Down Bolts**

All holding down bolts and nuts, other than those used in structures retaining liquid shall be galvanised in accordance with SABS 763.

All holding down bolts and nuts in structures retaining liquid shall be stainless steel. Grade 316.

All holding down bolts and anchorages, shall be set in accordance with the drawings by means of accurate constructed steel templates and securely fixed in position to prevent displacement during the concreting.

Exposed threads of holdings down bolts shall be adequately protected with grease and sacking and this protection shall be maintained in all portions of the works until they are taken over.

### **PSG9.5 Ferrule Cap Holes**

Holes formed in reinforced concrete walls during the fixing of formwork shall be repaired on the waterside face with an approved epoxy or non-shrink grout. On the dry face the holes left in the concrete shall be repaired with a 1:3 cement-sand mortar. All grouting material shall be thoroughly panned in.

No system leaving holes passing through the walls will be permitted. Ferrules shall be of the permanent sacrificial type.

### **PSG9.6 Sterilization of Reservoirs**

Before a reservoir is sterilised, the roof shall have been tested for water tightness as set out in Clause 9.7 below, and the pipelines serving the reservoir shall have been sterilised. The reservoir shall then be thoroughly cleaned out and washed down with clean water.

The roof, beams, columns and walls shall thereafter be thoroughly sprayed down, using pressurised equipment, and the floors shall be scrubbed with water containing 0,015 g per litre of chloride of lime.

On completion of the sterilisation, the sterilising solution shall be run to waste before the reservoir is filled for testing its water tightness.



Should additional work be required to be done inside the reservoir after the water tightness test has been completed, the reservoir shall be re-sterilised at the Contractor's expense.

#### **PSG9.7 Testing for Water tightness**

Water for the initial filling will be supplied free of charge by the Employer.

The structure shall be filled with water at a uniform rate not exceeding 2.0 m in 24 hours until the top water level has been reached. The water level will then be carefully noted and recorded by the Engineer in relation to a fixed bench-mark, and the structure shall be allowed to remain filled for a period of two weeks to permit complete absorption of water by the concrete.

Any loss of water which may have occurred shall then be made up by again filling the structure to the top water level and by allowing the water to remain undisturbed for a period of not less than four days. The structure shall be considered to be watertight if the drop in level in 96 hours (less the drop caused by evaporation) does not represent more than 0,06 % of the volume of the reservoir.

The evaporation shall be measured by the mean drop in level caused by the evaporation of the water in three flat containers floating in the water, being recorded.

The Contractor is free to attend the taking of all measurements by the Engineer.

In the event of an appreciable leakage being evident or visible at any stage of the filling or testing, or in the event of the final degree of water tightness being unsatisfactory, the Contractor shall, when so ordered by the Engineer, discontinue such filling or testing and shall, at his own expense, take approved steps to rectify the leakage, until a test proves that a sufficient degree of water tightness has been obtained.

The water tightness of the reservoir roof shall be tested before that of the reservoir itself by water being continuously sprinkled over the roof in an approved manner so that a film of water is maintained on the surface of the slab. The roof shall be considered watertight if no damp patches are visible on the underside after 48 hours of sprinkling.

Before the expiry of the defects liability period, the Engineer shall have the right to retest the structure for water tightness. Results of such further tests will be made available for the information of the Contractor. In the event of these tests indicating an unsatisfactory degree of water-tightness, the Engineer will, before issuing the final certificate, again require the Contractor to rectify the leakage, at his own expense, in such a manner as will cause the least interruption of the water supply to consumers and as will ensure the soundness of the work, to the satisfaction of the Engineer.

Should the failure of the reservoir to pass the first or any subsequent test for water tightness necessitate the drainage of the structure, the Employer reserves the right to utilise the water by discharging it into its water-reticulation network, in which case the Contractor –



- a) shall not have to pay for the subsequent refilling of the reservoir;
- b) shall, if applicable, reimburse the Employer for any additional costs incurred to make the water fit for consumption; and
- c) shall not be entitled to claim for extra time whilst waiting for the water to be discharged into the network.

The costs of re-testing the reservoir for water tightness shall be borne by the Contractor.



## **PSGA CONCRETE (SMALL WORKS)**

### **PSGA1 CEMENT** (Sub-Clause 3.2.1)

Only the use of Ordinary Portland Cement to SANS 471 will be permitted.

### **PSGA2 CONCRETE FINISHES** (Sub-Clause 4.4.2)

Concrete against which earth will be backfilled shall be classified as rough. All exposed concrete surfaces shall be classified as smooth. Degree of accuracy II shall prevail.

### **PSGA3 STRENGTH CONCRETE** (Sub-Clause 5.4.1.5)

The grade of concrete and nominal size of aggregate shall be as specified on the Drawings. The successful tenderer will be required to submit samples of the coarse and fine aggregate, which he proposes using, to the Employer's Agent's Representative(s) for tests regarding the suitability of such aggregates. The Contractor shall prepare trial mixes. These mixes shall be designed for vibration. All data and reports prepared by the Contractor shall be submitted to the Employer's Agent for information and approval prior to the commencement of concreting operations.

### **PSGA4 ANCHOR AND THRUST BLOCKS**

At tees, bends, terminal valves, end caps, and where otherwise directed, anchor/thrust blocks shall be constructed to dimensions ordered, shown on the Drawings or agreed to by the Engineer. Unless otherwise specified, anchor/thrust blocks and pedestals shall be constructed of prescribed mix 15/37.5 concrete.

The concrete shall be well punned round the pipe and, if in trenches, against the undisturbed faces and bottom of the trench. Backfilling behind or under thrust faces will not be permitted. Excess excavation shall be replaced with the prescribed mix concrete given above for anchor/thrust blocks at the Contractor's expense, unless an item is scheduled to cover payment of over break. Care shall be taken to leave the joints accessible. No anchor/thrust blocks and pedestals shall be concreted until the approval of the Employer's Agent has been obtained.

Anchor and thrust blocks will be measured by volume of concrete; the rate tendered shall include for any form work required constructing the block.

Should the Contractor offer an alternative method of coupling involving flexible joints, he shall design suitable thrust and anchor blocks in order to prevent movement of the pipeline under operating and test conditions. The working and test pressure to be used by the Contractor for the calculation of anchor and thrust blocks shall be in accordance with the design information that is issued together with the tender. The earth bearing pressure to be used for the



calculation of anchor and thrust blocks shall be based on field tests. The factor of safety to be used in calculating the above shall be 2.5.

## **PSGA5 GROUTING TO MACHINE AND STRUCTURAL BED PLATES** (Sub-clause 5.5.13)

### **PSGA5.1 Materials**

- a) Water. Water for grout shall comply with the requirements given in sub-clause 3.3 of SANS 1200G.
- b) Aggregates. Notwithstanding the requirements of Sub-clause 3.4.1 of SANS 1200G, the grading of fine aggregate (sand) and coarse aggregate (stone or pea gravel) shall conform to the gradings given in Tables 1 and 2, respectively, below.
- c) Cement. Cement shall be ordinary Portland cement complying with SANS 471.
- d) Admixtures. Admixtures shall comply with the requirements of Sub-clause 3.5 of SANS 1200 G, and shall have a proven record of satisfactory performance under conditions encountered in the North West Province.
- e) Proprietary Grouting Materials. Unless otherwise approved by the Employer's Agent, Proprietary Grouting Materials shall be obtained ready mixed in sealed pockets as supplied by the manufacturers.

| Table 1 - Sand                                |                        | Table 2 - Stone or Pea Gravel      |                        |
|-----------------------------------------------|------------------------|------------------------------------|------------------------|
| 1                                             | 2                      | 1                                  | 2                      |
| Test sieve<br>Nominal<br>aperture<br>size, mm | % Passing<br>(by mass) | Test sieve<br>aperture<br>size, mm | % Passing<br>(by mass) |
| 9.5                                           | 100                    | 9.5                                | 100                    |
| 4.75                                          | 95-100                 | 4.74                               | 95-100                 |
| 1.18                                          | 45-65                  | 2.36                               | 0-5                    |
| 0.3(300)                                      | 5-15                   |                                    |                        |
| 0.15(150)                                     | 0-05                   |                                    |                        |

\* Portland cement (ordinary, rapid-hardening, and sulphate-resisting).



## **PSGA5.2 Preparation and Procedures**

- a) Before a machine or structural bed plate is placed on the concrete the following shall be carried out:
  - 1) All defective concrete, laitance, dirt, oil, grease and loose material shall be removed from the concrete foundation by bush-hammering, chipping, or other means until sound clean concrete is obtained. The surface of the foundation shall be scabbled, but shall not be so rough as to interfere with proper placing of the grout. All foundation bolt sleeves shall be cut out, or cut off flush if the sleeves cannot be removed. The top of the foundation shall be reshaped if necessary.
  - 2) The underside of each steel base, particularly in the bearing areas, shall be cleaned and any burrs and ragged edges removed before the base is placed in its final location.
  - 3) All holding-down bolt sleeves shall be thoroughly cleaned of any materials that may prevent the grout from flowing freely to the bottom of the bolt sockets.
- b) The base shall be properly aligned and levelled and shall be maintained in that position during grouting.
- c) After the machine or structural bed plate has been placed the following precautions shall be observed:
  - 1) Shimming shall be kept to a minimum. Steel plates shall be used for packing and shall be ground to the required thickness, where necessary.
  - 2) Before grouting is started all loose dirt, oil, grease and other foreign matter on the surface of the foundation, the underside of bed plates, and in the bolt holes shall be removed by means of compressed air or other approved means. The surface of the foundation slab shall be thoroughly saturated with clean water and free water shall be removed from the surface and the bolt holes just before the grout is placed.
  - 3) The grouting shall not be carried out until the alignment of all units to be grouted has been checked and approved by the Engineer.
  - 4) Special care shall be taken with grouting in hot or cold weather to ensure proper setting and gain of strength and, in the case of Proprietary Grouting Materials, by having ice or hot water available, as the case may be, in accordance with the instructions of the manufacturer. Enclosures shall be provided for the grout such that, until it has set, its temperature will be in the



range 15-27°C. Shields to protect the grout from the sun and from hot winds shall be provided by the Contractor when so ordered.

### **PSGA5.3 Form work**

Form work for grouting shall comply with the applicable requirements of Sub-clause 5.2 of SANS 1200 G. Forms shall be caulked where necessary. Adequate clearance between forms and bed plates shall be provided to enable the grout to be worked into place.

### **PSGA4.4 Mixing** (All free-flowing grouts except epoxy grouts)

The grout shall be mixed to a homogenous uniform mixture and delivered ready for placing at a temperature between 15°C and 25°C.

The materials and water shall be mixed in a mortar mixer for at least 3 min. or, in the case of small jobs only, shall be thoroughly mixed by hand, the entire mass being turned over enough times to ensure even distribution of its components.

The mixing shall be done as close as possible to the place(s) where the grout is placed. No more grout shall be mixed at any one time than can be placed in a period of 20 min. After the grout has been mixed it shall not be retempered by the addition of water.

### **PSGA4.5 Grouting** (All free-flowing grouts except epoxy grouts)

The grout shall be placed quickly and continuously to avoid the undesirable effects of over-working. (These effects are segregation, bleeding and breaking-down of initial set). The method of placement shall be subject to approval. The means of placing the grout shall be such that the grout will completely fill the space to be grouted, will be thoroughly compacted, will be free of air pockets and will have evenly distributed contact over an area in excess of 80 % or, in the case of expanding grout, 95 % of the bearing area of the item to be supported.

Wherever applicable, grout shall be placed from one side only and where this is not practicable, care shall be taken to ensure that any entrapped air is released. After the grout has taken its initial set:

- a) the forms shall be removed;
- b) excess grout shall be so cut away as to leave a smooth and neatly finished job;
- c) except where the grout is intended to provide resistance to side thrust, all edges shall be trimmed at 45° to the vertical, from the bottom edge of the bed plate; and



- d) all excess grout on or about the bed plate shall be removed.

Damage to paint work, if any shall be repaired within 24 hours. Packing plates, shims and other levelling devices shall remain in position.

#### **PSGA4.6 Dry-packed grout** (Standard dry sand and cement grout)

Dry-packed grout shall have a minimum compressive strength at 28d of 20MPa. The quantity of water after placing shall be kept to a minimum consistent with placing conditions, and the cement, sand and, where applicable, pea gravel proportioned by mass shall be as follows:

- a) Where the clearance between bed plate and foundation is 25 mm or less : 1 part of Portland cement, and 2 parts of sand;
- b) Where the clearance exceeds 25 mm : 1 part of Portland cement, 1 part of sand and 1 part of pea gravel. Dry-packed grout shall be rammed by means of tamping rods against form work placed along three sides of the bed plate.

#### **PSGA4.7 Non-shrink grout with metallic aggregate**

The manufacturer instructions shall be observed when non-shrink grout with metallic aggregate is used.

Where the clearance between the bed plate and the foundation is less than 50 mm a sand-based mix shall be used. Where the clearance exceeds 50 mm the Employer's Agent may order a mix with a base of sand plus pea gravel to be used.

#### **PSGA4.8 Expanding grout with powdered aluminium additive**

The manufacturer instruction shall be observed when the expanding grout powdered aluminium additive is used.

Where the clearance between the bed plate and the foundation is less than 25 mm, a sand-based mix shall be used. Where the clearance exceeds 25 mm the Employer's Agent may order mix with a base of sand plus pea gravel to be used.

Each batch shall be mixed for at least 6 minutes after the powdered aluminium has been added. Where a ready-mixed grout is used, the powdered aluminium shall be added at the placing site and the batch mixed as specified. Grout shall be placed within 45 minutes after the addition of the powdered aluminium.

The Contractor shall not use powdered aluminium additive when the ambient temperature is below 5°C.

#### **PSGA4.9 Epoxy grout** (epoxy mortar type only)

The manufacturer's instructions shall be observed when an epoxy grout is used.



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## **PSHA STRUCTURAL STEEL (SMALL WORKS)**

### **PSHA1 GRADE OF STEEL** (Sub-Clause 3.1.1)

Structural cold-formed steelwork to be to Grade 43A or 43B with the minimum properties as tabled in Table B-2 of SANS 0162-1982.

Structural hot-rolled steelwork to be to Grade 300W with the minimum properties as tabled in "Steel design date: No. 6" of the South African Rolled Steel Producers Co-ordinating Council and the South African Institute of Steel Construction.

### **PSHA2 SHOP DRAWINGS** (Sub-Clause 5.1.2)

The contractor is to provide shop details.

Steelwork generally of welded construction with site connections bolted:

All holes 18 dia. for M16 bolts

All gussets ex 8 mm U.O.S.

All welds, 6 mm fillet

The Employer's Agent must be notified, (at least 72 hours before hand) of the completion of the fabricated steelwork at the contractor's workshops, to enable him to make an inspection if he so desires. The fabricated steelwork, thus to be inspected shall be in its prepared specified state immediately before the application of prime coat painting.

### **PSHA3 WELDING** (Sub-Clause 5.3.4)

Delete this clause in its entirety and add the following clause:

Welding shall be done in accordance with the relevant requirements of SANS 0162 BS5135 and AWS.D.1/18 (American Welding Society).

Welding shall be Grade B welding.

The qualification of welders shall be in accordance with the relevant clauses of the above standards, and specifically SANS 044 Part III and shall be Grade I welders. Grade 2 welders shall be permitted only with the Employer's Agent's approval.

The Contractor shall provide evidence, acceptable to the Employer's Agent, that welding procedures and welders have been tested in accordance with the requirements of AWS D1.1.



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## **PSHA4 PROTECTIVE TREATMENT** (Sub-Clause 5.3.9)

### **PSHA4.1 Shop Painting**

- a) Steelwork after fabrication shall be wire brushed to a finish equal to or better than Grade St3 or SIS 05 59 00.
- b) Within 4 h after the completion of wire brushing, 2 coats of an approved primer such as a Type II. Grade 2 red lead, on a zinc chromate or red oxide (see Sub clause 3.7 of SABS 1200 H) shall be applied to provide a dry film of thickness between 25 and 30 micron. Except that red lead shall not be sprayed, a primer may be applied by means of brush, roller, or spray.

### **PSHA4.2 Painting after erection**

- a) After the erection of steelwork, all areas where the primer coat has been damaged shall be touched up as specified in PSH2.1.
- b) An intermediate coat of an approved general-purpose alkyd undercoat shall then be applied to provide a dry film of thickness between 25 and 30 micron. The paint may be applied by means of brush, roller, or airless or conventional spray.
- c) Provided that the undercoat is touch-dry within 2 hours, the finishing coat may be applied the following day. One coat of an approved alkyd enamel, the non-volatile vehicle of which contains at least 24 % authalic anhydride, shall be applied to provide a dry film of thickness between 25 and 30 micron.
- d) The total dry film thickness of the paint and primer coats shall be between 70 and 100 micron.

### **PSHA4.3 Galvanising**

Where galvanising is specified, it shall be carried out by the hot dip process in accordance with SABS 763-1977 (or latest amendment).

The minimum thickness of the zinc coating shall be for general application and shall in all cases be at least 65 micron, thus giving a minimum equivalent mass per unit of 455 g/m<sup>2</sup>.



**PSHA5 SITE WELDING (NEW CLAUSE)**

No welding shall be permitted on site without the express approval of the Employer's Agent, with the exception of those details shown on the drawings as site welded.

**PSHA6 CUTTING (NEW CLAUSE)**

No oxy-acetylene or other gas cutting and bending will be permitted on site without the Employer's Agent's approval.

The Employer's Agent will have no hesitation in considering rejection of any relevant component, member or unit should oxy-acetylene or other gas cutting and bending, process be carried out by the Contractor without the Employer's Agent's approval.

**PSHA7 ERECTION PROCEDURE (NEW CLAUSE)**

The setting out of all holding-down bolts shall be accurately checked by the Contractor. Any discrepancies in excess of the permissible deviations of the positions of these bolts shall be reported immediately to the Employer's Agent.

The Contractor shall not be permitted to make any relevant adjustment in the steelwork without the Employer's Agent's approval. (Refer to paragraph 2 of PSHA6).



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## **PSL MEDIUM PRESSURE PIPELINES**

### **PSL1 WATER SUPPLY MAINS**

The pipes to be used for pressure mains are as follows:

1. 63 mm and larger - Unplasticized Poly Vinyl Chloride (uPVC)  
- High Density Polyethylene (HDPE) Type IV
  2. 50 mm and smaller - High Density Polyethylene (HDPE) Type IV
- a) Couplings for uPVC pipes to be watertight and be able to withstand the relevant test pressures, unless otherwise indicated. uPVC pipe fittings shall be cast iron or aluminium.
  - b) HDPE pipes shall confirm to SABS 533. Couplings for HDPE pipe fittings shall be compression fittings only.
  - c) Steel fittings and specials shall be manufactured in accordance with the requirement of BS 534 but to the dimensions shown on the detailed layouts. Steel pipe sections shall be 6mm thick grade A complying with the requirements of SABS 719.
  - d) Cast iron fittings and specials shall be, manufactured in accordance with the requirements of 1200L, clause 3.3.
  - e) Flexible slip-on type Viking Johnson couplings shall be complete with removable centre registers (locating lugs). The area surrounding the locating lug shall be built up to prevent damage to the female thread on the Viking Johnson coupling.

### **PSL2 GRADE OF STEEL FOR STEEL PIPES**

All steel piping shall be made electric welded low carbon steel pipes in accordance with the requirements of SANS 719-1971 and BS 534-1966. Where non-standard specials have been detailed on the drawings, such dimensions shall be adhered to. All flanged pipes and fittings shall have flanges as specified, and shall be supplied complete with all packings, nuts, bolts and washers. Steel piping shall be made from Grade A steel. The minimum wall thickness for steel pipes shall be 6 mm. Viking Johnson couplings complete with all seals, bolts, nuts, etc. shall be used where detailed. Where new installations couple up with existing, the Contractor shall ascertain what the flange drillings are the same as all existing fittings prior to any placement or order and shall confirm this information with the Employer's Agent's.

### **PSL2 PIPE COUPLINGS FOR OTHER PIPES (Additional to clause 3.7)**

#### **PSL2.1 Polyvinyl Chloride**



Pipes and fittings shall be supplied with factory fitted 'Z type' couplings. Solvent welded joints will be permitted for pipes of diameter smaller than 50 mm. PVC pipe fittings shall be Aluminium or Cast Iron.

#### **PSL2.2 Polyethylene**

Pipes shall be supplied suitable for, and with compression or insert type fittings as scheduled. No screwed fitting shall be used without written approval. Polyethylene pipe fittings shall be Nylon.

#### **PSL3 FIBRE-CEMENT PIPE FITTINGS (Clause 3.8.1)**

Fibre Cement pipe fittings shall be Cast Iron or Steel. Where steel fittings are provided, they shall be adequately reinforced against ovalness (over the entire circumstances and width corresponding to half the width of the approximate standard AC coupling) by means of welded collars of minimum thickness 12mm.

#### **PSL4 VALVES (Clause 3.10)**

##### **PSL4.1 Gate Valves**

###### **i) General**

All gate valves in compliance with SANS 664, waterworks application, clockwise closing, with a non-rising spindle and plain thrust collar. Valves and flanges (if any) to be to the class specified.

Valves to be operated by either hand wheel, cap top and tee-key or extended spindle and hand wheel/tee-key. Operation to be specified.

Valves to be flanged or spigot ended as specified.

###### Note :

"As specified" will mean as described in the schedule of quantities.

In the event of no description in the schedule the following will prevail:

- Valves to be at least class 10 with a standard hand wheel operator and valves to be flanged.

###### **ii) Gate valves of 300mm diameter or smaller**

All gate valves falling into this category to be fitted with resilient seal, rubber lined gates similar to "Elypso compression-sealing valves".

##### **PSL4.2 Butterfly valves**



All Butterfly valves to be of the 'Boving' (or similar approved) resilient sealing type and shall be supplied complete with geared operator and hand wheel. All geared operators shall have horizontal spindles.

### PSL4.3 Valve spindles

All extended valve spindles shall be supplied at both ends with cast iron tops for valve key operation. The spindle shall be fitted into the valve box with a bearing for easy operation. The lengths of extended spindles are to suit the dimensions of their installation positions, all spindles supplied supported at 4m max. intervals.

### PSL5 STEEL FLANGES (Clause 3.8.3)

**PSL5.1** All flanges to be drilled to SANS 1123 table 15 unless otherwise specified.

**PSL5.2** All valve and hydrant tee flanges to be drilled as follows:

| AIR VALVE SIZE<br>(inlet dia. mm) | FLANGE<br>OD (mm) | BOLTS<br>no. x dia. | PCD |
|-----------------------------------|-------------------|---------------------|-----|
| 50                                | 203               | 4 x M16             | 165 |
| 80, 100 and 150                   | SANS 1123         | Table 15            |     |

Flange holes to be drilled to allow exact alignment vertically and horizontally as detailed on the drawings of all pipe work and equipment.

### PSL6 CORROSION PROTECTION (Clause 3.9)

#### PSL6.1 General

Protective coatings described in this sub-section shall not be measured for payment but shall be included in the rates tendered for piping, fittings, couplings and specials.

- a) All cast iron valves, cast iron or steel fittings and cast iron or steel specials shall receive a two-component solvent borne epoxy pipe coating and lining such as Copon KSIR 88 from Plascon or similar approved equivalent.

Surface preparation, application, testing and performance shall comply with the requirements of SABS 1217 type 1A, except that the minimum total dry film thickness shall be 300 micron.

Materials shall be applied in accordance with SABS 1217 and in accordance with the manufacturer's data sheet. Attention is drawn to the need for strict observance of the



manufacturer's minimum and maximum coating thickness and time interval between coats relative to ambient and steel temperatures.

The coating shall be applied in either two or three coats with either one or two coats being applied in the workshop. After installation any scratch or chip marks shall be touched up and the whole item covered with a further coat (or two coats) of coupon to give a total thickness of not less than 250 micron.

- b) All bolts, nuts and washers used for flanges and couplings shall be heavy duty galvanised (clause 3.9.5 of 1200L)
- c) All steel fittings and specials indicated for encasing in concrete shall be wire brushed externally and left uncoated for encasing in concrete. Lining shall be as described in (a) above.
- d) Steel fittings that are partly enclosed in concrete shall be coated internally as well as the exposed external part of the fitting up to 100 mm into the concrete encasement as described in (a) above.

#### PSL6.2 Mechanical preparation

The valves shall be rendered smooth and free from undercuts, protrusions, sharp edges and spatter. Edges should have minimum radius of 1 mm.

Cast materials shall only be cast in a mould coated with a suitable mould wash.

Castings shall similarly be ground smooth and surface blow holes accepted after mechanical inspection shall be filled with weld metals or an approved epoxy filler and ground down to a smooth surface.

#### PSL6.3 Surface Cleaning

Surfaces to be coated shall be abrasive blast cleaned in accordance with SABS 064, Section 4.3, especially Procedure 4.3.4, to the following parameters.

| DESCRIPTION AND MATERIAL       | BLAST MEDIUM                                        | PROFILE MICROMETERS                            | CLEANLINESS SA | RESIDUE |
|--------------------------------|-----------------------------------------------------|------------------------------------------------|----------------|---------|
| Fabricated or cast-iron valves | Clean, fine non-metallic & non-recycled or metallic | Fabricated max. 75<br>Casting Max 50<br>Min 30 | 3              | 0.3%    |

Other preparation methods, where required or agreed upon shall also be in accordance with SABS 064 as described in the appropriate sections. Laminations, scabs and occluded scale which



become visible after cleaning shall be ground out and the ground area re-cleaned. Excessive grinding depth may be repaired by welding, or the metal shall be rejected at the discretion of the Engineer.

#### **PSL6.4 Casting**

The first cast shall be applied as soon as possible, but never exceeding 4 hours after blast cleaning if the relative humidity (RH) is below 70% or 2 hours if the RH is between 70% and 85%. Coating shall not take place if the RH is 85% or above, nor when the surface is less than 2 above dew point.

If unfavourable conditions prevent applications of the first coat, the surface shall be re-cleaned when conditions are acceptable.

Strict cleanliness between coats shall be maintained. The directions laid down by the specification and by the paint manufacturer for mixing, curing, use of solvents, suitable environmental conditions, and over-coating times shall be strictly adhered to. Adequate ventilation to remove volatile matter shall be ensured.

#### **PSL6.5 Quality of coating**

The fully cured coating system shall be uniform, smooth, glossy and have acceptable adhesion. Excessive runs and sags, wrinkling, bubbling, blisters, change in colour or gloss, excessive orange peel, dirt, dust or fluff occlusions and other visible defects shall not be permitted. Paint work showing evidence of entrapped solvents after full cure will also be rejected. No inter-cast lamination must take place.

The colour of each coat shall be different to that of the previous coat except where two finishing coats of the same colour are necessary to achieve colour uniformity.

All coating surfaces for water immersion or frequently wetted in service shall show no electrical insulation defects when tested in accordance with the inspection parameters.

Finishing coat colours.

In addition to the finishing coat colour, if specified, the colour recommended for identification marking in SANS 0140 shall apply. Where not specified, the selection of paint colours shall be decided.

All damage that occurs during handling, assembly, transport, storage and erection shall be repaired to the requirements of the specifications. All damage sustained during transport will be repaired by the Contractor.

Proprietary items



Components supplied already painted or protected e.g. gear boxes, etc, may be accepted in this condition provided that they meet the requirements of this specification in general.

Quality control by the Contractor

The Contractor shall produce his own quality control records and tests carried out during all stages of corrosion protection procedures. These shall be made readily available to the Department's Inspector.

#### PSL6.6 Paint Systems required

All valves and fittings shall be coated as follows:

| SURFACE                    | COATING                                                          | THICKNESS<br>(MICROMETERS) |
|----------------------------|------------------------------------------------------------------|----------------------------|
| Lining (inside surface)    | Epoxy                                                            | 300                        |
| Coating *outside surface)  | (i) Epoxy plus<br>(ii) Vinyl enamel<br>colour Brilliant<br>Green | 200<br>25                  |
| Flange faces               | Epoxy                                                            | 125                        |
| Stainless steel components | Pickled and passivated<br>with Duva chemicals or<br>equivalent   | -                          |
| Fasteners                  | Cadmium plated and<br>dichromate (yellow)<br>passivated          | 15 to 20                   |

The epoxy applied shall be polyamide cured and preferably be solvent free in accordance with SANS 1217. Solvent containing epoxies will, however, be considered.

All external fasteners shall be Epoxy coated after assembly and testing.

#### PSL7 HANDLING AND RIGGING (Clause 4.1)

##### PSL7.1 Transportation

Pipes and valves shall be protected during transportation and handling against damages caused by impact, dropping, etc. Special care shall be taken during transportation to protect pipes. Rubber lined vertical posts shall be spaced on the sides of transporting vehicles to provide adequate support to the loaded pipes. Large diameter fibre cement and concrete pipes (that is, diameter above 800mm) shall be supported on supporting stools in transit. All pipes shall be inspected for defects immediately before laying and faulty pipes or pipes which have suffered damage which would affect their serviceability shall not be used in the Works.



### **PSL7.2 Off-loading and storage**

Pipes which cannot be off-loaded by hand shall only be lifted by means of suitably approved broad band slings. The use of wire, chains, hooks, crowbars and similar items shall not be permitted and the pipes, fittings and specials shall not be handled in such a manner as could cause damage to occur.

Pipes, fittings and specials shall at no time be laid, stacked or rolled directly onto the ground but shall be supported on suitable padded cradles or other approved material near each end of the pipe, fittings or special. Particular care shall be taken where pipes with fitted couplings are handled or stacked to prevent any pressure on the couplings. Where loose AC-couplings are provided the couplings shall be stored flat on their sides and under no condition be rolled or stored in an upright position.

All PVC-pipe work as well as the rubber sealing rings in pipe couplings shall be protected from the elements to prevent deterioration of the pipe work.

### **PSL7.3 Inspection on delivery**

The Employer's Agent's Representative will thoroughly inspect all pipes, fittings and specials delivered to the site but his acceptance of same as being in good condition shall not relieve the Contractor of any of his obligations or responsibilities under this Contract.

Materials rejected by the Employer's Agent shall be removed from the site and shall be replaced by other approved materials by the Contractor at his own expense.

### **PSL8 SETTING OUT (Clause 4.2)**

Alignment of the pipes may be done either by means of infrared sighting equipment or by sight rails. The following method should be followed if alignment is to be done by sight rails :

Prior to the preparation of the pipe bedding, the Contractor is to erect sight rails of 38mm x 150mm timber at intervals of a maximum of 60m or at points of change of pipe gradient, whichever may be the lesser. These shall be supported by wooden posts on each side firmly fixed on solid ground and the rails shall be accurately placed in position as regards alignment and invert level of the proposed trench.

The centre line of the trench (i.e. pipeline) shall be denoted on each sight rail, both back and front by a single vertical line drawn therein, and the rail on either side of the centre line painted in two contrasting colours. The Contractor shall also provide boning rods of an approximate length marked in even decimetres for use in the fixing of the trench bottom to the correct line and level.



## **PSL9 LAYING AND JOINTS**

No pipe laying shall commence on any particular section until the Employer's Agent has approved of the trenches and bedding. No pipes shall be laid in trenches with free standing water. The pipes shall be laid true to the lines, levels and grades shown on the drawings or ordered by the Employer's Agent, to within a tolerance specified.

The open ends of all pipes and fittings shall be suitably closed to prevent the ingress of soil or other matter into the pipes. After the pipes have been laid, they shall be inspected and checked by the Employer's Agent for grade, direction and line. If any pipes have been inaccurately laid, the work shall be rectified as ordered by the Employer's Agent at the Contractor's expense.

All valves and fittings are to be checked beforehand to ensure their operational order before being placed in the line. They are to be set correctly in position as indicated on the drawings or as ordered by the Employer's Agent, and where required, are to be supported by bedding or concrete supporting stools. Care shall be taken to ensure that no loose fill material or foreign matters enter the pipes or fittings. After the pipelines have been inspected and passed by the Employer's Agent, backfilling shall proceed and brought up evenly on both sides of the pipe with selected material as specified.

Jointing of pipes shall be carried out strictly in accordance with the manufacturer's instructions. Ends of pipes and joints shall be completely free of dirt and grit when the joints are assembled.

## **PSL10 BACKFILL**

Following the inspection by the Employer's Agent with respect to the grade, direction and line, as well as the successful testing of the pipeline, the Contractor shall promptly refill trenches and excavations.

### **PSL10.1 Material and Method**

The Contractor shall promptly refill trenches and excavations as soon as the works have been inspected, tested and passed by the Engineer.

The backfilling in contact with pipes and for a distance of 200 mm above the barrels of the pipes shall consist of selected material from the excavations, free from excess clay, vegetable matter and stones. Shortages of selected material in any section of a trench shall be made up free of additional cost by borrowing from adjacent excavations containing a surplus of suitable material.

The selected material shall be brought up in 150mm layers, uniformly moistened to the optimum moisture content to attain the specified compaction and shall be thoroughly compacted round the pipes and joints. Special care shall be taken in filling joint holes and the selected material



shall be firmly punned in, slightly moistened if required in order to ensure bearing for the length of each pipe.

Sufficient topsoil shall be set aside during excavation to form not less than the upper 150 mm of backfill material for re-establishment of vegetation.

In no case shall any filling be deposited in water. Trenches shall be kept free of water until backfilling has been completed. From above the top of the selected backfilling, unselected excavated material, excluding stones larger than 150 mm in any dimensions, shall be used for backfilling, which shall be compacted in layers not exceeding 150 mm.

Only equipment approved by the Employer's Agent shall be used for the compaction of the fill.

The superimposed loading resulting from the use of self-propelled or tractor-drawn compaction equipment shall not exceed the maximum external loading for any particular pipe in accordance with H20 Highway Loading as specified by the manufacturers.

The backfill shall be mounded to a height of 100 mm above ground level with gaps allowed at regular intervals for cross drainage.

Immediately after completion of the backfilling all surplus materials shall be levelled off adjacent to the pipeline.

Any settlement during the excavation of the contract and the period of maintenance shall immediately be made good by the Contractor with topsoil of the same type as that adjacent to the trench.

The Contractor shall fill in with approved material and consolidate all cavities caused by slips, rain, floorings, etc. or any other cause whatever at his own expense, to the satisfaction of the Engineer.

The Contractor shall make good promptly, to the entire satisfaction of the Employer's Agent at his own expense, during the whole period that the works are in his hands, including maintenance period and, as often as necessary, any settlement that may occur in the surface of roads, footpaths, private or public property, etc., caused by his trenches or excavations. He shall be liable for any accidents caused thereby and repair at his own cost any damage caused to property by such settlement.

During the execution of the Contract, the Contractor shall maintain a regular patrol, particularly after rains, of all completed backfilled excavations, in order to locate any subsidence, which he shall make good properly without any delay and shall not defer such action until complaints are received.



## **PSL11 TOLERANCES**

The more stringent of SANS 1200 L 6.2 and 6.3, and the following relative deviation shall be applicable to pipe work.

- a) Relative Deviation laterally from line : 0,1% of distance between points.
- b) Deviation from gradient  
Design gradient less than 1% : 0,04%  
Design gradient greater than 1% : 0,08%

## **PSL12 PIPELINE MARKERS**

A detail of the required concrete pipeline marker is included in the Annexures to the Specifications. Measurements will be per unit and the payment made accordingly shall be full compensation for the supply and installation of the pipeline marker.

## **PSL13 MARKING OF ROUTE AND POSITION**

The route and position of reticulation and bulk supply mains shall be marked on the surface by one of the following methods:

- pipeline route markers
- standard service markers
- painted service marking

## **PSL15 STANDARD HYDRAULIC PIPE TEST (Clause 7.3)**

Field test pressures shall be 1,5 times the recommended maximum working pressure for the class of pipe and/or valves, specials and fittings being tested.

## **PSL16 MEASUREMENT AND PAYMENT**

### **PSL16.1 Principles**

Measurements of the pipelines, specials and valves shall be as per the appropriate items in SANS 1200L i.e. Items 8.2.1, 8.2.2 or 8.2.3.

Payment shall be subdivided as follows:

- a) Supply of pipes to site - the percentage allowed for in the Appendix to the Form of Tender. (i.e. 80%)



- b) Successful testing of pipeline - remainder of the tendered amount, save for the normal retention.

## PSL16.2 Scheduled Items

### PSL16.2.1 Supply, Lay and bed Pipes complete with couplings Unit : m

Pipelines will be measured by length over all lengths as laid. No deduction will be made for specials and valves. Separate items will be scheduled for each diameter and each type and class of pipe laid. The rates shall cover the cost of the provision of the pipes complete with couplings, and the costs of the handling, inspecting, transporting, bedding, laying, jointing, cutting, testing and when relevant, disinfecting of the pipes and the joints.

### PSL16.2.2 Extra-over 15.2.1 for the supplying, laying and bedding of specials complete with couplings Unit : no

### PSL16.2.3 Extra-over 15.2.1 for the supplying, fixing and bedding of valves Unit : no

Specials and valves will be measured by the number of each type, class and size.

The rates which shall be extra-over the rates for 15.2.1, shall cover the cost of provision of each special or valve, complete with couplings and the cost of the handling, fixing, bedding and testing of the special or valve, as applicable and the cutting of the pipes.

No extra payment over and above the rates will be made in respect of any additional cutting, turning and jointing of pipes required for the location of valves, specials, etc., in the positions given on the drawings.

Unless specific provision is made in the schedule, no separate payment will be made for the supply and fitting of any additional joints and jointing materials which may be required for the connection of shortened pipe lengths.



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**PSLB      BEDDING (PIPES)**

**PSLB1      BEDDING** (Sub-Clause 3.3)

**PSLB1.1      Rigid Pipes**

All steel, and concrete pipes shall be laid on a class C bedding as shown on Drawing LB-1 of SANS 1200LB.

**PSLB1.2      Flexible pipes**

uPVC, and polyethylene pipes will be regarded as being flexible and shall be bedded as per Drawing LB-2 of SANS 1200 LB.

**PSLB2      MATERIAL NOT AVAILABLE FROM TRENCH EXCAVATION** (Clause 3.4.2)

Bedding and selected fill materials shall be obtained from trench excavation, other necessary excavations or from borrow pits in accordance with the provisions of Clause PSD3. The employer's Agent reserves the right to designate alternative sources. He also reserves the right to make a ruling whether special efforts must be made to construct specifically a separate bedding for pipes where the in-situ material proved to be of good quality.

**PSLB3      CLASS A BEDDING** (Sub-Clause 5.2.1)

Concrete to be used in class A bedding to pipes shall be of grade 20/19.

**PSLB4      CONCRETE CASING TO PIPES** (Sub-Clause 5.4)

Concrete to be used in the casing of pipes shall be of grade 20/19.

**PSLB5      TOLERANCE ON COMPACTION OF BEDDING MATERIAL**

Degree of accuracy II shall prevail.



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**PSMJ      SEGMENTED PAVING**

**PSMJ1      CLASS AND TYPE** (Sub-clause 3.1.2)

Class 35 blocks are required for vehicular routes. Type A, S-A blocks as shown in Figure 17 of UTG2 shall be used in this instance.

Class 25 blocks are required for pedestrian walkways. Type W, S-C blocks shall be used in this instance.

**PSMJ2      SAND FOR BEDDING AND JOINTING** (Sub-clause 3.3)

Add the following to the first paragraph of the clause:

Sand for bedding shall conform to the relevant requirements of SANS 1083 for fine concrete aggregate, with the exception of the grading which shall conform to the specification below.

**PSMJ3      LAYING OF UNITS** (Sub-clause 5.4)

Units shall be laid in the herringbone pattern.

Where existing segmented paving have to be extended, all previously cut paving blocks at the joining face shall be removed and the new paving blocks shall be laid from the joining face so that the existing herringbone pattern is extended, except where a concrete edge beam is specified by the Engineer.

**PSMJ4      DEGREE OF ACCURACY**

Paving shall be constructed to a degree of accuracy I.



## Phokwane Local Municipality

### HARTSWATER BULK WATER SUPPLY UPGRADE

#### CONSTRUCTION

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**PA BUILDING WORK**

**PA1 SCOPE**

This section of the Specifications deals specifically with all the building work associated with the Works.

Concrete work, steelwork, cladding, pipe laying, mechanical and electrical equipment, etc. forming part of or to be housed in a building erected in terms of this specification shall conform to the requirements of the relevant standardised or particular specifications referred to in the Project Specification.

**PA2 INTERPRETATIONS**

The relevant SANS 1200 Standardised Specifications such as Site Clearance, Earthworks, Earthworks (pipe trenches), Concrete (structural), Low pressure pipelines, Bedding (pipes), Sewers and Stormwater drainage shall also apply to the work under this section.

**PA3 MATERIALS**

All materials used for the Building Work shall, where such mark has been awarded for a specific type of material bear the SABS mark.

**PA3.1 Brick and Plasterwork**

Cement, sand and water shall conform to the requirements of SANS 1200 G - Concrete.

Unless otherwise described cement mortar shall be composed of six parts by volume of sand to one part by volume of cement. The materials are to be mixed dry until the mixture is of a uniform colour and then clean water is to be added gradually through a fine rose and the mixture turned over until the ingredients are thoroughly incorporated.

Cement mortar must be mixed in small quantities and must be used within one hour of mixing, as the use of cement mortar that has commenced to set will not be permitted.

Plaster on concrete ceilings, beams, columns, etc. shall be mixed one part cement to three parts sand.

Bricks shall be of the best quality sound hard burnt pressed bricks or in the absence of clay bricks, concrete bricks; even in size and shape and equal to a sample submitted to an approved by the Employer's Agent prior to commencement of work.

Clay bricks shall conform with the requirements of SANS 227 and concrete bricks to SANS 987.

Damp proof courses, unless otherwise described, shall be an asphaltic damp proof course with a base of fibre felt, and complying with the requirements of SANS 248



Horizontal Damp Proof Courses, and with a mass of 3,25kg/m<sup>2</sup> or a plastic damp proof course of 375-micron thickness as Type B, complying with the requirements of SANS 952.

### **PA3.2 Fascias, Barge Boards and Window sills**

Asbestos cement fascias and barge boards, where specified, shall be 10mm thick pressed sheets, 200mm wide free from cracks, twists, blemishes or other defects and complying with the requirements of SANS 685.

Internal asbestos cement sills shall be in single lengths cut between reveals, fitted with fixing lugs and solidly bedded in 3:1 cement mortar with a slight projection beyond the finished wall face below. Sills shall be pressed asbestos cement of approved manufacture 152 x 15mm thick set level.

### **PA3.3 Paintwork**

#### **PA3.3.1 Primers**

Plastered surfaces must be cleaned down and have one coat alkali resisting primer of an approved brand applied in strict accordance with the manufacturer's instructions, before any undercoats are applied.

Galvanised metal surfaces must be treated with one coat Metal Elch Primer complying with the requirements of SANS 723.

Steel surfaces must be treated with one coat Tupe Zinc Chromate Primer complying with the requirements of SANS 679.

Steel windows and doors and steel door frames, before being built in, must have all loose primer together with all rust spots, dirt, etc. removed and be treated with one coat red oxide zinc chromate primer complying with the requirements of SANS 909.

Wood surfaces to receive paint finish must be cleaned down, all knots treated with knotting and be primed with Type I Wood Primer externally and Type III Wood Primer internally, both complying with the requirements of SANS 678.

PA3.3.2 Emulsion paint for interior use must be Grade I Emulsion Paint complying with the requirements of SANS 663. Emulsion paint for exterior use must be of the Synthetic Polymer Base Type complying with the requirements of SANS 634.

PA3.3.3 High Gloss Enamel Paint shall be used on all surface other than specified above. High Gloss enamel paint must be Grade I paint complying with the requirements of SANS 630 for decorative High Gloss Enamel Paints with a Non-Aqueous Solvent Base, for Interior and Exterior use.

Undercoats for paints, except Emulsion paints, must be Type I undercoat Paint complying with the requirements of SANS 681.



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## **PA3.4 Doors, Windows and Glazing**

### **PA3.4.1 Doors**

Unless indicated otherwise on drawings all doors and door frames shall be of solid hardwood. Frames shall be fitted with suitable tie bars and braces at bottom, and lugs for building in, three to each jamb or frames with fanlights. All doors shall be provided with locks to the requirements of SANS 4 and each lock shall be provided with a duplicate key.

### **PA3.4.2 Windows**

Steel windows must be of approved manufacture and design, constructed of rolled mild steel sections, properly mitred and welded at angles with welding cleaned off smooth on all faces and complying with the requirements of SANS 727. Window types and sizes shall be as specified on the drawings.

### **PA3.4.3 Glazing**

Sheeting glass for glazing, unless otherwise specified, must be flat drawn clear glass of the thicknesses indicated below:

|                                                                              |       |
|------------------------------------------------------------------------------|-------|
| For panes not exceeding 0,65 m <sup>2</sup>                                  | : 3mm |
| For panes exceeding 0,65 m <sup>2</sup> and not exceeding 1,5 m <sup>2</sup> | : 4mm |

## **PA3.5 Tiling**

### **PA3.5.1 Adhesive and Grouts**

#### **a) Wall adhesive**

A grey, cement-based thin bed, wall tile powder adhesive for fixing tiles to walls.

#### **b) Floor adhesive**

A grey, cement-based thick bed, floor tile powder adhesive for fixing heavy tiles to floors or walls.

#### **c) Wall grout**

A cement-based, plasticized grouting compound for wall tile installation.

#### **d) Bonding agent**

A latex modified for use with adhesives and grouts to improve water resistance.



PA3.5.2 Tiles

Tiles shall be of first grade quality, white in colour, a maximum size of 160mm square, of a minimum thickness of 5mm and shall be glazed ceramic tiles (unless specified to the contrary).

**PA3.6 Electrical connection**

Electrical wiring and fittings are to comply with the requirements laid down by:

- (i) The latest issue of the "Standard Regulations for wiring of premises" issued by the South African Institute of Electrical Engineers.
- (ii) The Factories, Machinery and Building Works Act of 1941.
- (iii) The local authorities By-laws and any special requirements of the Local Supply Authority.

**PA3.7 Sink units**

Sink units shall be fitted with one shelf and a stainless steel sink and fluted drainer unit, with tiling key to one or more sides as required, complying with the requirements of the relevant SANS specification and bearing the standardisation mark of the SANS. The stainless steel shall be of Grade 1770 and of such gauge as laid down for the particular size of fitting. Outlet of bowls shall be fitted with chromium-plated brass work fittings with vulcanite plug and chromium-plated chain. Each 1500mm long sink unit shall have a single bowl, either left hand or right hand as shown, size 460 x 350 x 150mm deep. Each sink to be fitted with chromium-plated bibcocks and connected to hot and cold water supply.

**PA3.8 Sanitary equipment**

PA3.8.1 Pedestal Water Closet Pans

Pedestal water closet pans shall be of wash-down type approximately 450mm high, of white glazed fireclay or vitreous china, complying with the requirements of the relevant SANS specification.

Pans shall be bedded on the floors in 3:1 cement mortar. Pans shall be fitted with approved plastic seats with double flap of size and shape required to fit the pans and each attached to pan with two non-ferrous metal fixing bolts.

PA3.8.2 Flushing Cisterns

Low level PVC cisterns, no less than 12mm thick in any part, shall be provided complying with the relevant SANS specification and shall have a capacity of +/- 12 litres and shall be of the valve less siphonic type of approved manufacture.



Cisterns shall be fixed to walls with 6mm brass bolts, 150mm long, two to each cistern, built into walls in 3:1 cement mortar, with leather compression washers and brass nuts.

**PA3.8.3** Hand wash basins

Hand wash basins shall be of the bracket type of white fireclay or vitreous china, complying with the requirements of the relevant SANS specification and having overflow, fitted with chromium plated grid.

Unless otherwise specified, basins shall be size 585 x 430mm each fitted with 38mm plug and chromium-plated chain, and with two 12mm chromium-plated brass easy clean pattern screw down pillar to PHS. Basins shall be fixed on concealed wall hangers fixed to walls with 6mm brass bolts, 150mm long.

**PA4 PLANT**

Plant, equipment, tools, scaffolding, etc. utilised in building work shall be of suitable capacity, condition and design to ensure the satisfactory and timeous completion of the Works within the specified period and in terms of these specifications and good building practices.

Only registered artisans (e.g. plumbers, electricians, etc.) shall be employed on any work where this is compulsory building practise.

**PA5 CONSTRUCTION**

**PA5.1 Brick-and-Plasterwork**

**PA5.1.1** Normal brick walls

Brickwork, wherever practicable, and not otherwise described, must be built in English bond. Half brick walls, walls in two skins and cavity walls must have the separate skins built in stretcher bond. No false headers are to be used and none but whole bricks except where legitimately required to form bond. The bricks are to be well wetted (saturated in hot weather) with water before being laid and the course of bricks last laid is to be well wetted before bedding fresh bricks upon it. All perpend and angles are to be kept plumb. The brickwork is to have the joints flushed up at every course solid throughout the whole width of the course, and each course is to be laid on a solid bed of mortar. Pointing is to be done as the work proceeds.

The joints of all walls to be plastered or tiled are to be raked out 15mm as the work proceeds to form a key for plaster or screed. All walls are to be built up in regular and horizontal courses and carried out so that no part built is more than 1,2m higher than any adjoining walls. Mortar beds generally are not to exceed 12mm thickness.

**PA5.1.2** Face brick walls



In all faced brickwork the bond must be set out on the first level course of brickwork, at floor level internally and two courses below ground level externally. The bond, if necessary, is to be broken in the centre of panels under windows or to piers between windows. All perpend must be kept true and all courses must be built to gauge rods. Facings must be carefully protected from damage, mortar droppings, paint splashes, etc. during the whole period of the Contract and, on completion, they must be thoroughly cleaned down and left perfect. The practice of oiling facings on completion will not be allowed.

#### PA5.1.3 Cavity Walls

Cavity walls are to be built with two brick skins with a cavity between the skins and the two skins tied together with wire ties, four to the metre square, carefully laid and in no case to fall inwards towards the inner skin of the wall.

Care must be taken to keep the cavity free of mortar droppings or other matter by movable boards or other means, and temporary openings must be left at plinth level through which any such droppings, etc. can be removed, and the openings made good on completion.

At door, window and other openings, the cavities shall be stopped 102,5mm back from heads, jambs and sills of openings.

#### PA5.1.4 Reinforced Brick Lintels

Brick lintels are to be built of normal, sound, well burnt, good quality building bricks, similar to the facings where exposed properly bonded longitudinally and bedded and pointed in cement mortar as described. Special care must be taken to ensure solid bedding, particularly where the reinforcement occurs.

The lintels are to be reinforced with straight continuous mild steel rods of the size and number scheduled. The rods must each extend 300mm on each side of the opening and are to be evenly spaced across its thickness in the first horizontal joint above the soffit.

Brick lintels in cavity walls must have all rods placed below the solid sections of the walls, excepting for those rods specifically scheduled to occur below the cavity.

Cavity walls must be built solid for the number of courses scheduled above the lintel soffit. This solid section must extend the full width of the opening, plus 300mm on each side. Combined brick and concrete lintels may have the reinforcement divided proportionately between the brick and the concrete skins. Where two or more openings are less than 665mm apart, the lintel shall be continuous over all such openings and the dividing piers, plus 300mm bearing at each extreme end as before, shall have such height and reinforcement as scheduled for widest openings spanned.



| Span in mm | Min. height of lintels above soffit course, in brick courses | Reinforcement per half-brick thickness of wall above for solid walls |         | Additional reinforcement for cavity, placed below cavity |         |
|------------|--------------------------------------------------------------|----------------------------------------------------------------------|---------|----------------------------------------------------------|---------|
|            |                                                              | No. of Rods                                                          | Dia. mm | No. of Rods                                              | Dia. mm |
| 600        | 2                                                            | 1                                                                    | 6       | 1                                                        | 6       |
| 900        | 3                                                            | 2                                                                    | 6       | 2                                                        | 6       |
| 1200       | 3                                                            | 3                                                                    | 6       | 1                                                        | 6       |
| 1500-1800  | 4                                                            | 2                                                                    | 10      | 1                                                        | 10      |
| 2100-2400  | 5                                                            | 3                                                                    | 10      | 1                                                        | 10      |

#### PA5.1.5 Damp proof courses

The sheeting is to be cut into strips of the required width and laid on all foundation walls to the full thickness of the walls to the full thickness of the walls and without any longitudinal joints. At ends, angles and intersections the sheeting must be lapped 150mm and sealed. In cavity walls the sheeting must be laid across the full width of the wall, including the cavity, and must be stepped up one course in the cavity, over a cement triangular fillet, so that the sheeting under the inner skin of the wall is higher than that under the outer skin of the wall.

Under all window sills exposed to the weather, the sheeting must be laid to form damp proof course as detailed above for solid walls and cavity walls.

#### PA5.1.6 Reinforcing in Brick walls

Reinforcing (brick force) on an approved manufacture shall be place on every fourth course in all brick walls. In half-brick and cavity walls 100mm wide reinforcing mesh shall be used and 150mm wide mesh in the case of the one-brick walls.

#### PA5.1.7 Plasterwork

All chases must be cut and electrical conduiting and boxes fixed before any plastering is done. On no account will chasing be allowed in finished plaster work, and if such chasing is necessary, the entire wall surface must be hacked off and re-plastered.

Except where otherwise described, all external plaster is to be finished with a wooden float and all internal plaster is to be finished with steel trowel, all to perfectly true and even surfaces, free from tool marks and other defects on completion.

All finished surfaces are to be protected from injury. All joints in brickwork are to be well raked out, all surfaces, brickwork and concrete, to be plastered must be brushed down to remove all dirt and dust and be thoroughly wetted directly before plastering. Concrete surfaces must be roughened or hacked as necessary to give a proper key for



plaster. The surfaces must then be sloshed with coarse cement grout before plastering is commenced. The surfaces of all internal plaster must be steel trowelled to a smooth even and true finish. External plaster must be finished to a true and even surface with a wood float. Plaster must be returned into reveals and soffit of openings and all angles and edges must be true and straight. All plaster surfaces must be free from blemish and any cracks, blisters, or other defects must be cut out and made good and the whole left perfect at completion. Plaster on walls must be not less than 12mm or more than 20mm in thickness, and plaster on concrete work must be not less than 10mm or more than 15mm in thickness, except where specifically otherwise described.

#### PA5.1.8 Slip Joints

Slip joints shall be provided between brickwork and concrete slabs and beams by leveling up and steel trowelling smooth the bearing surfaces of brickwork with 3:1 mortar and covering the bearing surface before concrete is cast with 2 layers of 500m five hundred micron) black general purpose sheeting membrane.

The ends and sides of beams and edges of concrete slabs shall be separated from the brickwork with 12mm polystyrene placed vertically against the brickwork before the concrete is cast.

#### PA5.1.9 Beam Filling

Unless otherwise specified, beam filling shall be half brick thick, built in cement mortar, cut in between roof timbers and carried hard up to underside of roof covering and flushed up in mortar with a groove formed between covering and mortar to the satisfaction of the Employer's Agent.

#### PA5.1.10 Securing of Roofs

Roof plates shall be fixed to walls with bands of 1,6mm thick galvanised hoop iron, 32mm wide, built six (6) courses deep into brickwork or embedded 300mm deep into concrete, at not exceeding 1,5 metre centres, and well lapped and spiked to plates and to roof trusses where adjacent, otherwise taken up to a lapped round the nearest purlin and well spiked thereto. A layer of brick force shall be provided at each alternate course above the building in of the hoop iron to fix the roofs.

### PA5.2 Rainwater Goods

All gutters, downpipes and flashings shall be 0,6mm thick galvanised sheet iron. Rates for sheet iron eaves gutter and rainwater pipes shall include for short lengths and for lapped, riveted and soldered joints. Eaves gutters are to be screwed or welded to fascia boards or roof timbers/beams with 38 x 3mm galvanised mild steel gutter brackets at approximately 900mm centres, or as otherwise described. Rainwater pipes are to be fixed with sheet iron ears to and including 25 x 76 x 150mm chamfered hardwood blocks, plugged to brickwork or concrete and oiled, or with 38 x 14 gauge galvanised hoop iron



straps build into walls not more than 2 meter apart, bent around pipe and bolted at back.

Finishings shall be properly cut, lapped and shaped to render a waterproof finish. Flashings turned up against walls must be finished with cover flashing bent to shape, dressed over the under flashing and with top edge wedged into joint of brickwork and pointed or secured by other approved means.

### **PA5.3 Paintwork**

All surfaces not being painted such as face brickwork, sills, floors and stained woodwork, must be covered up and protected against paint and distemper sports before any painting is commenced. All floors must be swept clean and walls dusted down before any paintwork is commenced and no sweeping or dusting must be done while painting is in progress.

All plastered wall; ceiling and similar surfaces must be perfectly dry and in a fit state to receive the finishings, before the work is put in hand.

All coats of paints, etc. must be thoroughly dry before subsequent coats are applied, and rubbed down where necessary.

All work must be finished to colours approved by the Employer's Agent.

The tints of undercoats must approximate those of the finishing colour and in order to indicate the number of coats applied and to avoid misses when applying a succeeding coat a slight difference shall be made in the tint of each coat.

The Contractor must provide all necessary dust sheets, covers, etc. and shall exercise all necessary care to prevent marking the surfaces of joinery, walls, floors, glass, electrical fittings, etc. and must keep all parts of the works perfectly clean and free at all times from spotting, accumulation of rubbish, debris or dirt arising from the painting operations. Any surface disfigured or otherwise damaged must be completely renovated or replaced as necessary, by the Contractor at his own expense. The premises must be left clean and fit for occupation at the completion of the work.

### **PA5.4 Floor Finishes**

Where a floated concrete floor finish is specified on the drawings, the requirements of SANS 1200G or GA, whichever is irrelevant, shall apply.

Granolithic finish to floors, treads and risers of steps, thresholds, landing etc. must be composed of two parts hard stone chippings; half part sand and one part cement, steel trowelled to a true and even surface. The granolithic must be laid before the concrete surface bed has matured, otherwise the surface of the concrete must be thoroughly cleaned with a wire brush and a coat of neat cement grout applied immediately before the granolithic is laid. The granolithic must be laid in panels not exceeding 6 m<sup>2</sup> in areas,



and jointed to lines of panels and lined into smaller square as directed with sunk V-joint. The joints between the panels should coincide with joints in the concrete surface bed, where these occur. No dusting on of colouring pigment will be allowed.

Terrazzo floor tiles shall be even in size and shape, free from cracks, chips, twists, blemished or other defect uniform in colour and equal to samples to be submitted to and approved by the Employer's Agent. Special care must be taken to preserve arises and faces during transit and handling.

Pointing, etc.: Terrazzo floor tiles are to be bedded and jointed solidly in cement mortar and unless otherwise described, flush pointed on all exposed faces with semi-dry cement mortar pressed in. On no account must liquid grout be poured in. Terrazzo floor tiles work must be well protected to prevent all possibility of damage or discoloration and thoroughly off cleaned on completion.

Vinyl floor tiles shall be fixed on to a screed of thickness at least 25mm. The screed shall have a wood floated finish and shall be smooth with no obstruction greater than 3mm protruding and with the screeded surface level in such a way that no gap greater than 5mm would show underneath a 3m straight-edge or part thereof.

Vinyl tile adhesives shall carry the same product name as the vinyl tiles and the adhesives shall be applied as stipulated by the suppliers.

The acceptable tolerance of the final filed floor shall be similar to that specified for the screeded surface underlying the tiles.

#### **PA5.5 Tiling Work**

The area to be tiled, shall first be plastered as described under plasterwork leaving a wood float finish. The plastered surface shall be left for two weeks to cure before any tiling may start.

Tiles shall only be cut by approved tungsten tile cutters, or for irregular shapes by approved tile saws. The use of nibblers shall not be permitted.

A tiled panel shall be planned beforehand to minimise cuts. An initial perpendicular tiling configuration shall be laid against perpendicular fixed battens. A clear space of 1 to 2mm shall be left between tiles by inserting positive temporary spacers.

Prior to the application of any adhesives the rendering shall be vacuum cleaned. Adhesives shall be mixed with a bonding agent and not with water. The mixing proportions shall be as specified by the supplier. Adhesives shall be applied within a 15minutes period after mixing with those adhesives or used during such time to be thrown away.

Adhesives shall be applied in a solid bed, some 6mm thick and then struck with an approved serrated steel trowel. Adhesives shall not be applied by "the fire point tiling method".



Grouting of the joints shall only start 48 hours after a tiled section has been completed. The grout shall also be mixed with the bonding agent as specified by the supplier. The grout shall be worked off leaving a neat superficial rut in the joint centre. All the faces shall be cleaned directly after grouting.

No tiling shall be done over a structural joint. In large tiled panels, a movement joint shall be left every 3 metres in the horizontal and vertical direction as detailed. At a structural joint (contraction or expansion joint) the rendering, adhesive and tiles shall be interrupted over the joint and the joint sealed at the surface.

The permissible deviation on the final surface shall be a maximum gap of 3mm measured under a 3m straight edge or part thereof.

#### **PA6 TOLERANCES**

Where tolerances are not specified in the clauses above those generally accepted as representing good workmanship in the building trades shall apply.

#### **PA7 TESTING**

The Employer's Agent reserves the right to order any tests, whether at place of manufacture or on site, necessary to evaluate the quality of the work and to ensure the finished building conforms to all the specified requirements.

#### **PA8 MEASUREMENT AND PAYMENT**

##### **PA8.1 Schedule items**

##### **PA8.1.1 Brickwork**

Brickwork, if measured as a separate item, shall be measured in square metre of the nett brick walled area (with the wall width and type of brick-finish, indicated). No adductions will be made for small openings such as air bricks, etc. The tendered price per square metre of brickwork shall include also for the following, if such items are not listed separately:

- (a) Plaster work as indicated
- (b) Damp proofing
- (c) Brick forcing (every fourth layer)
- (d) Reinforcing of lintels
- (e) Miscellaneous items built into brickwork shown on the drawings such as air bricks.



PA8.1.2 Wall, ceiling, roof and floor finishes

Cement plaster on walls and ceilings, roof screeds, floor screeds, paint and any other finish described or specified, shall if measured as separate item be measured in square metre of the nett surface are. No deductions shall be made for small openings nor shall additions be made for small protrusions and reveals. No separate payment shall be made for the processes involved and material supplied for the complete painting of all fixtures and fittings, as specified herein and the cost thereof shall be included in the tendered price for the supply, manufacturing and erection of all such items to be erected.

PA8.1.3 Miscellaneous

- (a) Timber doors and windows shall be measured per unit of door or window complete with door frame, lock keys, glazing, painting, etc., for each type and size of door or window or as a lump sum payment for all doors and windows included in the door and window schedule of the Works.
- (b) Other items of building work, fixtures and fittings, shall be measured and paid for in the units of measurements listed in the Schedule of Quantities.



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**PB FENCING**

**PB1 SCOPE**

This sub-section includes all work in connection with the erection of shockproof, vermin proof, residential or security fencing as shown on the drawings or as directed by the Employer's Agent. It also includes any work necessary on the lifting and re-erecting of existing fences. The standard of fencing, the positioning of the gates and the quantities shown in the Schedule of Quantities against each item under this section, may be subject to variation and the Contractor shall ascertain from the Employer's Agent, the exact location of, and specification to which the fencing shall be constructed, before placing any orders for material. The minimum standards of fencing required are indicated on the drawings.

**PB2 MATERIALS**

**PB2.1 Vermin, Shockproof and Residential Fencing**

Straining posts and stays, standards, and droppers shall be either of timber or steel sections. All sections shall be to the dimensions and masses indicated on the drawings. Timber sections shall be of creosote impregnated hardwood. Steel sections shall be either galvanised or painted to the specifications indicated on the drawings.

All plain wire, barbed wire, wire netting, diamond mesh and binding wire shall be according to the diameters and specifications indicated on the drawings.

**PB2.2 Security Fencing**

All posts, standards and droppers for security fencing shall be galvanised steel sections to the dimensions and details indicated on the drawings. Plain and diamond wire and other fencing materials shall all be according to the details indicated on the drawings.

**Gates**

All gates shall be to the details indicated on the drawings and components shall either be galvanised or painted according to the specifications on the drawings.

**PB2.3 Bolts**

Bolts shall be galvanised steel bolts of the required length and diameter which shall not be less than 12mm. Eyebolts to gates of 18mm diameter. All the necessary bolts together with nuts and washers, shall be supplied with each post or gate.

**PB3 CONSTRUCTION**

**PB3.1 Clearing of Fence Site**



All brush scrub and other obstructions which may interfere with the proper construction of the fences shall be removed and surface irregularities shall be graded so that the fence will conform to the general contour of the ground.

No separate payment will be made for this clearing and full provision for these costs must be made in the tender.

#### **PB3.2 Connections**

Existing cross fences shall be connected to the new fences. Straining posts with stays for every direction of strain shall be placed at the junction with existing fences and the wires in both fences properly fastened to the posts.

#### **PB3.3 Placing of Posts**

All posts, struts and standards shall be firmly planted into the natural ground, be it soil, gravel or rock to the depths detailed. Gate posts and struts shall be erected at all gates and straining posts and struts shall be erected at all ends and corners or bends in the line of the fence and at all junctions with other fences. Intermediate straining posts and struts, and standards shall be spaced at the intervals indicated on the drawings.

All posts (except struts), standards and droppers shall be placed in a vertical position except in unusual locations where, in the opinion of the Employer's Agent, it will be more satisfactory to place such member perpendicular to the slope of the ground. All posts, struts, standards and droppers shall be set in holes dug to the specified depth even in rock where blasting might be necessary to obtain the required depth. All gate posts shall be set in concrete and other members shall either be set in concrete or in well compacted backfill as indicated on the drawings. No concreting or backfilling shall be done until all members have been properly aligned.

All posts and struts for security fencing shall be set in concrete as shown on the drawings. Steel members are not buckled or otherwise damaged after being driven in, and provided further that the correct alignment or the driven members is maintained.

#### **PB3.4 Attaching Wire**

After all posts, struts and standards have been set firmly and after all concrete has hardened for at least four days the fence wire shall be attached according to the details indicated on the drawings. All wire shall be attached to the sides of the posts and standards furthest from the object being fenced. Wire shall be carefully stretched and strung in true alignment and without sag. Wire shall be attached to each post and standard by one of the following methods:

- a) by notching the member and securing the wire by means of binding wire or,
- b) by drilling holes through the member and stapling the wire with plain iron staples passing completely through the member, or



- c) where iron members are used, by securing the wire by means of binding wire must pass through the hole in the standard.

Droppers shall be placed parallel to the standards at the intervals detailed on the drawings. Droppers shall be fixed to each fence wire with binding wire in such a manner as to prevent any slipping.

#### **PB3.5 Attaching Wire Netting or Diamond Mesh**

Wire netting and diamond mesh covering shall be securely fixed to the fence according to the details on the drawings. In addition, the wire netting on vermin proof fencing shall be fixed according to the Employer's Agent's instruction by one of the following methods:

- a) by packing stones, placed end to end, on both sides of the fence so that no gaps exist beneath the fence, or
- b) by folding back the bottom 150mm of wire netting so that it lies flat on the ground, and packing stones end to end on this flap, or
- c) by embedding the lower part of the wire netting at least 100mm into the ground and ramming the earth thoroughly to secure the netting.

#### **PB3.6 Installing Gates**

Gates shall be installed in the position indicated by the Employer's Agent. The gates shall be erected so as to swing in a horizontal plane at right angles to gate post clear of the ground in all positions.

#### **PB4 FINISHING: TRIMMING AND PAINTING**

Where timber posts have been used, the tops of the posts shall be trimmed after the fencing has been erected, such that the top of the completed fence has a pleasing profile. The cuts shall be liberally painted with creosote. An un-galvanised metal components of fencing has been erected, any chipped or damaged paint work shall be touched according to the same paint specifications.

#### **PB5 MEASUREMENT AND PAYMENT**

##### **PB5.1 Vermin proof, Shock proof, Residential and Security Fencing**

This fencing shall be measured in metres between the centres of gate and end posts along the general slope of the ground. Payment shall include full compensation for the clearing of the line, for the supply, painting and erection of all standards, intermediate straining posts and stays, droppers, plain wire, barbed wire, binding wire and all other components on the drawings but shall specifically exclude corner, end and gate posts and their stays. Payments shall also include for the concreting of posts where specified.



## **PB5.2 Corner, Bends and Ends**

Corners, bends and ends shall be measured by the number and shall include compensation for the supply, painting and erection of all posts and stays required at such ends, corners or bends and shall include for any concreting where so specified.

## **PB5.3 Gates**

Gates shall be measured by the number. A double gate as required for security fencing shall be measured as one number double gate. Payment shall include full compensation for the supply, painting and erection of the gate and ancillary components, as well as for the supply, painting and erection of gate posts and struts and for the concreting of such posts and struts (where required).

## **PB5.4 Pay Items**

|    |                                                                                                                         |   |    |
|----|-------------------------------------------------------------------------------------------------------------------------|---|----|
| 1. | Vermin proof Fencing                                                                                                    | : | m  |
| 2. | Shockproof Fencing                                                                                                      | : | m  |
| 3. | Residential Fencing                                                                                                     | : | m  |
| 4. | Security Fencing                                                                                                        | : | m  |
| 5. | Corners, bends and ends (shall distinguish between the different type of fencing)                                       | : | no |
| 6. | Gates (shall distinguish between the different type of fencing and between the different types and dimensions of gates) | : | no |



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**PC FINISHING AND CLEANING UP**

**PC1 GENERAL**

No section of the work will be regarded as satisfactorily completed until the final cleaning up has been performed.

**PC2 SCOPE**

All completed work shall be trimmed and all the debris of construction, such as unsuitable or rejected materials and spillage, shall be removed. The site and its environs shall be rehabilitated, where practically possible, by taking the following measures: -

- \* The site of work shall be cleaned of all rubbish, excess materials, falseworks, temporary structural installations and abandoned equipment.
- \* All construction scars resulting from this contract shall be treated to blend with the contour and vegetation of the surroundings.
- \* All trench subsidence shall be made good and surcharged backfill materials shall be removed unless otherwise directed.

**PC3 ACCEPTANCE**

Three weeks before the anticipated date of completion of any section to be handed over, the Contractor shall formally request a check list of defects from the Employer's Agent.

Within one week the Employer's Agent will detail in writing the particulars of the work to be done in finishing the Works, and the general standard of aesthetics to be observed in trimming and cleaning.

Before offering the work for acceptance on a completion certificate the Contractor shall satisfy the Employer's Agent's site representative that all the work scheduled on the checklist has been attended to.

**PC4 PAYMENT**

Payment shall be the tendered lump sum and shall become due on the date of signature of the Certificate of Completion.



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**PD SETTING OUT**

**PD1 GENERAL**

This Particular Specification describes the requirements for setting out of the Works. No separate payment will be made for work described in this section.

**PD2 FIELD WORK**

- (a) All survey shall be based on the appropriate Lo system of the national triangulation.
- (b) All points to be set out by the Contractor shall be located in the X, Y and Z directions according to land-survey methods generally accepted in the Republic of South Africa so as to ensure that the required degree of accuracy is achieved.
- (c) The Contractor shall identify and list the beacons that he used as traverse terminals, or for the fixing of points by trigonometrical survey methods.

**PD3 SURVEY RECORDS AND CALCULATIONS**

- (a) All records shall be neat, orderly, fully annotated and cross-referenced, adequately checked and shall include the following:
  - general report,
  - all field placings and checks,
  - final co-ordinate list and differences between polars,
  - levels and check levels, and
  - a summarized list of final X, Y and Z values on all pegs.
- (b) Plans, field books and all calculations shall bear the field surveyor's and the Contractor's signatures, be fully dated and numbered sequentially.
- (c) Only originals shall be submitted.
- (d) The calculations are required to follow basically the principles in common use in the Republic of South Africa, as described in the Annexures to the Survey Regulations framed under the Land-Survey Act of 1927 (as amended).

**PD4 SURVEY BEACONS**

Beacons that have been or will be erected by the Engineer are shown on the Drawings, generally at inflexion point and 400m maximum spacing. Additional survey beacons shall



be provided by the Contractor at intermediate points in order to provide line of sight at all points and for the proper construction of the Works.

#### **PD5      REFERENCE PEGS**

- (a)      Reference pegs have been placed approximately every 400m and at all inflexion points. Two references have been placed per point to be referenced.
- (b)      The Contractor shall protect these references, and place further references as may be necessary to secure the position of the pipeline at all times. All reference peg positions shall be determined by means of a double polar or by traverse.
- (c)      Reference pegs placed by the Contractor shall at least consist of a steel peg (Y10 or Y12) cast into a concrete block of 300mm diameter and 200mm depth. The Contractor shall note that the value of the survey depends largely on the permanence of its reference points. The Contractor shall apply suitable additional measures in unstable soils to assure the permanence of points.
- (d)      Reference pegs shall be numbered consecutively with a 10mm stamp on an aluminium tag cast into the concrete, in accordance with the node numbering sequence indicated on the Drawings.
- (e)      The allowable error is 0,02m in the XY plane.



## PE ELECTRICAL – PARTICULAR SPECIFICATION

### **GENERAL TECHNICAL REQUIREMENTS FOR THE EXECUTION OF THE ELECTRICAL WORKS. (MATERIALS)**

#### **1. SCOPE OF WORKS**

The scope of work includes the refurbishment of the entire Water Treatment Works, including (but not limited to):

- 11kV switchgear & protection
- 11kV / 400V Transformers
- 400V switchgear
- Motor Control Centre
- Power Factor Correction
- Power cabling
- Control cabling
- Small power and lighting
- External Area lighting
- Automation & control
- Instrumentation
- Fire Detection
- Intruder Alarm
- Telemetry
- Network Communication
- Scada

Installation of new equipment shall include the removal of the existing equipment, delivery and offloading to the client's centralized stores.

#### **2. STANDARDS**

All materials and equipment to be supplied and installed under this contract shall be new and of the best quality available.

All materials and equipment shall comply with the requirements laid down in the latest editions of the BS, SABS and IEC specifications and their amendments (if any) as well as those laid down in this specification. Where items bearing the SABS mark are available for any of the materials and equipment specified, only materials bearing the said mark, will be acceptable.

The following Standard Specifications and drawings shall apply:

|           |   |                                                                                                              |
|-----------|---|--------------------------------------------------------------------------------------------------------------|
| SABS 780  | - | Distribution Transformers                                                                                    |
| SABS 555  | - | Transformer oil                                                                                              |
| SABS 833  | - | Bushings                                                                                                     |
| SABS 97   | - | Medium voltage cables                                                                                        |
| SABS 763  | - | Galvanizing                                                                                                  |
| SABS 0142 | - | Code of Practice for the wiring of Premises                                                                  |
| BS 923    | - | Testing                                                                                                      |
| BS 2631   | - | Switch gear                                                                                                  |
| BS 162    | - | Switch gear                                                                                                  |
| BS 159    | - | Bus bars                                                                                                     |
| SABS 1091 | - | Paint colour                                                                                                 |
| S 3938    | - | Current Transformers                                                                                         |
| BS 3941   | - | Potential Transformers                                                                                       |
| BS 89     | - | Ammeters                                                                                                     |
| BS 638    | - | Welding cables                                                                                               |
| SABS 1507 | - | Electrical cables with extruded solid dielectric insulation for fixed installations (300/500V to 1900/3300V) |
| SABS 256  | - | Moulded Case Circuit Breakers                                                                                |
| SABS 767  | - | Earth leakage protection units                                                                               |
| SABS 1084 | - | Cover plates for wall outlet boxes                                                                           |



|           |   |                                                                                    |
|-----------|---|------------------------------------------------------------------------------------|
| SABS 1085 | - | Wall boxes for the enclosure of electrical accessories                             |
| SABS 1065 | - | Metal conduit Part 1                                                               |
| SABS 1065 | - | Metal fittings Part 2                                                              |
| SABS 1574 | - | Electric cables and flexible cords                                                 |
| SABS 163  | - | Wall and appliance switches                                                        |
| SABS 1119 | - | Ballasts for fluorescent lamps                                                     |
| SABS 890  | - | Fluorescent lamp reference ballasts                                                |
| SABS 086  | - | Interior luminaries for fluorescent lamps                                          |
| SABS 1029 | - | Miniature substation                                                               |
| SABS 1152 | - | Metal working chisels for hand use                                                 |
| BS 3939   | - | Graphical symbols for electrical power, telecommunication and Electric Diagrams    |
| BS 148    | - | Specification for unused mineral insulating oils for transformers and switch Gear. |
| BS 142    | - | Electrical Protection relays                                                       |
| BS 1650   | - | Specification for capacitors for connection to power – frequency System.           |
| BS 4504   | - | Circular flanges for pipes, valves and fittings (PN Designated)                    |

### 3. SYSTEM AND SITE CONDITIONS

All materials and equipment supplied under this contract shall be suitable for operation under the following conditions unless specifically specified otherwise elsewhere in this document:

Medium voltage system: 11 000, 50 Hz, 3-phase, 3 wire, alternating current.

Low voltage system: 400/230V, 50 Hz, 3 phase, 4 wire, alternating current with solidly earth neutral.

Atmosphere: dry, dusty, warm and highly corrosive

### 4. LAWS, REGULATIONS AND CODES OF PRACTICE TO BE OBSERVED

The work shall be carried out strictly in accordance with and all material and equipment supplied shall comply with the following laws and regulations where applicable:

- (a) The latest edition of the "Code of Practice for the Wiring of Premises", SANS 10142, as amended;
- (b) Occupational Health and Safety Act (Act No.85 of 1993);
- (c) The "Electricity Supply By-Laws and Regulations" of the Local Supply Authority;
- (d) The local Fire-Office Regulations;
- (e) The Requirements of the Department of Communications;
- (f) The Acts and Regulations applicable to the use of explosives;
- (g) "The Code of Practice for the Installation and Maintenance of Electrical Equipment used in Explosive Atmospheres" (SABS 086);

The contractor will be responsible for serving all notice and paying all fees due in terms of the above laws & regulations.

### 5. RADIO AND TV INTERFERENCE

All equipment installed under this Contract shall comply with the Government Notice. R.2246 and any other applicable rules and regulations in respect of radio and TV interferences. Any equipment found producing interference subsequent to commissioning shall be suppressed or replaced to the satisfaction of the Engineer without any additional cost.



## 6. PROTECTION OF EQUIPMENT AGAINST VOLTAGE SURGES AND SPIKES

Tenderers shall allow in their tender prices for adequate protection of the equipment supplied and installed under this Contract against direct as well as induced voltage surges and spikes which may be experienced on the system.

Surge arrestors shall be provided on each phase as well as neutral on the incoming power supply terminals of each board.

Electronic equipment shall be adequately protected on both the incoming and outgoing terminals as well as on both ends of cables leaving and entering a building by means of suitable arrestors compatible with the relevant equipment.

Arrestors shall be of COPA manufacture (as supplied by Surge Technologies (Pty) Ltd.) or similar.

All arrestors shall be connected to earth along the shortest possible route and only conductors of adequate rating for the discharge currents catered for shall be used for connections to arrestors.

Tenderers shall submit full particulars of the arrestors offered as well as written confirmation that it will provide adequate protection for the relevant equipment against possible voltage surges and spikes on the system.

## 7. DRAWINGS

Standard Drawing Sizes

The following standard drawing sizes are preferred.

|                                       |              |
|---------------------------------------|--------------|
| Electrical Single Line Diagrams       | A1 or A2     |
| Electrical Schematic Diagrams         | A3           |
| Electrical Wiring Diagrams            | A3           |
| Electrical Cable Schedule             | A3 or A4     |
| Electrical Connection Schedules       | A3 or A4     |
| Electrical Panel General Arrangements | A1, A2 or A3 |
| PLC Hardware Configurations           | A2, A3 or A4 |
| Electrical Substation Layouts         | A1           |
| Electrical Cable Routing and Racking  | A1           |
| Lighting Layout Drawings              | A1           |

A0 drawings are to be avoided due to the difficulty in physically handling the drawing. If an A0 drawing is reduced in size when using AutoCAD all scales shall be removed and the drawing designated "Not to Scale".

Document Format

The following defines which documents shall be prepared as "drawings" or which are to be prepared as computer generated schedules:

Drawings

Electrical Single Line Diagrams  
Electrical Schematic Diagrams  
Electrical Wiring Diagrams  
PLC I/O Schedule  
Electrical Panel General Arrangements  
PLC Hardware Configurations  
Electrical Substation Layouts  
Electrical Cable Routing and Racking  
Lighting Layout Drawings  
Electrical Equipment Lists



#### Schedules

Electrical Cable Schedules  
Electrical Connection Schedules  
PLC I/O Listings (optional as schedule)

Where document is specified as a schedule it shall be prepared as a spread sheet file with field names and lengths as specified.

#### Drawing Sheets

All drawings shall be drawn on the Employer's drawing sheets unless otherwise approved by the Engineer. Contractors may add their own logos, title blocks and numbers provided that the main title block is the Employer's title block. The requirement shall apply for the following drawings:

- Single line diagrams
- Schematic diagrams
- Equipment schedules

#### Drawing Numbers

All drawings shall bear the Project number as the main number. Contractors may add their number as a secondary number in which case the number shall be clearly identified as the contractor's number. This requirement shall apply for the following drawings:

Single line diagrams  
Schematic diagrams  
Equipment schedules

#### Equipment Numbering

All electrical equipment shall be numbered using an acceptable equipment numbering system. Provision shall be made on the drawings to incorporate this number.

#### Electronic format

All drawings, schematic diagrams and schedules shall be handed over to the Engineer on Compact Disk on completion of the project.

### **8. DRAWINGS SYMBOLS AND LETTERING**

#### Drawing Symbols

All electrical symbols shall be drawn as detailed in the South African Rationalized Specification NRS 002 – 1990 Graphical Symbols for Electrical Diagrams.

Symbol sizing shall be according to that specified in the NRS. Electrical symbols shall not be reduced in size to fit into a drawing. Attention shall be paid to the layout to allow for future drawing additions.

Where the NRS 002 – 1990 does not propose a suitable symbol reference shall be made to IEC 617, or a purpose made symbol may be developed. In such case the symbol selected from IEC 617, or created, shall be to the approval of the Engineer.

#### Lettering Requirements

The following lettering sizes shall be used (dimensions in mm)



| Item                                        | A0  | A1  | A2  | A3 & A4 |
|---------------------------------------------|-----|-----|-----|---------|
| Drawing Number                              | 7   | 7   | 7   | 5       |
| Mark, Item No. View, Section No.            | 5   | 5   | 5   | 3,5     |
| Title – in the block                        | 3,5 | 3,5 | 3,5 | 2,5     |
| Title under detailed item, info on sections | 5   | 3,5 | 3,5 | 2,5     |
| Letters and Figures (Body of Drawings)      | 3,5 | 3,5 | 2,5 | 2,5     |
| Exponents, Small Letters in SI Units        | 3,5 | 2,5 | 1,8 | 1,8     |

## 9. SPECIFIC REQUIREMENTS FOR SINGLE LINE DIAGRAMS

### General Requirements

Single line diagrams shall be updated regularly during the project to include plant additions as and when they occur.

### Pumping Station Overall Single Line Information Requirements

The plant overall single line diagrams shall not be over simplified for the sake of maximizing the amount of information on a single sheet. If necessary, the drawing shall be split into more than one sheet in a logical manner so that information is grouped by plant sections on each of the sheets.

For this purpose, the single line diagrams shall include the following information:

- Protection scheme details
- Cable sizes
- Cable lengths
- Transformer ratings, ratio, vector group and impedance
- Large motor details (typically only MV motors for overall single line diagrams)
- Supply authority substation details including transformer size and impedance

### Drawing layout

The overall single line drawing shall be laid out with the power flow from top to bottom or left to right. The drawing layout should avoid unnecessary crossing of lines.

### Individual Switchboard Single Line Diagrams

These drawings shall be comprehensive in detail and shall, along with the requirements listed for overall single line diagrams, show all the feeder and motor circuits connected to the board, with the following information:

- Rating of all circuit breakers
- Load details including rating and full load current
- Normal running load (calculated) of the incomer circuit(s).
- On the incomer circuit the source of the power shall be specified
- Cross reference to the overall single line diagram on which the specific single line diagram appears.

## 9. SPECIFIC REQUIREMENTS FOR SCHEMATIC DIAGRAMS

### Use of Multiple Drawing Sheets on One Drawing Number

Schematic diagrams for a particular plant item e.g. a Motor Control Centre, MV switchgear panels or similar shall be drawn under one drawing number with multiple sheets.



The set shall include a cover sheet (Sheet 1) and an index sheet (sheet 2, 3 etc. as required). The index sheet(s) shall list all drawings in the set and shall include the sheet number, drawing title and latest revision for that sheet.

#### Drawing information

The information depicted on a single schematic sheet shall be limited to the equipment within a particular panel cubicle. A panel cubicle may extend over more than one sheet but a sheet may not contain more than one panel cubicle's equipment and wiring schematic.

#### Grid System

Schematic diagrams shall be drawn on a grid system, columns numbered from 0 to 9 rows numbered from A. to E. Equipment shall be numbered and cross referenced on this grid system.

All n/o and n/c relay contacts and auxiliary contacts on equipment shall be listed in close proximity to the relevant component with cross reference to the specific sheet where that contact is utilized.

#### Schematic Diagram Layout

Schematic diagrams shall be laid out with a minimum spacing of 10mm between vertical lines. Components shall be laid out evenly in the horizontal plane with the requirements that relay type devices are drawn at the bottom of the sheet.

The power circuit section shall be drawn on the left of the schematic diagram.

#### Schematic Diagrams – Medium Voltage Switchgear

Each MV circuit shall have the schematics split over a number of sheeting as follows:

|                                   |                                                      |
|-----------------------------------|------------------------------------------------------|
| 1 <sup>st</sup> sheet in sequence | ac circuit details including protection and metering |
| 2 <sup>nd</sup> sheet in sequence | closing circuits                                     |
| 3 <sup>rd</sup> sheet in sequence | tripping circuits                                    |
| 4 <sup>th</sup> sheet in sequence | indication and interlocking with external devices    |

The drawing shall cross reference each other.

## 10. OPERATING MAINTENANCE MANUALS

#### General details

Separately bound operating manuals and maintenance manuals shall be provided.

Final versions of the operating and maintenance manuals shall contain the following sections:

- Equipment maintenance: Maintenance data  
Setting and resetting information  
General technical data including spare parts lists and drawings  
Fault diagnoses procedures
- Test and Guarantee: Protection test report  
Final test report
- Equipment operation: Operating instructions  
(Summary version)  
Start and stop instructions
- Equipment operation: Operating instruction (detailed version)
- Drawings: All relevant drawings



- Electronic version:                      Electronic version of all drawings  
                                                     Electronic copy of PLC programming software

#### Quantities

The following quantities of the above manuals shall be provided:

- Originals:                                      3 (with original brochures)

#### Preparation sequence

The above manuals shall be made available in the following sequence:

- Draft version:                                To be submitted to the Engineer for approval before the beginning of erection.
- Preliminary version:                      To be submitted when initial commissioning begins.
- Final version:                                To be submitted when acceptance tests are over.

#### Preliminary operating and maintenance manuals

During the commissioning period the Contractor shall submit two draft copies of each of the following, for all equipment supplied, for the Engineer's approval:

- Operating manuals (including technical data, check lists, procedures etc.)
- Maintenance manuals (with schedules of routine and regular maintenance and routine tests of equipment).
- Technical data manuals (including schematic wiring diagrams, particular technical data, adjustments details, reference lists, local agents for supply and repair, spare lists etc.).

#### Preparation of the final manuals

After the Engineer has approved the draft manuals described above, copies of each manual shall be supplied by the Contractor.

These manuals shall be permanently bound in book form, together with "as installed" drawings where applicable, with hard plastic covers able to withstand prolonged and repeated use.

Manuals shall be properly indexed to facilitate quick reference.

#### Preparation of the final manuals

The abovementioned copies of the final "Operating and Maintenance Instruction Manuals" shall be prepared as follows:

##### a) Binding

The manuals shall be securely bound in A4 size heavy duty hard backed plastic/waterproof 4 ring binders with clear pockets on the spine and front cover for insertion of title slips giving Contract number, scheme, dam and equipment supplied, etc.

##### b) Separate plastic pockets

Drawing larger than A3 size, index and other title pages shall be contained in separate pockets.

##### c) Layout



Each manual shall contain sections separated by subtitle sheets in plastic pockets that are clearly and visibly marked to match the index.

#### Sections of manual

These various sections of each manual shall be arranged as follows:

- Title page
- Index
- Final acceptance certificate relating to tests carried out
- Operating instructions: These should be clear, concise and easy to follow and must include where applicable pre-start, safety and shut down procedures
- Routine maintenance and lubricating schedules
- Fault diagnosis and repair procedures
- Spare parts lists; names of suppliers/agents' details
- Drawings: These shall include general arrangements, assembly drawings, parts and materials lists, etc. in A3 size. The names of suppliers/agents, original brochures and instrument literature shall also be included in the manual.

#### 11. ROUTE PLANS TO BE SUBMITTED BY THE CONTRACTOR

On completion of the work, but before the certificate of completion will be issued, the contractor shall submit to the Engineer, route plans as well as electronic copies, indicating cable routes in a satisfactory manner:

- (a) The exact cable routes with reference to fixed points (e.g. buildings);
- (b) The exact length of cable (HT and LT) installed between terminating points and between joints where relevant; and
- (c) The exact positions of cable joints with reference to fixed points (e.g. buildings).

Prints of the various plans for the marking up of the information required will be supplied to the contractor on request.

#### 12. INTERCHANGEABILITY

All equipment must be manufactured to such close tolerance that all similar components and spares must be fully interchangeable without any further alterations or adjustment being necessary.

#### 13. WATER AND DEBRIS ACCUMULATION

All outdoor equipment shall be designed so that water and debris will not readily accumulate to cause deterioration of equipment or an electrical discharge hazard. Where this cannot be avoided, such places shall be easily accessible for cleaning.

#### 14. NAME TAGS

Identification tags shall be attached to all equipment, sub-assemblies, components such as instruments, fuses etc., cable ends etc. The tags shall be screws on with brass or plated steel screws (no self-tapping screws will be permitted). Where screws are not possible such as on the cable, other means of attachment must be submitted for approval to the Engineer.

Cables shall be tagged at end, whether the end terminates in a through joint or an end box, and at regular intervals in between as prescribed in the Detail Specification. Outdoor tags shall be of stainless steel or brass.

Tags mounted indoors or protected by an enclosure shall be made of Ivorene or similar sandwich material with black letters on a white background.

All lettering and text shall be approved by the Engineer.



Letter sizes must be compatible with the application, e.g.

|                                     |             |
|-------------------------------------|-------------|
| For fuses, terminals, relays etc.   | 3 to 5 mm   |
| For panels or cubicles              | 12 to 20 mm |
| For switchboards or MCC board names | about 50 mm |

## 15. FASTENERS

All bolts and studs shall protrude at least one thread but not more than four threads through the nut, with all washers in position.

If any bolts, nuts, screws or other fasteners are placed in a position that are not accessible to conventional tools, then the Contractor shall provide special tools. This also applies where the size or shape of the fastener is not conventional.

## 16. COLOR AND FINISHING

All metal parts of equipment shall either be finished in baked enamel or powder coating or galvanized (depending on the circumstances) after manufacture and treatment to SABS 064.

Colors of paint to be used shall be confirmed with the Engineer prior to application.

All steel areas subjected to corrosive atmospheres, which cannot be painted and the paint work must be maintained afterwards, or specified to be galvanized must be hot dip galvanized to SABS 763. The galvanizing must be clean, smooth, of uniform thickness and unblemished. The galvanizing must not affect the mechanical properties of the covered metal.

All drilling welding, cutting and bending must be complete and the metal must be cleaned of any machining blemishes, mill scale, rust and lubricants before galvanizing. If site trimming, drilling and cutting cannot be avoided then all such denuded surfaces must be dressed with cold galvanizing paint.

The Engineer must approve any other proposed corrosion protection before it is applied.

Galvanized areas must be kept free of lubricants.

Wire must be galvanized to SABS 935.

## 17. LV CIRCUIT BREAKERS, ISOLATORS & SWITCHES

### MOULDED-CASE CIRCUIT BREAKERS

This section covers single or multi-pole moulded-case circuit-breakers for use in power distribution systems, suitable for panel mounting, for rating up to 1 000 A, 600 V, 50 Hz.

The circuit breakers shall comply with SANS 156:1977.

Only circuit breakers from reputable suppliers will be accepted. The Tenderer shall provide a technical schedule of all circuit breakers with supplier brochures to the Engineer before procuring any circuit breakers.

The continuous current rating, trip rating and rupturing capacity shall be as specified.

The contacts shall be silver alloy and shall close with a high-pressure wiping action.

Where specified, the circuit breaker shall be capable of accommodating factory fitted shunt trip or auxiliary contact units or similar equipment.

The operating handle shall provide clear indication of "ON", "OFF" and "TRIP" positions.



The mechanism shall be of the TRIP-FREE type preventing the unit from being held in the ON position under overload conditions.

All moulded-case circuit breakers in a particular installation shall, as far as is practical, be supplied by a single manufacturer.

The incoming terminals of single-pole miniature circuit breakers shall be suitable for connection to a common busbar.

The circuit breaker shall have a rating plate indicating the current rating, voltage rating and breaking capacity.

Extension type operating handles shall be provided for units of 600 A rating and above.

Where circuit breakers are cascaded, The Tenderer will submit proof from the supplier that the specific circuit breakers are suitable for cascading and the Tenderer shall also guarantee the proper functioning of the cascading.

#### **EARTH LEAKAGE RELAYS**

Earth leakage relays shall be single or three-phase units with a sensitivity of 30 mA, with associated circuit breaker or on-load switch for use on 220/250 V single phase or 380/433 V three-phase, 50 Hz, supplies.

The units shall be suitable for installation in switchboards in clip-in trays or bolted to the chassis.

The earth leakage relay shall function on the current balance principle and shall comply with SANS 767-1:1982 as amended, and shall bear the SABS mark. Integral test facilities shall be incorporated in the unit.

Circuit-breakers with trip coils used integrally with earth leakage units (two-pole for single-phase units and three-pole for three-phase units) shall comply with SANS 156:1977.

On-load switches used integrally with earth leakage units (two-pole for single-phase units and three-pole for three-phase units) shall comply with SANS 60947-3:2006.

The fault current rating of the unit shall be 2,5 kA or 5 kA as required / specified, when tested in accordance with SANS 156:1977.

#### **MIKROGAP SWITCHES**

Microgap switches shall be suitable for ratings up to 400 A at 660 V (triple-pole) and may be used for main and distribution switches in domestic applications, offices, small factories and similar applications.

Double-pole switches shall be suitable for voltages up to 250 V.

The switches shall comply with SANS 60947-3:2006.

Microgap switches may be used on AC circuits only.

Metal-clad and molded casings are acceptable.

Mikrogap switches shall be capable of carrying rated current continuously and making and breaking rated current.

Heavy, fully accessible, brass terminals with two screws each shall be provided to facilitate easy wiring. Contacts shall have large contact surfaces, made from high quality material such as solid silver.

The "ON" and "OFF" positions and the rating of the switch shall be clearly and indelibly marked.



### **TRIPLE-POLE ON-LOAD ISOLATORS**

This section covers switches suitable for panel mounting for use in power distribution systems up to 600 V, 50 Hz. Switches for motor isolation are included.

The switches shall be of the triple-pole, hand operated type complying with SANS 60947-3:2006.

The switches shall have a high-speed closing and opening feature.

The switches shall be suitably rated for the continuous carrying, making and breaking of the rated current specified as well as the through-fault current capacity as specified.

To distinguish the switches from circuit breakers the operating handles shall have a distinctive colour and/or the switch shall be clearly and indelibly labelled "ISOLATOR".

### **ROTARY CAM SWITCHES**

This section covers rotary cam switches used for control functions in switchboards, motor control centers, etc. up to 600 V.

The switches shall be equal or similar to "KLOCKNER-MOELLER" type T rotary cam switches and shall comply with BS 4794, IEC 337 and VDE 0133, where applicable.

The switches shall be of the cam actuated type with two breaks per pole. The required number of poles and number of control functions shall be provided by the assembly of switching units on a common spindle.

The spindle shall be operated by a control handle suitable for the method of installation of the switch. The control handle shall be located by a keyway on the spindle.

The switches shall be provided with a suitable faceplate of non-conductive material, indicating the angle of throw and the switch positions. The latching mechanism shall ensure positive positioning in accurate relation to the positions indicated on the faceplate.

The switches shall be suitable for use with the supply voltage level. The contacts shall be silver-plated or gold laminated and shall be suitably rated for the switching function intended.

For normal applications the making capacity of the switch shall be at least three times the normal current rating. For AC4 duties (inching, reversing, plugging) the rated current of the switch shall be at least equal to the stalled rotor current of the motor.

Special contacts, e.g. late-making, early-breaking, etc. shall be inherent in the design and shall not be improvised by loading or bending contacts, etc.

Time-delay units (if required) shall be of the electronic type with an adjustable time delay on energisation from 50 to 600 s. The units shall be suitable for clip-on rail mounting and supply voltage as specified.

### **TIME SWITCHES**

All time switches shall bear the SABS mark. Only reputable manufacturing suppliers will be accepted.

Time switches shall be of single-pole type, suitable for 220/250 V systems, with contacts rated for the duty to be performed with a minimum rating of 15 A. Contacts shall be of high-quality material, e.g. silver-plated or solid silver.

The time switch shall be housed in a dust-tight moulded plastic or metal case, consisting of a plastic clip-on front cover and a moulded plastic or metal base. Time switches to be used for surface mounting on walls shall be provided with a suitably positioned 20 mm conduit knock-out.

#### 6.1 Analogue



The clock shall be driven by a self-starting, hysteresis synchronous motor, keeping accurate mains time. All clocks shall be controlled by an electrically wound escapement providing the main spring with a minimum of 15 hours reserve in case of a power failure. The main spring shall be kept fully wound without the use of slipping clutch devices that may wear and fall out of adjustment.

The main spring shall have a minimum of 15 hours reserve under full load and if fully discharged, shall be completely rewound within 15 minutes of the restoration of power.

An external manual bypass switch shall be provided to permit the circuit or be switched "ON" or "OFF" manually without affecting the operation of the time switch.

The time switch shall have a 24-hour dial, with day and night indication, that can be set to switch in 30-minute steps. The dial shall be fitted with 48 tappets corresponding to 48 change-over operations in a 24-hour period.

The time switch shall be fitted with a day omission dial comprising a total of 14 tappets, which can be set to switch in 12-hour steps.

#### 6.2 Digital

The power supply shall be 240VAC 50Hz and allow for 85% to 110% fluctuation.

Degree of protection shall be IP66.

The timer shall have a display that can display at least 4 digits with an indicator for ON / OFF / AUTO modes.

The timer shall have an EEPROM with at least 8 different programs for both ON and OFF operations. The program memory shall not be erased when external power is lost. Memory to be retained for at least 10 years.

The interval for each program will be at least to 1 minute accuracy.

The timer shall have a battery backup that shall keep the date / time set for a duration of at least 24 hours. The battery shall be of the re-chargeable type.

The timer shall have a master reset button which can clear the EEPROM data.

### **CONTACTORS**

Contactors shall be of the open or totally enclosed, triple- or double-pole, electromechanically operated, air-break type suitable for 380/433 V or 220/250 V supplies and shall comply with SANS 60947-4-3:1999.

Contactors shall have the following characteristics:

- a) Enclosed coil easily replaceable.
- b) A permanent air gap in the magnetic circuit to prevent sticky operation.
- c) Provision for quick and simple inspection of contacts.
- d) Clearly marked main and auxiliary terminals.

All parts shall be accessible from the front.

Contactors, which are not located in switchboards, shall be housed in enclosures, which comply with IP 54 of IEC 144.

The current rating of the contactor shall be as specified for the circuit with a switching duty in accordance with the SANS 60947-4-3:1999 or IEC 158-1, utilisation category AC1 for lighting and power circuits and utilisation category AC3 for motor starting.



In addition to the required current carrying capacity and switching duty of a contactor, the contactor chosen for a particular application shall be rated for the maximum through fault current allowed by the back-up protection devices at the point where the contactor is installed. Careful co-ordination of short circuit devices shall take place.

All laminations of the magnetic system of the contactor shall be tightly clamped. Noisy contactors shall not be accepted.

Non-current-carrying metallic parts shall be solidly interconnected and a common screwed earth terminal shall be provided. The contactor shall be earthed to the switchboard earth bar.

Latched contactors shall be provided with a trip coil and a closing coil. The contactor shall remain closed after de-energising the closing coil and shall only trip on energising the trip coil.

Contactor operating coils shall have a voltage rating as required by the control circuitry and shall have limits on aeration and temperature rise as specified in Clause 7.5 and Table IV of IEC 158-1. Latched contactors shall be capable of being tripped at 50% of the rated coil voltage.

Contactors for normal/standby change-over circuits shall be electrically and mechanically interlocked. Contactors in star-delta starters shall be electrically interlocked.

Contactors with provision to add auxiliary contacts and convert auxiliary contacts on site are preferred. Contactors with permanently fixed auxiliary contacts shall have at least 1 x N/O and 1 x N/C spare auxiliary contacts in addition to the contacts specified for control purposes and in addition to contacts required for self-holding operations or economy resistances. Where the number of auxiliary contact required is greater than the number of contacts that can be accommodated on the contactor, an auxiliary relay or additional contactor shall be provided to supply the additional contacts.

It shall be possible to replace main contacts without disconnecting wiring.

Auxiliary contacts shall be capable of making, carrying continuously and breaking 6A at 220 V AC, unity power factor for contactors used on 380-433/220-250 V systems.

Auxiliary contact functions required e.g. "lazy" contacts, late-make, late-break, make-before-break, etc. shall be inherent in the contact design. Under no circumstances may these functions be improvised by bending contacts, loading contacts, etc. These functions shall be available in all contactors.

Spare auxiliary contacts shall be wired to numbered terminal strips in the switchboard and shall appear on the switchboard drawings.

All contactors on a specific project shall be from a standard range of one single manufacturer, unless specified to the contrary.

### **INDOOR SURGE ARRESTORS**

Surge arrestors shall comply with the requirements of SANS 61643-1:2003 or VDE 0675.

Surge arrestors shall be suitable for installation at altitudes of up to 1800m above sea level.

The unit shall be contained within a thermoplastic or cast resin housing and all internal components shall be fully sealed in.

The unit shall be supplied complete with a galvanised steel-mounting bracket for convenient mounting onto the metalwork or tray of a switchboard.

Alternatively, the unit shall be of the type, which can be mounted into the clip-tray of a switchboard.

Surge arrestors shall be provided in all cases where a switchboard is supplied directly from an overhead line.

The surge arrestor shall be of the Class I, II or III as specified complete with fuses and LED indication.



## **18. INSPECTIONS AND TESTS**

All equipment will be inspected and tested both in the factory during manufacturing and on-site during installation. The Engineer will prescribe the inspections and tests required elsewhere in this specification. The Engineer will do all inspections accompanied by the Contractor and the Contractor will do all tests with the Engineer as witness.

The Engineer will require seven (7) days notification to avail himself for any test or inspection and the Contractor must arrange for the maximum number of inspections and tests to be done on the same day. The Contractor must provide all testing facilities and instruments, all equipment required for a test or inspection and all safety clothing prescribed by the Engineer.

The instruments must have valid test certificates issued by an accepted testing authority and the results of the test done must be recorded on a test certificate, of which the Engineer must receive two copies. The Engineer reserves the right to call for a calibration test on any instruments used during the test.

The cost of all tests must be included in the tender price.

## **19. PERFORMANCE TESTS**

On completion of erection and installation the Contractor must carry out the following tests, where applicable, in addition to any other tests, which may be specified elsewhere:

Before commissioning

- (a) Cable Insulation test.
- (b) Earth continuity test.
- (c) Test for correct direction of rotation of motors and reverse if necessary.
- (d) Test for correct operation of control gear, setting of overload protection equipment, etc.
- (e) The Contractor must obtain SABS test certificates for samples of insulating oil in HT switchgear and transformers. These certificates must be submitted to the Engineer.

On completion of installation and putting into proper operation all the plant and equipment, the Contractor will be required to make suitable arrangements for the testing of all plant and equipment supplied under his Contract and running the plant for at least one week, during which time he shall also train the operators in the correct running of the plant. He shall also explain the maintenance manuals to the operator during this time.

The entire cost of testing including supply of test equipment, must be borne by the Contractor and an adequate allowance for such tests must be made in the Tendered price.

## **20. DEFECTS LIABILITY PERIOD**

During this period the Contractor must visit the Site at least three times, say 1, 6 and 12 months respectively after the Commissioning Date, to inspect and check all the plant supplied and installed by him for proper operation and to adjust where necessary, and to satisfy himself that the regular maintenance of the plant is being carried out correctly and in accordance with the written instructions supplied by him. The Contractor shall make sufficient provision in the correct price for these visits.

## **21. SPARES**

Tenderers shall submit on the appropriate Schedule in this document a list of spares and special tools which is recommended and should be kept by the Employer for maintenance of the plant. Spares which the Employer decides to order must be manufactured simultaneously with the rest of the equipment and be subjected to the same tests for dimensions, tolerance, strength, etc. All spares and special tools must be packed separately and the cases appropriately marked. All



spares and special tools must be new and unused and where possible should be standard to all sections of the plant.

## **22. INTRUDER ALARM SYSTEM**

The contractor shall be responsible for the supply, installation, commissioning and testing of the Intruder Alarm System.

The detail design and installation of the Intruder Alarm System shall be installation by a reputable Sub Contractor.

The alarm system shall consist of the following basic components:

- a. Control panel complete with integrated rechargeable sealed 12V battery
- b. Remote keypad
- c. Passive Infrared detectors
- d. Sounder / Alarm
- e. Power supply
- f. Interconnecting cabling

All components shall be sourced from reliable manufacturers with a proven record of successful products and acceptable support services.

Control panel shall be housed in a vermin and insect proof enclosure with appropriate cable connections.

The keypad shall activate and de-activate the alarm by a coded numeric key on the keypad and must only be changeable by authorised personnel using a Master Code. The master codes will not be issued for use except in extreme situations where a contractor has failed to perform as contracted or requested by the Client.

Passive Infrared detectors shall have adequate detection distance for its positioning and purpose with high reliability, 40 detection zones in a standard sealed optic lens with digital signal processing and LED indicator for alarm testing which can be switched off or covered. The detectors shall be installed according to the drawings and connected to the alarm controller with pre-agreed zones.

Magnetic proximity devices (reed switches) for hinged doors shall have the magnetic portion of the device secured to top of the door with the reed switch portion secured to the top of the door frame and aligned with the magnetic portion of the device. Roller or tilt type doors will have the devices secured to the bottom of the doors.

The system shall be supplied from the essential power distribution board unless specifically otherwise directed.

The audible siren shall be mounted to the external wall and indicated on the drawing.

All cabling and cabling methods shall be in accordance with recognised best industry practice and regulations. All cables shall be installed in a 20mm conduit or trunking.

All equipment shall be fully compatible, expandable by the addition of modular units and complete with all connections between individual components to ensure correct operation of the completed system.

The equipment shall be suitable for the environment in which it is anticipated to operate. The system shall be designed and installed not to be adversely affected by external environment conditions or influences.

All detectors, control panels, equipment housings shall have factory installed with anti-tamper devices and shall be wired in such a manner that any attempt to compromise the system will give a tamper indication when the system is de-activated and a tamper alarm when the system is activated.



The contractor shall on completion of the Intruder Alarm System installation:

- a. Fully test the system in the presence of the Engineer and Client representative.
- b. Provide training on the effective use of the system to client representatives and keep an attendance register of such training which must be submitted as part of the compliance certification with the As-Built documentation.

The complete system and all equipment shall be in current production and shall carry a minimum 12-month warranty against failure or reduction in technical performance from the date of practical completion.

## **23. DISTRIBUTION TRANSFORMERS**

The transformer shall be designed and manufactured in strict accordance with the latest editions of NRS 054, SANS 780 and SANS 60076 as amended.

The transformer to be supplied shall be 500kVA, 11kV/415V Dyn11, ONAN, OCTS, sealed type.

It is required that the transformer be equipped with the following fittings:

- a. All windings shall be copper conductors
- b. Off circuit tapping switch
- c. Sealed
- d. Skid underbase
- e. Mounting holes
- f. Jacking pads
- g. All bushings (creepage 31mm/kV)
- h. Dial type thermometer
- i. Malthoid gasket

The transformer shall be designed with dimensions to fit into the designated transformer room.

All radiators are to be hot dipped galvanised to SANS 121.

### **Primary and Secondary Bushings**

The Primary and Secondary bushings shall be in strict accordance to the latest edition of SANS 1037. Unless otherwise specified, the bushings shall be of the outdoor type with a creepage of not less than 31mm/kV.

### **Dial Type Thermometer**

Dial type thermometers shall be graduated in °C for registering "top oil" temperatures. The instrument shall indicate the normal operating temperature of the transformer oil and shall furthermore be equipped with a resettable maximum temperature indicator and a pair of adjustable alarm contacts.

### **Sound Level**

During the design and manufacturing stage of all the transformers, care shall be taken to limit transformer noise and vibration to the level at present being attained in good practices. The transformer sound levels set out in Table 6 of SANS 780 may be used as a guideline.

### **Identification Tags**

All data on the identification tags shall be in the SI system and written in English.

### **Transport & Off-Loading**

Transportation, loading and off-loading shall be done by competent personnel and proof of experience shall be submitted for acceptance to the Engineer at least one month prior to planned operations.

### **Tests and Commissioning**

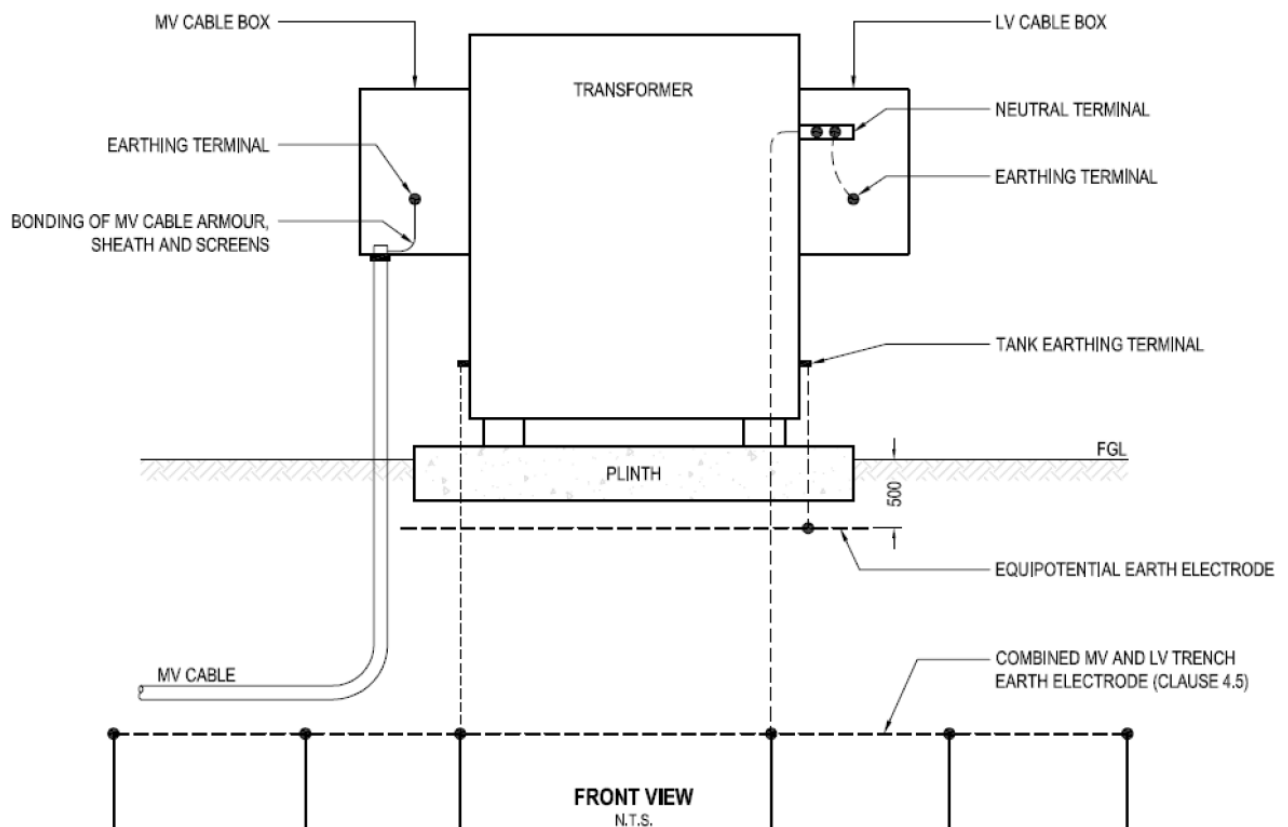
- a. All tests shall be arranged to represent working conditions as closely as possible and shall be carried out strictly in accordance with the standards and specifications and NRS 054, SANS 780 and SANS 60076.
- b. All type and routine tests shall be carried out before dispatch to site at the manufacturer's plant. The test results and certificates must be provided to the Engineer before dispatch.
- c. All test certificates shall be in English.

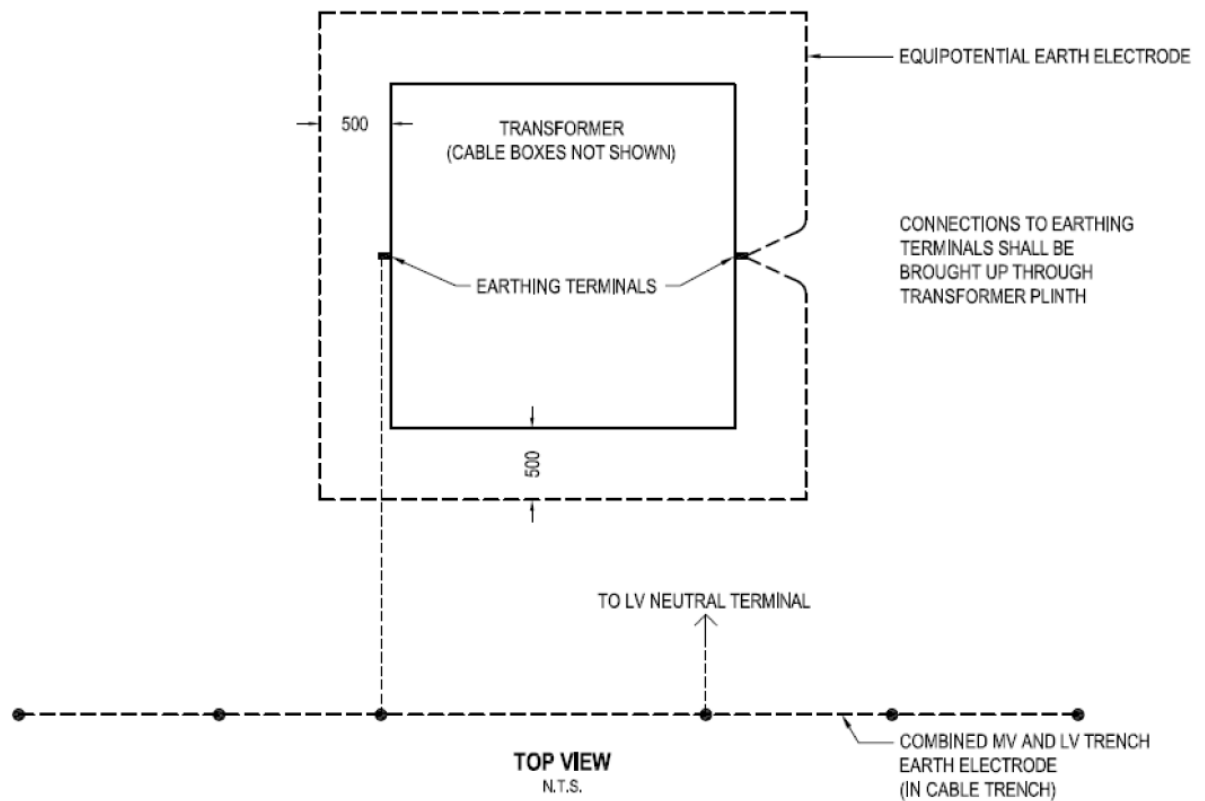


- d. Routine testing as required by BSS 171 and IEC 76 shall be carried out. The tests conducted at the factory will be witnessed by the Engineer and one other person from the Employer. Where required, provision shall be made in the tender price for return flights, transport and accommodation from Richards Bay.
- e. The Contractor shall certify that all insulating oil supplied in this contract is P.C.B. free.
- f. Original test certificates or certified copies of all tests carried out in the factory and on site shall be provided with the As-built drawings and manuals at handing-over.
- g. All test certificates must be submitted in hard copy and electronically in Adobe Acrobat – PDF format to the Engineer before hand over.
- h. Once the transformer has been electrically connected, a full-on site commissioning of the new transformer, new tap change scheme and protection scheme shall be carried out.

#### Earthing

- a. The transformer shall be connected to the substation earth as per NRS 054 earthing details for power transformers.
- b. Earthing shall be by means of 3 x 50mm flat copper tails.
- c. The neutral point of the 400V winding of the transformers shall be solidly connected by means of two 50 mm x 3 mm copper earthing straps, laid one upon the other, shall not be less than that of the connection provided at the neutral terminal of the transformer.
- d. Transformer earthing shall be as follows:





## 24. DIESEL ALTERNATOR GENERATING SET

### 24.1 General

This specification covers the design, manufacture, assembly, delivery to site, off-loading, installation, testing, commissioning and handing over a new and in first class working order of a complete sound attenuated self-contained emergency diesel alternator generator set and all ancillary equipment necessary and to comply with the requirements of this specification.

The plant generally shall comprise a diesel engine coupled to an alternator mounted on a steel fabricated base frame that incorporates an integral fuel tank, starting batteries, automatic charging unit, interconnecting cables, a control panel housing the generator M.C.C.B. with all necessary switchgear, change-over starting and interconnecting cables and on-load bypass switch.

Any deviation from this standard specification or additional information will be given in the specific specification. In case of contradiction between this standard specification and the specific specification, the specific specification shall apply.

Full particulars, performance curves and illustrations of the equipment offered, must be submitted with the tender. Tenderers may quote for their standard equipment, complying as closely as possible with this specification, but any deviations from the specification must be fully detailed.



The questionnaire following this specification must be completed by Tenderers in all respects.

All equipment used shall be new and durable quality.

The Client reserves the right to accept any portion of any tender and does not bind itself to accept the lowest or any tender.

## 24.2 Site conditions

The stand-by generator set herein specified is to be installed at Hartswater WTW.

The following site conditions will be applicable and equipment shall be suitably rated to develop their assigned rating and duty at these conditions:

| Description                                 | Condition |
|---------------------------------------------|-----------|
| ht above sea level                          | [1500m]   |
| imum ambient temperature                    | 45°C      |
| imum ambient humidity at lowest temperature | 98%       |

The new generator set shall to be installed in an existing generator room and to fit on the existing plinth.

The main incoming and outgoing power cables will be provided by others, but termination of these and all other works required for the successful completing and commissioning of the plant shall form part of these works.

Tenderers are advised to acquaint themselves with the site conditions including access, as no claim on the grounds of lack of knowledge will be entertained.

## 24.3 Output power rating & voltage

After the de-rating factors for the engine and alternator have been taken into account, the generator must have a site output and voltage as follows:

| Description                                             | Specification |
|---------------------------------------------------------|---------------|
| No load voltage – 3 phase, 4 wire system requirements   | 415/240V      |
| Full load voltage – 3 phase, 4 wire system requirements | 400/230V      |
| Rating at 0.8 power factor                              | 500kVA        |
| From start-up - 60% of initial load within              | 15sec         |
| Balance of 40% of the load after a further              | 10sec         |
| Frequency                                               | 50Hz          |
| Noise level dbA at 7m                                   | <70dbA        |



## 24.4 Construction

The engine and alternator set shall be built together on a common hot dipped galvanised steel base frame with anti-vibration mountings between the engine/alternator combination and base. The set must be able to be placed direct onto the plant room concrete floor.

The frame must be of the " DUPLEX " type.

The generator set shall be bolted to the base frame by means of stainless steel bolts, nuts and washers.

Provision shall be made in the design of the base for outgoing cables and the main earth connection to pass through and to be connected and disconnected whenever necessary.

## 24.5 Operation

The diesel generating set and its ancillary equipment shall normally operate as an automatic mains failure unit. It shall be capable of delivering its full rated output at any time and any ambient conditions likely to occur at the site. The set is required to supply the essential power requirements in the case of a mains supply failure and be rated for continuous service.

The generating set will not be required to be synchronized with the main supply.

The set shall be fully automatic i.e. It shall start when any one phase of the mains supply fails and shall shut down when the normal supply is re-established. In addition, it shall be possible to manually start and stop the set by means of pushbuttons on the switchboard.

The automatic control shall make provision for three consecutive starting attempts. Thereafter the set must be switched off, and the start failure relay on the switchboard must give a visible and audible indication of the fault.

To prevent the alternator being electrically connected to the mains supply when the mains supply is on, and visa-versa, a safe and fail proof system of suitably interlocked contactors shall be supplied and fitted to the change-over switchboard.

Important notice: The Tenderer must submit, together with his offer, the design of the control system to comply with the requirements for automatic starting, stopping, interlocking and isolation as specified.

Essential power from the stand-by generating plant will be required for 72-hour continuous running capacity including the day tank and bulk fuel tank.

## 24.6 Engine

### 24.6.1 General

The engine must comply with the requirements laid down in BS 5514 and must be of the atomised injection, compression ignition type, running at a speed not exceeding 1500 r.p.m. At normal full load conditions. The engine must be rated for the required electrical output of the set, when running under any of the specified extreme site conditions.



The engine shall be of the multi cylinder, four stroke cycle, cold starting, direct fuel injection, compression ignition type, suitable for operation on commercial grade diesel fuel.

Any one of the following manufacturer's engines may be used: John Deere, Perkins, Deutz, Volvo, Mitsubishi, Caterpillar or similar approved and confirmed by the Engineer in writing prior to closing of the tender.

The starting period for either manual or automatic switching-on until the taking over by the generating set of a load equal to the specified site electrical output, shall not exceed 15 seconds. This must be guaranteed by the Tenderer.

Turbo-charged engines will only be accepted if the Tenderer submits a written guarantee that the engine can deliver full load within the specified starting period.

Curves furnished by the engine makers, showing the output of the engine offered against the speed, for both intermittent and continuous operation as well as fuel consumption curves when the engine is used for electric generation, must be submitted with the tender.

#### 24.6.2 Rating

The rating of the diesel generating set shall be based on operation of the set when equipped with all necessary accessories such as radiator fan, air cleaners, lubricating oil pump, fuel transfer pump, fuel injection pump, water circulating pump, and battery charging alternator.

The set shall be capable of delivering the specified output continuously under the site conditions, without overheating. The engine shall be capable to deliver an output of 110% of the specified output for one hour in any period of 12 hours consecutive running in accordance with BS 5514.

In addition, the engine shall be capable of delivering 110 % load for one hour, after the set has been running at full load for a period of six hours and shall, after the overload period of one hour be capable of maintaining the rated output continuously without any undue mechanical strain, overheating, incomplete fuel combustion or other adverse effects.

The engine shall have sufficient capacity to start up and shall within 15 seconds from mains failure, supply the full rated load at the specified voltages and frequency.

#### 24.6.3 Derating

The engine must be de-rated for the site conditions as set out in this document.

The derating of the engine for site conditions shall be strictly in accordance with BS 5514 of 1977 as amended to date. Any other methods of derating must have the approval of the Client and must be motivated in detail. Such derating must be guaranteed in writing and proved by the successful Tenderer at the site test.

#### 24.6.4 Starting and Stopping

The engine shall be fitted with a 12/24 volt starting system of sufficient capacity to crank the engine at a speed, which will allow starting of the engine. The engine shall easily start from cold condition without the use of any special ignition devices under summer as well as winter conditions.



The starting equipment shall include a D.C. starter motor engaging directly on the flywheel ring gear.

Tenderers must state what type of heating is provided to ensure easy starting in cold weather. Full details of this equipment must be submitted. In the case of water-cooled engines, any electrical heaters shall be thermostatically controlled.

The electrical circuit for such heaters shall be taken from the control panel, and must be protected by a suitable circuit breaker.

#### 24.6.5 Starter Battery

The set must be supplied with a fully charged heavy duty type battery, charging alternator and maintenance free batteries.

The battery shall be one of the following reputable manufacturers: Willard; Exide; Delco/Deltec or similar approved by the Engineer prior to ordering.

The batteries shall be mounted in a lockable battery box being protected against the corrosive action of the battery electrolyte.

The battery must have sufficient capacity to provide the starting torque stipulated by the engine manufacturer. The battery capacity shall be capable of providing three consecutive start attempts from cold and thereafter a fourth attempt under manual control of not less than 20 seconds duration.

The batteries shall be connected to the engine with suitably rated P.V.C. insulated flexible leads.

The batteries shall have sufficient capacity to provide three automatic attempts to start immediately followed by three manual attempts without any appreciable drop in voltage. The automatic attempts to start shall each be of not less than 10 seconds duration with 10 second intervals between and the manual attempts shall be based on the same cranking period.

A device shall be provided to limit the cranking time of each automatic attempt to start, to the 10 seconds specified above and to provide three automatic attempts after which the automatic starting mechanism will cut out until manually reset and at the same time sound an audible alarm and illuminate the L.E.D. on the AMF 120 controller. The engine driven battery charging alternator shall have sufficient capacity to recharge the batteries back to normal starting requirements in not more than six hours.

A battery charging unit of the trickle charge type shall be provided to maintain the batteries at full capacity. The charging equipment shall be connected so that the battery is normally charged from the mains, but is also charged under mains failure conditions from the diesel generating plant and if required, via an inhibitor relay to prevent dual charging. The unit shall be complete with voltmeter, push button test, D.C. and A.C. protective gear. The charging unit shall be incorporated in the diesel generator control cabinet.

#### 24.6.6 Cooling

The engine shall be of the water-cooled type and the cooling system shall be of sufficient capacity to cool the engine when the set is delivering its full rated load in the ambient conditions specified.



The engine shall be equipped with a heavy-duty tropical type pressurised radiator complete with engine driven fan and centrifugal water circulating pump and a thermostat to maintain the engine at the manufacture's recommended temperature level.

A thermostatically controlled immersion heater shall be provided and fitted in the engine cooling circuit to ensure easy starting of the engine at any ambient temperature. The heater shall be fitted that it can easily be withdrawn without having to drain the system. The heater shall be suitable for a 230 volt 50 Hz supply.

A low radiator level shutdown sensor switch shall be fitted in the radiator header tank. A separate temperature sensor must be fitted on the block for the normal high engine temperature shutdown and gauge for protection against running at excessive temperatures. The operation of this protective device must give a visual and audible indication on the switchboard.

Water-cooled engines shall be supplied complete with engine cooling system shall be supplied filled with pure glycol or anti-freeze liquid and be fitted with a low-water, cut-out switch installed in the radiator, to switch the set off in the event of a loss of coolant. The protection shall operate in the same way as the other cut-outs (e.g. Low oil pressure).

A permanent notice is to be affixed adjacent to the header tank that only anti-freeze or clean water is to be used for filling or topping up purposes.

All air ducts for the cooling of the engine are to be allowed for.

#### 24.6.7 Radiator Extract Ducting

A galvanized duct shall be provided and installed between the radiator face and outlet louver to positively duct the hot expelled air out of the plant room.

The air shall not re-circulate in the room and the air duct shall fully cover and enclose the space between the cooling fan cowling/ radiator face to the air outlet louvers in the wall.

#### 24.6.8 Air Cleaners

The engine shall be provided with one or more dry type air cleaners which shall provide positive air filtration.

#### 24.6.9 Lubrication

The engine shall be provided with a forced feed lubricating system with a gear type lubricated oil pump for supplying oil under pressure to the main bearings, crank pin bearings, pistons, piston pins, timing gears, camshaft bearings, valve rocker mechanism and all other moving parts.

Full flow replaceable element type oil filters, conveniently located for servicing, shall be provided. Filters shall be provided with a spring-loaded by-pass valve to ensure circulation if the filters become clogged.

An automatic low oil pressure cut-out must be fitted, operating the stop solenoid on the engine and giving a visible and audible indication of the switchboard.

#### 24.6.10 Cylinder liners

The engine shall be provided with removable wet or dry type cylinder liners of close grained alloy iron.



#### 24.6.11 Fuel and fuel pump

The engine and fuel injection equipment shall be capable of satisfactory performance on a commercial grade of distilled petroleum fuel oil such as number 2 fuel oil, (commercial grade diesel fuel normally available in South Africa).

#### 24.6.12 Day fuel tank

The fuel tank shall be an integral part of the base frame of the generator set. The tank shall have sufficient capacity to run the engine on full load for a minimum period of 12 hours.

The tank shall be fitted with a suitable filter, gauge, removable inspection cover, drain, filler cap, low level and extra low shutdown alarm sensors. These shall supply an audible and visible signal on the control panel.

A water trap and fuel filter must be fitted in the fuel pipeline from the tank to the engine.

The tank shall have a removable cover suitable to facilitate the cleaning of the tank. The cover, with packing, shall be bolted in position with four bolts.

A drainage valve shall be fitted to the tank to drain sludge and water.

The tank shall be fitted with a mechanical contents indicator or meter calibrated 0% to 100%. A sight tube type will not be acceptable.

A visual level gauge, removable inspection cover, drain, low level and extra low-level shutdown alarm sensors shall be provided which shall supply an audible and visible signal on the control panel. The tank shall be provided with a filler cap which is positioned to conveniently facilitate the filling of the tank from a 20 litre container.

The interconnection fuel piping between the engine and day tank shall consist of copper tubes and the connection to vibrating components shall be in flexible tubing with armoured covering.

The set shall be supplied with switches and sensors to start and stop the electric self-priming electric pump. The pump shall be complete with fuel piping and be connected to the bulk fuel tank.

In addition, the set shall be supplied with a hand operated "wing pump" and a suitable length of oil-resistant hose. The hose shall be of the "push lock" type and shall be sufficient in length to extend to the door for filling from 200 litre drums.

#### 24.6.13 Bulk fuel tank

The composite bulk fuel tank together with all interconnecting supply and return pipes, low level alarm, fuel level indicators, lockable shut off valves, breather and an automatic filling system shall be provided. This installation shall be carried out by a specialized petrochemical installation Contractor in accordance with SABS 0131 Part 2/1979 and SABS 089 Part 3/1991. The existing bulk fuel tank is positioned as adjacent to the existing generator room.

The automatic filling of the day tank, from the bulk tank, shall be controlled by level switches mounted in the day tank.



The bulk tank shall be encased in a bund walled area that is of sufficient size to contain any spillage equivalent in volume of the bulk storage tank.

The containment area shall be fitted with an outlet pipe located at floor level and a lockable valve located on the outside of the bund wall.

The complete system including bulk and day tank shall be sized to allow the set to run continuously for 72 hours at full load.

#### 24.6.14 Governor

The speed of the engine shall be controlled by the latest electronic type controller, or by a Class A1 accuracy governor to maintain a speed for 50 Hz during any operational or site conditions.

The permanent speed variation between no load and full load shall not exceed 4, 5% of the nominal engine speed and the temporary speed variation shall not exceed 10%. External facilities must be provided on the engine to adjust the nominal speed setting by  $\pm 5\%$  at all loads between zero and rated load.

#### 24.6.15 Exhaust system & silencer

The engine shall be fitted with an efficient stainless steel exhaust system. Flexible bellows shall be fitted between the exhaust outlet and the silencer. The exhaust silencer shall be suitably lagged then clad in polished stainless steel sheet.

The flexible piping must at no account be used to form a bend or compensate for misalignment. The silencer and discharge piping shall be suitably supported with stainless steel brackets, nuts, bolts and washers.

The silencer shall be located in the plant room and the discharge pipe run from the silencer out through the wall. The silencer shall be of the highly efficient type suitable for use in residential areas and shall be capable of providing 20 to 30 decibels of suppression.

The exhaust pipe shall be installed in such a way that the exhaust fumes will not cause discomfort to the public or adjacent activities.

The exhaust pipe must be flexibly connected to the engine to take up vibrations transmitted from the engine, which may cause breakage. The exhaust piping and silencer shall be lagged to reduce the heat and noise transmission into the plant room and shall be protected against the ingress of driving rain at 45° to the horizontal. The pipe must extend minimum of 0,5m above the room guttering.

Openings through the wall are to be neatly drilled and stainless steel flashing plates must be fitted on both sides.

#### 24.6.16 Flywheel

A suitable flywheel must be fitted, so that lights supplied by the set will be free from any visible flicker.

The flywheel shall be designed to limit the cyclic irregularities to within the limits laid down in BS. 5514 as amended.

#### 24.6.17 Engine instruments



The following instruments with suitable limit markings shall be provided on the generator panel:

- Water temperature gauge. The gauge shall be calibrated at the lower part of the temperature range, so that when the engine is inoperative, the temperature of the water is readable when heated by the immersion heater only. The temperature range shall extend beyond the operating range of the engine.
- Lubricating oil pressure gauge.
- Battery charging ammeter.

#### 24.6.18 Accessories

The engine must be supplied complete with all accessories, air and oil filters, three (3) instruction manuals and a comprehensive spare part list.

An easily removable drip tray must be fitted under the engine. The tray must be large enough to catch all dripping from any part of the engine.

### 24.7 Alternator

#### 24.7.1 Construction and manufacture

The generator shall be a revolving field type, coupled directly to the engine flywheel through a flexible disc for positive alignment. The generator housing shall bolt directly to the engine flywheel housing and shall be equipped with a heavy-duty ball bearing support for the rotor. The motor shall be dynamically balanced up to 25 % over speed.

The generator shall be of heavy-duty compact design. Insulation shall be Class H to BS 5514.

The generator field excitation shall be performed by a rotating exciter mounted on the generator motor shaft through a brushless rotating diode system. The voltage regulator shall be of the static-magnetic type with silicon diode control. It shall be mounted on the top or side of the generator and enclosed in a drip proof enclosure.

The alternator shall be of the self-excited brushless type, with enclosed ventilated drip-proof housing and must be capable of supplying the specified output continuously with a temperature rise not exceeding the limits laid down in BS 5000 for rotor and stator windings.

Both windings shall be fully impregnated for tropical climate and must have an oil resisting finishing varnish.

The alternator manufacturer shall be one of the following reputable names and any one of the following manufacturer's engines may be used: Leroy Somer, Marelli Motori, Newage Stamford or similar approved by the Engineer in writing.

#### 24.7.2 Regulation

A built-in voltage adjusting rheostat shall provide 10 % voltage adjustment.

The alternator must be self-regulated in accordance with BS 4999 Part 4 of 1977 - Class VR 2.31.



The inherent voltage regulation must not exceed plus or minus 2,5% of the nominal voltage specified, at cold or hot conditions and all loads with a power factor between unity and 0,8 lagging and within the driving speed variation of 4,5% between no-load and full load.

The shape for the voltage and current wave shall be within the limits laid down by BS 5000.

Upon application of any load specified in transient, maximum voltage dip shall not exceed 20% of the nominal voltage when measured at the alternator terminals.

#### 24.7.3 Performance

The excitation system shall be designed to promote rapid voltage recovery following the sudden application of the full load. The voltage shall recover to within 2,5% of the steady state within 300 milliseconds following the application of full load and the transient voltage dip shall not exceed 18%.

Upon application of any load specified in transient, maximum voltage dip shall not exceed 20% of nominal voltage when measured at the alternator terminals.

The alternator shall be capable of delivering continuously delivering the full rated load specified output of 110% of the specified output, for one hour in any period of 12 hours consecutive running.

#### 24.7.4 Windings

The alternator stator windings shall be star connected with the star point brought out and connected to the neutral terminal in the terminal box to provide a 400/230 volt supply under full load conditions.

#### 24.7.5 Terminal box

The terminal box shall be fitted to suit the cable route and it shall be large enough to allow for glanding and connecting the cables specified.

#### 24.7.6 Radio and TV interference

The alternator set shall be suppressed within the limits of BS 800 against radio and television interference against radio and television interference in accordance with South African statutory requirements.

#### 24.7.7 Couplings

The engine and alternator must be directly coupled by means of a high-quality flexible coupling, equal and similar to the "HOLSET" type.

### 24.8 Change-over switchboard and control panel

#### 24.8.1 Construction

The panel shall be designed for the control of the diesel generating set with instrumentation and protective devices to meet both manual and automatic mode requirements.

The control panel shall have a robust construction; floor mounted, totally enclosed and dust proof.

The switchboard shall be of the free-standing type, manufactured from 3CR12 steel, carried on a substantial framework construction with front entry through hinged doors.

Internal chassis plates, circuit breaker pans and gland plates shall be provided.



The gland plate shall be suitably braced to prevent distortion after the cables are secured thereto.

Suitably size holes shall be punched in the gland plates for the required number of cable terminations for both incoming and outgoing cables. Holes which are not used must be blanked off with blind grommets.

Cables shall be secured to the gland plate by means of SABS approved glands. Cable glands shall be Pratley, CCG, type or similar approved.

Special attention shall be given to vermin proofing and dust sealing.

All hinged doors shall have suitable bracing to ensure rigidity with heavy duty hinges and door handles.

Prior to painting, all steelwork must be thoroughly degreased and de-rusted and then primed with a zinc chromate primer. All internal steel chassis plates, gland plates and switchgear brackets shall be painted with two coats of white powder epoxy paint and all exterior steel surfaces finished with red powder epoxy paint.

The switchboard must be supplied and installed to incorporate the equipment necessary for the control and protection of the generating set, the automatic change-over, and the battery charging.

The control panel shall be flush fronted with all equipment to be mounted back on the front panel on suitable supports.

All equipment, connections and terminals shall be easily accessible. The front panels may be either hinged or be removable and fixed with studs and chromium-plated cap nuts.

Self-tapping screws shall not be used in the construction of the board.

#### 24.8.2 Cabling, bus-bars, wiring & switchgear

The Contractor shall install all interconnecting cables between the alternator and control panel.

All cabling, bus-bars and wiring shall be adequately rated and suitably supported.

Control wiring shall be neatly laced and numbered with durable plastic ferrules, for easy tracing.

Suitable terminals are to be provided for incoming and outgoing cables.

Circuit breakers shall be of moulded case construction.

All instrumentation shall be of 1,5 % accuracy and their performance shall comply with BS 89. The instruments shall be flush mounted and the dial dimensions shall be 96 mm x 96 mm.

Tenderers must give an assurance with their tender that replacements for the equipment, switchgear and instruments used in the construction of the panel are readily available from stock held in the Republic of South Africa.

All switch and control gear shall be rated for the highest of the system fault level specified or the generator fault level.

All pushbuttons, pilot lights, control switches, instrument and control fuses, shall be mounted on hinged panels with the control wires in flexible looms.



Suitably rated terminals must be provided for all main circuits and the control and protection circuits. Where cable lugs are used, these shall be crimped onto the cable strands. Screw terminals shall be of the type to prevent spreading of cable strands.

All terminals shall be clearly marked.

For the control wiring, each wire end shall be fitted with a wire marker of approved type and numbering of these markers must be shown on the wiring diagram of switchboards.

Control wiring shall be installed in PVC trunking as far as possible. The trunking shall be properly fixed to the switchboard steelwork. Adhesives shall not be acceptable for the fixing of trunking or wire looms to the steelwork.

The automatic control and protection equipment shall be mounted on a separate easily replaceable small panel with printed circuits. The equipment shall mainly be the "solid state" type. After mounting the equipment on the panel, the rear of this panel shall be sealed with epoxy-resin. However, other proven control systems may also be considered, but must be described in detail.

All equipment on the switchboard, such as contactors, isolators, bus bars, etc. Shall have ample current carrying capacity to handle at least 110% of the full load alternator current.

#### 24.8.3 Switchgear

One triple pole MCB rated to suit the generator offered and shall have both adjustable thermal and instantaneous overload elements.

Alternators over 150kVA:

One set of four pole automatic change-over isolators with motor operated mechanisms (minimum rating of 630A) with appropriate auxiliary and control contacts complete with electrical and mechanical interlocking arrangements to the approval of the Client.

One on-load hand operated by pass switch (minimum rating of 630amps) of the isolator type with three operating positions labeled "NORMAL", "OFF" and "BYPASS" to enable the change-over equipment and control circuitry to be by-passed for maintenance purposes.

The units are to be Stromberg type or similar approved.

#### 24.8.4 Alternators under 150kVA

One set of four-pole suitably rated contactors with electrical and mechanical interlocking arrangements with appropriate auxiliary and control contacts to the approval of the Client. The units are to be Stromberg type or similar approved.

No by-pass switch is required.

3 x open ring CT's suitably scaled.

110% full load rated phase, neutral and earth bus-bars.



## 24.9 Control, protection and alarm devices

Only a solid-state programmable system will be accepted.

Control systems may not consist of the electromagnetic relay type.

Only the AMF120 MK4 or equivalent solid state programmable systems complying with the following will be accepted:

The solid-state control systems shall be of South African manufacture.

Be available "off the shelf".

Has a proven local operating history of at least five years.

Imported or specially made solid state control systems or engine control and/or management systems will not be acceptable under any circumstances.

The control system shall consist of a single unit including all indicators/switches and allow for quick installation using locking connectors.

The solid-state controller and associated systems wiring shall be in accordance with the manufacturer's guidelines and shall be adequately protected against transient over voltages arising from lightning effects, switching and power system surges and alternator borne noise or interference. Full details of the suppression system must be provided with the tender. Wiring to and from the solid-state programmable controller shall be screened where necessary to prevent electrostatic and magnetic interference.

A circuit breaker and an adjustable current limiting protection relay must be installed, for protection of the alternator. The protection relay shall be of the type with inverse time characteristics. The relay shall cause the contactor to isolate the alternator and stop the engine.

Protection must be provided for high engine temperature, low lubricating oil pressure, over speed, start-failure, low water level, low fuel level.

Individual relays with reset pushes are required, to give a visible signal and stop the engine when any of the protective devices operate. In the case of manual operation of standby sets, it shall not be possible to restart the engine by pushing the reset.

Panel indicators and re-set pushes must be clearly marked or displayed.

The controller status including warning and shutdown/ critical alarms shall be indicated by a combination of LEDs and messages on the LCD display.

The following indications and alarms shall be provided:

| Item | Condition          | LED | Display Message | Alarm | Cut-out | Reset |
|------|--------------------|-----|-----------------|-------|---------|-------|
| a    | Overload           |     | X               | X     | X       | X     |
| b    | High Temperature   |     | X               | X     | X       | X     |
| c    | Oil Pressure Low   |     | X               | X     | X       | X     |
| d    | Over / Under Speed |     | X               | X     | X       |       |



| Item | Condition                               | LED | Display Message | Alarm | Cut-out | Reset |
|------|-----------------------------------------|-----|-----------------|-------|---------|-------|
| e    | Heater Fault                            |     | X               | X     | X       |       |
| f    | Fuel Low                                |     | X               | X     |         | X     |
| g    | No Fuel                                 |     | X               | X     | X       |       |
| h    | Water Level Low                         |     | X               | X     | X       |       |
| i    | Emergency Stop                          | X   | X               | X     | X       | X     |
| j    | Start Failure                           |     | X               | X     |         | X     |
| k    | Mains & Alternator On                   | X   |                 |       |         |       |
| l    | Mains & Alternator Phase Rotation Fault |     | X               | X     | X       |       |
| m    | Mains & Alternator Over Voltage         |     | X               | X     | X       |       |
| n    | Mains & Alternator Under Voltage        |     | X               | X     | X       |       |
| o    | Battery Voltage Low                     |     | X               | X     |         | X     |
| p    | Battery Charger Fault                   |     | X               | X     |         | X     |
| q    | Control System Fault                    |     | X               | X     |         | X     |
| r    | Auto                                    | X   |                 |       |         |       |
| s    | Test                                    | X   |                 |       |         |       |
| t    | Manual                                  | X   |                 |       |         |       |
| u    | Manual Start                            | X   |                 |       |         |       |
| v    | Manual Stop                             | X   |                 |       |         |       |

Relays with reset pushes must be fitted giving an audible and visible signal when "FUEL LOW".

In addition, a low-low level sensor must be provided. At this level the engine must stop to prevent air entering the fuel system.

This is also applicable to the engine driven generator/alternator.

All relays must operate an alarm hooter. A pushbutton must be installed in the hooter circuit to stop the audible signal, but the fault indicating light and/or on the control panel must remain lit until the fault has been rectified and reset.

After the hooter has been stopped, it must re-set automatically, ready for a further alarm. An on/off switch is not acceptable.

The hooter must be of the continuous duty and low consumption type. Both hooter and protection circuits must operate from the battery.

Potential free contacts from the alarm relay must be wired to terminals for remote indication of alarm conditions.

A lamp test push button must be provided to test all indicator lamps.

An alarm mute push button must be provided on the front panel.



## 24.10 Operation switches

Four individual mode selector push button switches: "OFF, AUTO, MANUAL, TEST"

"AUTO" - the set shall automatically start and stop, according to the mains supply being available or not.

"TEST"- it shall only be possible to start and stop the set with the pushbuttons; full functional testing and the running set shall not be switched to the load without a mains failure.

"MANUAL" - the set must take the load when started with the manual pushbutton, but it must not be possible to switch the set on to the mains, or the mains onto the running set. In this mode the load will not be transferred in the event of a mains failure.

"OFF"- the set shall be completely disconnected from the automatic controls, for cleaning and maintenance of the engine.

## 24.11 Logging of events

All events relating to the status of the generator set shall be logged with date and time in a non-volatile memory (which can retain information for a period of 6 months in the absence of power to the controller) and the user shall be able to obtain a hard copy on site.

The controller must have sufficient memory to log at least three months of typical generator set operation and include details to determine the time from mains failure to alternator on load.

## 24.12 User programmable

The controller shall be user programmable on site via a menu system with an access code and clear prompts for the required data and shall incorporate the following parameters:

| Condition              | Description             |
|------------------------|-------------------------|
| HIGH battery volts     |                         |
| LOW battery volts      |                         |
| HIGH Mains volts       |                         |
| LOW Mains volts        |                         |
| HIGH Alternator volts  |                         |
| LOW Alternator volts   |                         |
| OVER-SPEED             |                         |
| UNDER-SPEED            |                         |
| Crank Release RPM      |                         |
| Start delay            |                         |
| Run-up delay           |                         |
| Mains return delay     |                         |
| Cool down time         |                         |
| Low Oil Pressure       | (Normally open /closed) |
| Low Oil Pressure gauge | Warning level           |
| High Temperature       | (Normally open /closed) |
| High Temperature gauge | Warning level           |



| Condition           | Description             |
|---------------------|-------------------------|
| Low Water           | (Normally open /closed) |
| Low Fuel            | (Normally open /closed) |
| No Fuel             | (Normally open /closed) |
| Low Bulk Tank       | (Normally open /closed) |
| Alternator CT Ratio |                         |
| Emergency Stop      | (Normally open /closed) |
| Charging Alternator | (Normally open /closed) |

#### 24.13 Printer

The controller shall be able to connect to a printer used to obtain a hard copy of the log on site and this printer must be able to operate from internal rechargeable batteries or allow charging from a 12V DC supply in the event a mains supply is not available.

#### 24.14 Computer remote status

The controller shall be able to be fitted with an RS-485/ Modbus module to allow the controller to be connected to a BMS or SCADA system.

#### 24.15 Manual starting

The switchboard shall be equipped with two separate push buttons marked "START" and "STOP" for manual starting and stopping of the set.

#### 24.16 Battery charging equipment

The switchboard shall be equipped with a constant voltage battery charging unit.

The charger shall operate automatically in accordance with the state of the battery and shall generally consist of an air-cooled transformer, a full wave solid state rectifier, and the necessary automatic control equipment to maintain a constant charge voltage.

The charger must be supplied from the mains. An engine driven alternator must also be provided for charging the battery while the set is operational. Failure of this alternator must also activate the battery charger failure circuit.

#### 24.17 Switchboard instruments

The switchboard shall be equipped as follows:

One (1) flush square dial voltmeter, reading the alternator voltage, scaled 0-500V.

One (1) six position and off selector switch for reading all phase to phase and phase to neutral voltages.

A flush square dial combination maximum demand and instantaneous ampere meter for each phase, with resettable pointer suitably scaled 20% higher than the alternator rating. A red arc stripe above



the scale markings from 0-20A and a red radial line through the scale at full-load current shall be provided. This instrument shall be supplied complete with the necessary current transformer.

One flush square dial vibrating type frequency meter, indicating the alternator frequency.

A six-digit running hour meter with digital counter, reading the number of hours the plant has been operating. The smallest figure on this meter must read 1/10th hour.

Fuses for the potential circuits of the meter.

One (1) 22 mm dia "Twist to release" type pushbutton marked "Emergency Stop" for the immediate stopping of the engine, by-passing all control circuits.

One (1) flush square dial ampere meter suitably scaled for the battery charging current.

One (1) flush square dial voltmeter with a spring-loaded pushbutton or switch for the battery voltage.

Circuit breaker for electric fuel pump.

#### **24.18 Markings**

All labels, markings or instructions on the switchgear shall be in English.

#### **24.19 Earthing**

An earth bar must be fitted in the switchboard, to which all non-current carrying metal parts shall be bonded.

The neutral point of the alternator must be solidly connected to this bar by means of a removable link labelled "EARTH". Suitable terminals must be provided on the earth bar for connection of up to three earth conductors, which will be supplied and installed by others.

#### **24.20 Automatic change-over switch**

A fully automatic change-over system must be provided to isolate the mains supply and connect the standby set to the outgoing supply in case of a mains failure and reverse this procedure on return of the mains.

The contactor for this system must be interlocked in a safe and fail proof way to prevent the alternator being switched onto the mains or visa-versa.

#### **24.21 Bypass switch and mains isolator**

The switchboard shall be equipped with an on-load isolator to isolate the mains and a manually operated, three (3) position on-load by-pass switch. The by-pass switch shall have an "OFF" position (centre) and shall either connect the incoming mains to the automatic control gear or directly to the outgoing feeder. In the "OFF" position the automatic control gear, including the main contactors, shall be isolated for maintenance purposes.

It shall not be possible to start the engine except with the selector switch in the "TEST" position.



It is required that this bypass switch and mains isolator be mounted away from the automatic control gear, in a separate compartment, either on the side or in the lower position of the switchboard cubicle, and that the switches are operated from the front of the compartment.

#### **24.22 Start delay**

Starting shall be automatic in event of a mains failure. A 0 -15 seconds adjustable, start delay timer shall be provided to prevent start-up on power dips or very short interruptions.

#### **24.23 Stop delay**

A stop delay with timer is required for the set, to keep the set on load for an adjustable period of 1 to 10 minutes after the return of the mains supply, before changing back to that supply.

An additional timer shall keep the set running for a further adjustable cooling period of 5 to 10 minutes at no-load before stopping.

#### **24.24 Dummy load**

Supply and install an automatic dummy load to ensure that the engine's load is never lower than 30% of the generators full load.

#### **24.25 Resistive elements**

The resistive heating elements shall be installed in the warm air ducting between the engine's radiator and the outlet louvers. The elements shall be of the mineral isolated tubular type.

The elements shall be connected in star with four conductors equal in a size.

The elements and connectors shall be easily accessible to ensure easy replacement.

#### **24.26 Control**

The dummy load shall be switched from a three-pole contactor of sufficient size. The contactors shall be installed in the control board.

Supply and install an indicator lamp on the control board to indicate when the dummy load is connected to the set.

The total load in kW of the generator set shall be monitored by a semi-conductor load monitor. The monitor shall be equipped with two adjustable control switching points. The switching points shall be set at 30% and 70% of the generator set's full load.

An adjustable timer relay (0-200 sec) must start timing the moment the generator set starts.

If the generator set's load is less than 30% after a pre-adjusted time, initially 60 seconds, the dummy load shall automatically be connected to the generator set. If the load rises above 70% the dummy load shall be disconnected. If the load falls below 30% the dummy load shall immediately be reconnected to the generator set.



#### **24.27 Dummy load connection**

The supply to the dummy load shall be through a circuit breaker of sufficient capacity and marked "DUMMY LOAD". The circuit breaker shall be installed on the front panel of the control board.

The connections between the control board and the elements must consist of a PVC/SDP/PVC copper cable of sufficient size.

The connections between the elements and the connectors must consist of asbestos isolated copper conductors.

#### **24.28 Cable installation**

The Tenderer shall allow for the complete installation and wiring of the plant, including the connection of the incoming main and outgoing feeder cables for the generating set switchboard.

All interconnection power cables must be provided and installed between the alternator and the change-over panel.

All interconnection control cables must be provided and installed between the alternator, engine fuel tanks and the control panel.

Power cables shall be PVC/SWA/ECC/PVC 4 core copper cables. The control circuits shall be multi-core PVC cables.

The cable conductors shall be terminated with suitably rated pressure crimped cable lugs.

#### **24.29 Earthing**

The neutral point of the generator shall be solidly connected to the earth bar on the alternator and the panel by means of an appropriate size of insulated earth conductor.

All plant ancillary equipment and steel work in the plant room shall be suitably bonded with an appropriate size of bare copper and also be solidly connected to the earth bar.

The earth bar shall be positioned in the cable trench to enable easy access for the main earth point to be connected.

#### **24.30 Phase rotation**

The Contractor shall ensure that the mains and generator phase rotations are identical.

#### **24.31 Painting**

The engine and generator shall be painted with best quality Grey Enamel paint.

#### **24.32 Warning notices**

Notices, in English must be installed in the plant room in terms of regulation 4 of the Electrical Machinery Regulations of the Machinery and Occupational Safety Act, No 6 of 1983.



The contents of these notices are summarised below:

Unauthorised entry prohibited.

Unauthorised handling of equipment prohibited.

Procedure in case of electrical shock.

Procedure in case of fire.

The successful Tenderer must consult the Act and get approval of the wording from the Client's representative, prior to ordering the notices.

Lettering must be black on yellow background.

Notice (a) must be installed outside, next to the entrance door. Notices (b) - (d) must be installed inside the plant room.

In the plant room a clearly legible and indelible warning notice of 450 x 450mm must be mounted in a conspicuous position with white lettering on red background.

**"DANGER**

**THIS ENGINE WILL START WITHOUT NOTICE. TURN THE SELECTOR SWITCH ON CONTROL BOARD TO "OFF" BEFORE WORKING ON THE PLANT."**

#### **24.33 Tests at Contractor's Premises**

An acceptance test shall be carried out at the Contractor's premises to establish that the diesel generating set and its ancillary equipment meets with the requirements of the specification.

The Contractor shall give the Consultant and representatives of the Client at least seven days' notice prior to testing the plant.

In the event of the plant failing the test and having to be re-tested, at some future date, all expenses (including travelling) incurred by the Consultant and representatives of the Client in attending the second test will be to the Contractor's account.

The following tests are to be carried out:

Simulate a mains failure to automatically start the plant from cold to test its ability to attain full rated speed and voltage and assume the full load in specified time of 10 seconds.

Test-run the plant at full load for a period of one hour.

Immediately after the above specified run, without stopping the plant, run in for a further one hour at 110% load.



Test the plant with regards to voltage dip, voltage and frequency recovery, with sudden application of various loads.

Test the plant for its ability to assume full rated load immediately on failure of normal supply.

Test and demonstrate (by simulation only where actual conditions could damage the plant and its ancillary equipment) the correct functional and operation of the engine safety controls and alarms together with other alarms as specified.

Any other tests the client or his representative may consider necessary to demonstrate that the diesel generator and its ancillary equipment as a whole is functioning correctly and in accordance with the specification.

The Contractor shall provide all the necessary instruments and equipment, resistance for the load, labour and consumables required to carry out the tests. The test equipment shall be capable to produce the load specified above continuously without interruption. The test load shall be adjustable and balanced over three phases.

The instrumentation shall be capable of recording and producing printed data pertaining to transient voltage dips, recovery time, applied load, etc, as specified. Complete test results of all tests shall be submitted to the Engineer at the end of the tests. In addition, an original set with copies shall be compiled and bound with the As-Built documentation.

#### **24.34 Tests on site**

On completion of the installation of the plant, following tests are to be carried out:

- Simulate a mains failure to automatically start the plant from cold to test its ability to attain full rated speed and voltage and assume the full load in specified time of 10 seconds.
- Automatic starting and stopping with load change over. The load in this instance will be provided by the client.
- Test by simulation only of the operation of the engine protection and alarm devices.
- Any other tests which the Consultant may require on site.

Drawings for approval

The Contractor shall, within one month after being awarded the contract, submit for approval the drawings in electronic format (pdf or dwg format) or 2 sets of drawings showing in detail particulars of the equipment to be supplied.

The following minimum details shall be submitted:

- o General arrangement of all plant and equipment.
- o Front layout of change-over and control panels.
- o Schematic of the complete electrical systems, including starter motor, battery and automatic battery charger.



- Details of diesel alternator base indicating dimensions and weight.
- General arrangement, wiring diagrams and details of the control panel and automatic change-over equipment complete with cabling.
- Details of silencer/s, exhaust system including expansion pieces and brackets.
- Details of the fuel day-tank, pump and piping arrangement.
- Detail of radiator (where applicable), fan cooling arrangement and ventilation ducting.
- Dimensioned layout of all plant in the plant room.

All drawings, circuit or schematic diagrams and documents prepared by or on behalf of the Contractor for submission shall be thoroughly checked, corrected where necessary and signed as accepted by the Contractor, prior to submission for approval.

Approval of drawings and documentation will not release the Contractor from any of his responsibility and obligation for the proper operation of the installation or for full compliance with the specification, drawings, local authority and statutory requirements. Special care shall be taken to ensure that the equipment physically fit through access and be accommodated within the space and via the access provided.

#### **24.35 Working instructions**

A complete diagram showing complete schematic diagram of the power and control circuitry of the plant together with detailed instructions, being plasticized shall be placed in a durable, non-deteriorating frame, neatly fixed to the wall of the plant room.

#### **24.36 Drawings and maintenance manuals**

The Contractor shall supply three complete comprehensive sets of operating and maintenance manuals in hard copy and on CD, complete with schematic control circuit diagrams for both engine and generator.

The above manuals are to be handed to Engineer prior to commissioning of the installation.

#### **24.37 Spare parts and information required**

Tenderers shall submit with their tender an assurance that the plant offered as a whole and spares parts for the plant are readily available within the Republic of South Africa and state all contact details where these spares are available.

Tenderers must furnish detailed descriptions and illustrations of the equipment offered and must complete the questionnaire following this specification. This includes drawings of the switchboard layout and control diagrams.

Failure to submit any of the information asked for, may disqualify the tender.



## **24.38 Guarantee, Repairs and Maintenance**

The successful Tenderer will be required to guarantee the complete plant for a period of 12 months from the date it has been taken over after first delivery of the plant.

If during this period the plant is not in working order, or not working satisfactorily owing to the faulty material, design or workmanship, the Contractor will be notified and immediate steps shall be taken by him to rectify the defects and/or replace the affected parts on site, at the Contractor's expense and to the satisfaction of the client.

The Contractor shall bear all expense incidental thereto including making good of work by others, arising out of removal or reinstallation of equipment. All work arising from the implementation of the guarantee or maintenance of equipment shall be carried out at times which will not result in any undue inconvenience to users of the equipment or occupants of premises.

If any defects are not remedied within a reasonable time the client may proceed to do the work at the Contractor's risk and expense, but without prejudice to any other rights which the client may have against the Contractor.

Should the standby plant defects be so frequent as to become objectionable or should the equipment otherwise prove unsatisfactory during the guarantee period of twelve months, the Contractor shall, if called upon by the client, at his own expense replace the whole or such parts thereof as the client may deem necessary with equipment to be specified by the client. Approval - tacit or otherwise - of the equipment installed shall be considered as provisional only and shall not invalidate the client's right as indicated above.

The successful Tenderer will be required to do initial maintenance and maintain the plant in good running order for a period of twelve (12) months after the plant has been taken over by the Client. The full cost of this maintenance must be included in the tender price, inclusive overheads and travelling fees.

Apart from the consumables as detailed below, the Client shall not acknowledge any cost claim additional to this maintenance cost as tendered.

However, should the Contractor fail to hand-over the plant in good working order on expiry of the specified twelve months, the Contractor will be responsible for further monthly maintenance until final delivery is taken.

At six monthly intervals (2) during the guarantee period of twelve months the Contractor shall adjust and maintain the standby plant and its ancillary equipment in proper working order by a qualified member of his staff.

As a minimum requirement the Contractor shall:



Report to the Officer-in-Charge, keeping the maintenance records, and enter into a log book the date of the visit, all the test carried out, adjustments made, and any further details that may be required.

Grease and oil moving parts where necessary.

Check the air filter, and when necessary, clean the filter and replace oil filter.

Check and top-up if necessary, the fluid levels in the radiator, engine sump, fuel oil tank and batteries.

Test run the standby plant and ancillary equipment for a period of 15 minutes.

Wipe down the standby plant and its ancillary equipment and report on any evidence of any fluid leaks or other defects.

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 number of hours run by the plant.

Under this heading only the cost of the actual oil used, shall be charged as an extra on the monthly account.

Clean the lubricating oil filter and/or replace filter element at intervals recommended by the engine maker, the cost of a new filter element to be charged as an extra on the monthly account.

Check and when necessary, adjust the valve settings and the fuel injection equipment.

Report to the Client and to the Consultant on any parts that become unserviceable through fair wear and tear, or damaged by causes beyond the control of the Contractor.

The Contractor, on receiving the report, shall immediately submit a detailed quotation for the repairs or replacement of such parts to the Client.

Advise the Client when it has become necessary to decarbonise the engine and submit a quotation for this service.

Top up the water of the radiator, if applicable.

Clean the plant and its components when necessary.

The cost of such inspections, maintenance, adjustments, repairs, etc., shall be included in the tender price, but the cost of renewing any part which may become worn through fair wear and tear, or damaged beyond the control of the Contractor (provided this is not due to unsuitable design) shall be excluded.



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#### **24.39 Maintenance Agreement**

After the lapse of this 12-month period, the Contractor may be required to enter into a maintenance agreement, as described under Clause 2.13.1 initially for one year with a possible yearly renewal.

Acceptance of the tender shall not bind the Client to accept this maintenance service.

Tenderers must state in the Price Schedule the charge per visit for carrying out the maintenance as detailed above.

After completion of the installation and when the plant is in running order, the successful Tenderer will be required to instruct an attendant in the operation of the plant, until he is fully conversant with the equipment and the handling thereof.

Three (3) copies of a maintenance fault-localising and operating manual are to be handed over to the Client's representatives on site.

#### **24.40 Latent Defects and Failure to Comply with Specification**

The client reserves the right to demand the replacement or making good by the Contractor at his own expense of any part of the contract which is shown to have any latent defects or not to have complied with the specification, notwithstanding that such work has been taken over or that the guarantee period has expired.

#### **24.41 Qualification by Tenderer**

Should any specified materials or equipment in the Tenderer's opinion be of inferior quality, or be unsuitably employed, rated or loaded, the Tenderer shall prior to the submission of his tender advise the Consultant accordingly. His failure to do so shall mean that he guarantees the work including all materials or equipment as specified.



## 24.42 Engine Technical Schedules

| Items    | Description                                                                        | Unit     | SCHEDULE A           | SCHEDULE B                    |
|----------|------------------------------------------------------------------------------------|----------|----------------------|-------------------------------|
|          |                                                                                    |          | Minimum Requirements | To Be Completed By Contractor |
| <b>A</b> | <b><u>DIESEL ENGINE:</u></b>                                                       |          |                      |                               |
| 1        | Manufacturer                                                                       |          | Stipulate            |                               |
| 2        | Country of manufacture                                                             |          | Stipulate            |                               |
| 3        | Model                                                                              |          | Stipulate            |                               |
| 4        | Type (two or four stroke)                                                          |          | 4 stroke             |                               |
| 5        | Continuous rated output at sea level                                               | kW       | [500]                |                               |
| 6        | Governed speed                                                                     | rpm      | 1500                 |                               |
| 7        | Number of cylinders                                                                |          | Stipulate            |                               |
| 8        | Diameter of cylinders                                                              | mm       | Stipulate            |                               |
| 9        | Stroke of piston                                                                   | mm       | Stipulate            |                               |
| 10       | Piston speed                                                                       | m/min    | Stipulate            |                               |
| 11       | Type of air cleaner                                                                |          | Stipulate            |                               |
| 12       | Type of lubricating oil filter                                                     |          | Stipulate            |                               |
| 13       | Make and type of injection system                                                  |          | Stipulate            |                               |
| 14       | Type and number of fuel filters                                                    |          | Stipulate            |                               |
| 15       | Manufacturer of turbo charger                                                      |          | Stipulate            |                               |
| 16       | Type of turbo charger                                                              |          | Stipulate            |                               |
| 17       | Lagging required over turbo charger?                                               | Yes / No | Yes                  |                               |
| 18       | Manufacturer of governor                                                           |          | Stipulate            |                               |
| 19       | Type of governor                                                                   |          | Stipulate            |                               |
| 20       | Max cyclic variations                                                              |          | Stipulate            |                               |
| 21       | Speed variation for sudden release or application of load                          |          |                      |                               |
| 22       | Temporary                                                                          |          | Stipulate            |                               |
| 23       | Permanent                                                                          |          | Stipulate            |                               |
| 24       | 100% Rated full load may be applied seconds after initiation of starting sequence  |          | Stipulate            |                               |
| 25       | Fuel consumption of the complete generator set at site with a generator output of: |          | (Submit curves)      |                               |
| 26       | - Full load                                                                        | l/hr     | Stipulate            |                               |
| 27       | - ¾ load                                                                           | l/hr     | Stipulate            |                               |
| 28       | - ½ load                                                                           | l/hr     | Stipulate            |                               |
| 29       | Air quantity required for engine cooling                                           | cu.m/min | Stipulate            |                               |
| 30       | Cross sectional area of radiator air discharge outlet required                     |          | Stipulate            |                               |
| 31       | Dimensions of engine:                                                              |          |                      |                               |
| 32       | - Length                                                                           | mm       | Stipulate            |                               |
| 33       | - Height                                                                           | mm       | Stipulate            |                               |
| 34       | - Width                                                                            | mm       | Stipulate            |                               |
| 35       | Mass of engine                                                                     | kg       | Stipulate            |                               |



## 24.43 Alternator Technical Schedules

| Items    | Description                                                 | Unit      | SCHEDULE A           | SCHEDULE B                    |
|----------|-------------------------------------------------------------|-----------|----------------------|-------------------------------|
|          |                                                             |           | Minimum Requirements | To Be Completed By Contractor |
| <b>B</b> | <b><u>ALTERNATOR:</u></b>                                   |           |                      |                               |
| 1        | Manufacturer                                                |           | Stipulate            |                               |
| 2        | Model                                                       |           | Stipulate            |                               |
| 3        | Country of origin                                           |           | Stipulate            |                               |
| 4        | Type of enclosure                                           |           | Stipulate            |                               |
| 5        | IP rating of enclosure                                      |           | Stipulate            |                               |
| 6        | Nominal speed at an output frequency of 50Hz                | r/min     | 1500                 |                               |
| 7        | Output voltage within governed speed range at:              |           |                      |                               |
| 8        | No load                                                     | V         | 430                  |                               |
| 9        | 50% load                                                    | V         | Stipulate            |                               |
| 10       | 100% load                                                   | V         | Stipulate            |                               |
| 11       | 110% load                                                   | V         | Stipulate            |                               |
| 12       | Method of voltage regulation                                |           | Stipulate            |                               |
| 13       | Phases                                                      | 3ph / 1ph | 3ph                  |                               |
| 14       | Continuous rated output at sea level                        | kW        | 50                   |                               |
| 15       | Power factor                                                |           | 0.8                  |                               |
| 16       | Output current at:                                          |           |                      |                               |
| 17       | - Full load                                                 | A         | Stipulate            |                               |
| 18       | - ¾ load                                                    | A         | Stipulate            |                               |
| 19       | - ½ load                                                    | A         | Stipulate            |                               |
| 20       | Percentage output loss due to site conditions               | %         | Stipulate            |                               |
| 21       | Percentage efficiency at:                                   |           |                      |                               |
| 22       | - Full load                                                 | %         | Stipulate            |                               |
| 23       | - ¾ load                                                    | %         | Stipulate            |                               |
| 24       | - ½ load                                                    | %         | Stipulate            |                               |
| 25       | Transient voltage-drop due to application of full load      |           | Stipulate            |                               |
| 26       | Time for voltage restoration after application of full load | min       | Stipulate            |                               |
| 27       | Reactance                                                   | kVAr      | Stipulate            |                               |
| 28       | Transient reactance                                         | kVAr      | Stipulate            |                               |
| 29       | Are brushes used in exciter?                                | Yes / No  | Stipulate            |                               |
| 30       | Insulation class of stator windings                         |           | Stipulate            |                               |
| 31       | Insulation class of rotor windings                          |           | Stipulate            |                               |
| 32       | Mass of alternator                                          | kg        | Stipulate            |                               |
| 33       | Alternator short circuit current                            | kA        | Stipulate            |                               |
| 34       | Dimensions of alternator (L x W x H)                        | mm        | Stipulate            |                               |
| 35       | <b><u>EXHAUST PIPE:</u></b>                                 |           |                      |                               |
| 26       | Manufacturer                                                |           | Stipulate            |                               |



| Items | Description                                               | Unit     | SCHEDULE A             | SCHEDULE B                    |
|-------|-----------------------------------------------------------|----------|------------------------|-------------------------------|
|       |                                                           |          | Minimum Requirements   | To Be Completed By Contractor |
| 27    | Material type                                             |          | Stainless steel        |                               |
| 28    | Wall thickness                                            | mm       | Stipulate              |                               |
| 29    | Diameter at end                                           | mm       | Stipulate              |                               |
| 30    | Total exhaust pipe length                                 | mm       | Stipulate              |                               |
| 31    | Does the diameter vary over the length?                   | Yes / No | Stipulate              |                               |
| 32    | Exhaust outlet height above finished floor level          | mm       | Stipulate              |                               |
| 33    | <b><u>DAY TANK:</u></b>                                   |          |                        |                               |
| 34    | Capacity                                                  | litre    | Stipulate              |                               |
| 35    | Material                                                  |          | Stipulate              |                               |
| 26    | Material thickness                                        | mm       | Stipulate              |                               |
| 27    | Type of level indication                                  |          | Stipulate              |                               |
| 28    | Type of level sensors                                     |          | Stipulate              |                               |
| 29    | <b><u>STARTING BATTERIES:</u></b>                         |          |                        |                               |
| 30    | Manufacturer                                              |          | Stipulate              |                               |
| 31    | Type of battery                                           |          | Stipulate              |                               |
| 32    | Capacity                                                  | A/hr     | Stipulate              |                               |
| 33    | Voltage                                                   | V        | Stipulate              |                               |
| 34    | Number of batteries                                       | No       | Stipulate              |                               |
| 35    | <b><u>BATTERY CHARGER:</u></b>                            |          |                        |                               |
| 36    | Manufacturer                                              |          | Stipulate              |                               |
| 37    | Time to recharge batteries                                | min      | Stipulate              |                               |
| 38    | Maximum charge current                                    | Amp      | Stipulate              |                               |
| 39    | Charge voltage                                            | V        | Stipulate              |                               |
| 40    | <b><u>CONTROL CUBICLE:</u></b>                            |          |                        |                               |
| 41    | Manufacturer                                              |          | Stipulate              |                               |
| 42    | Type                                                      |          | Enclosed free-standing |                               |
| 43    | Dimensions of control cubicle:                            |          |                        |                               |
| 33    | - Length                                                  | mm       | Stipulate              |                               |
| 45    | - Height                                                  | mm       | Stipulate              |                               |
| 46    | - Width                                                   | mm       | Stipulate              |                               |
| 47    | Type of control equipment                                 |          | Stipulate              |                               |
| 48    | Type, make and rating of by-pass switch                   |          | Stipulate              |                               |
| 49    | Type, make and rating of change-over breaker / Contractor |          | Stipulate              |                               |
| 50    | Rupturing capacity at rated voltage main circuit          | kA       | Stipulate              |                               |
| 51    | Method of tripping employed in main circuit breaker       |          | Stipulate              |                               |
| 52    | Range of load setting of main circuit breaker             |          | Stipulate              |                               |
| 53    | <b><u>VOLTMETER:</u></b>                                  |          |                        |                               |
| 54    | Make and type                                             |          | Stipulate              |                               |



| Items | Description                     | Unit  | SCHEDULE A           | SCHEDULE B                    |
|-------|---------------------------------|-------|----------------------|-------------------------------|
|       |                                 |       | Minimum Requirements | To Be Completed By Contractor |
| 55    | Dial dimensions                 |       | Stipulate            |                               |
| 56    | BSS. accuracy                   |       | Stipulate            |                               |
| 57    | <u>MAXIMUM DEMAND AMMETERS:</u> |       |                      |                               |
| 58    | Make and type                   |       | Stipulate            |                               |
| 59    | Dial dimensions                 |       | Stipulate            |                               |
| 60    | Time lag                        |       | Stipulate            |                               |
| 61    | BSS. accuracy                   |       | Stipulate            |                               |
| 62    | <u>FREQUENCY METER:</u>         |       |                      |                               |
| 63    | Make and type                   |       | Stipulate            |                               |
| 64    | Dial dimensions                 |       | Stipulate            |                               |
| 65    | BSS. accuracy                   |       | Stipulate            |                               |
| 66    | <u>OVERALL PLANT:</u>           |       |                      |                               |
| 67    | Mass of plant                   | kg    | Stipulate            |                               |
| 68    | Overall dimensions of plant:    |       |                      |                               |
| 69    | - Length                        | mm    | Stipulate            |                               |
| 70    | - Height                        | mm    | Stipulate            |                               |
| 71    | - Width                         | mm    | Stipulate            |                               |
| 72    | Delivery period                 | Weeks | Stipulate            |                               |

## 25. LOW VOLTAGE POWER FACTOR CORRECTION AND HARMONIC FILTER

Low voltage, fully automatic, indoor, floor standing power factor correction units shall be supplied and installed in the respective low voltage rooms of the new Substation. Each of the low voltage power factor correction units shall be connected to the respective low voltage main distribution board.

The 350kVAR rating with an actively filter tuned for specifically the third harmonic are provisional at tender stage. The ratings are only provisional and will be finalized after comprehensive power analyzing measurements have been completed and submitted to the Engineer. Tender prices must include for a power analysis of at least 36hrs, complete with all required instrumentation and reporting.

The power factor correction equipment shall be installed in panels of which the design shall be in accordance to the Low Voltage Switchboards Specification as discussed in the section above. The power factor correction unit shall be supplied from the respective low voltage Main Distribution Boards via 500mm<sup>2</sup> x 1c Cu PVC unarmoured cables.

The low voltage power factor correction / Filter panels must be equipped with the following equipment:

- Power Quality Active filter unit similar or equivalent to ABB Type ... complete with CT's, auxiliary and alarms contacts.
- Microprocessor reactive power control relay, incorporating a digital LCD power factor indicator, step indicators and separate alarm contacts.
- Three phase, 400V, self-healing, metallised film, dry type capacitors rated to IEC specifications and fitted with discharge resistors.
- The capacitors must incorporate an internal fuse in each element which must be rated for 525V nominal plus 10% according to IEC standards.



- Suitably rated contactors to switch the capacitors.
- Sets of suitably rated fuses to protect the capacitors and contactors.
- Indicating lamps to show the operation of the capacitor switching indicator.
- Industrial type hand operated OFF/AUTO selector switches.
- Set of control circuit fuses.
- Stop-lock pushbutton to disconnect all capacitors before isolation from main board.
- Suitably rated main incoming circuit breaker.
- Set of main busbars and secondary connections.

The power factor correction panels shall be equipped with all operating and mandatory signs to warn any operator(s) or person(s) of potential danger(s).

The panel shall have a locking mechanism that prevents the doors to open until the capacitors are fully discharged. Special warning signs must be fixed to the doors indicating: "**Discharge capacitors before opening door**".

Tender prices must include for a power analysis of at least 36hrs complete with all required instrumentation and reporting.

## 26. MEDIUM VOLTAGE PAPER INSULATED LEAD CABLES (6.6kV – 33kV)

All medium voltage paper insulated lead sheath (PILC) copper conductor steel wire armour screened cables in the voltage range of 6.6kV to 33kV shall be manufactured in strict accordance to the latest edition of SANS 97 as amended. This shall include the conductors, insulation, screening, impregnation, metal sheaths, bedding under armouring, armouring, marking, serving and oversheath.

Where armouring is specified, three-core cables shall comprise of a single layer of galvanized steel wires. Single-core cables shall be armoured with a single layer of hard drawn aluminium wires or other non-magnetic material complying to SANS 97 as amended.

The voltage rating and size of the cable shall be as per the detail specification and drawings of which the alternating current distribution system frequency shall be 50Hz.

All routine tests as specified by SANS 97 as amended shall be carried out on production runs of the cable. Two test certificates will be provided for each cable drum delivered to site.

Wooden cables drums shall be clearly marked on both sides providing the following information:

- Voltage
- Actual length
- Conductor size
- Number of cores
- Finish
- Drum Number
- Gross Mass
- Nett Mass
- Direction of rotation
- Manufacturers project or job number
- Information required in accordance with SANS.



Both ends of the cable on the wooden drum must be sealed to prevent penetration of moisture. Both ends of the cable shall furthermore be fixed to the flange of the wooden drum to avoid loose coiling and mechanical damage. Cable drums shall be placed on firm, well-drained surfaces.

All cable connections shall be of the hexagonal crimp method using correct size and type of lugs, ferrule and matching crimp head dices.

Cable ducting and trenches shall be in accordance with SANS 2001 PD3.

The successful Tenderer shall provide any technical or additional required information as requested by the Engineer at any given time.

## **27. SPECIFICATION FOR VARIABLE FREQUENCY MOTOR CONTROLLER**

### **GENERAL**

#### **Summary**

The Variable Frequency Drive (VFD) system shall contain all components required to meet the performance, protection, safety and certification criteria of this specification.

#### **References**

- a) SANS 60146-2: Semiconductor converters - Self-commutated converters including direct d.c. converters.
- b) SANS 60204-1: Safety of machinery - Electrical equipment of machines: General requirements.
- c) SANS 61378-1: Converter transformers - Transformers for industrial applications.
- d) SANS 61800-2: Adjustable speed electrical power drive systems - General requirements: Rating specifications for low voltage adjustable frequency a.c. power drive systems.
- e) SANS 61800-5-1: Adjustable speed electrical power drive systems - Safety requirements: Electrical, thermal and energy.
- f) SANS 61800-5-3: Adjustable speed electrical power drive systems - EMC requirements and specific test methods.
- g) SANS 61800-7-1: Adjustable speed electrical power drive systems - Generic interface and use of profiles for power drive systems.

#### **Submittals**

- a) Shop drawings for approval.
  - i. Drawings: Include dimensional information and conduit routing locations
  - ii. Unit Descriptions: Include amperage ratings, enclosure ratings, fault ratings, nameplate information, etc. as required for approval
  - iii. Wiring Diagrams
    - Power Diagram: Include amperage ratings, circuit breaker frame sizes, circuit breaker continuous amp ratings, etc. as required for approval
    - Control Diagram: Include disconnect devices, pilot devices, etc
  - iv. Major components list
- b) Product Data Sheets.
  - i. VFD and Operator Interface publications
  - ii. Data sheets and publications on all major components including but not limited to the following:
    - Contactors
    - Circuit breaker and fuse (power and control)
    - Control power transformers
    - Pilot devices
    - Relays / Timers
- c) Test procedures shall be per the manufacturer's standards.

#### **Closeout Submittals (Operation And Maintenance Manuals)**

- a) Shop drawings – Final as shipped
  - i. Drawings: Include dimensional information and conduit routing locations



- ii. Unit Descriptions: Include amperage ratings, enclosure ratings, fault ratings, nameplate information, etc. as required for approval
  - iii. Wiring Diagrams
    - Power Diagram: Include amperage ratings, circuit breaker frame sizes, circuit breaker continuous amp ratings, etc. as required for approval
    - Control Diagram: Include disconnect devices, pilot devices, etc
  - iv. Major components list
- b) Product data sheets
- i. Contactors
  - ii. Circuit breaker and fuse (power and control)
  - iii. Control power transformers
  - iv. Pilot devices
  - v. Relays/Timers
- c) Test procedures shall be per the manufacturer's standards
- d) Operation and Maintenance Data
- i. Service and Contact information
  - ii. VFD and Operator Interface User Manuals
  - iii. Troubleshooting / Service Manuals

#### **Quality Assurance**

- a) Qualifications
- i. Manufacturers:
    - The VFD and all associated optional equipment shall be UL listed or recognized.
    - The VFD shall contain a UL label attached on the inside of the enclosure cabinet.
  - ii. Suppliers:
    - All inspection and testing procedures shall be developed and controlled under the guidelines of the Supplier's quality system and must be registered to ISO 9001 and regularly reviewed and audited by a third-party registrar.
    - The VFD shall be factory pre-wired, assembled and tested as a complete package.

#### **Delivery, Storage and Handling**

- a) Contractor shall coordinate the shipping of equipment with the manufacturer.
- b) Contractor shall store the equipment in a clean and dry space at an ambient temperature range of -25 °C to 55 °C.
- c) The contractor shall protect the units from dirt, water, construction debris and traffic.

#### **Warranty**

- a) The manufacturer shall provide their standard parts warranty for eighteen (18) months from the date of shipment or twelve (12) months from the date of being energized, whichever occurs first.
- b) This warranty applies to variable frequency drive systems.

#### **PRODUCTS**

##### **Manufacturers**

- a) Reputable suppliers with local support

##### **Variable Frequency Drive Unit**

- a) Features
  - i. Hardware
    - Utilize diode bridge or SCR bridge on the input rectifier
    - Utilize DC bus inductor on all six-pulse VFDs only



- Utilize switching logic power supply operating from the DC bus
  - Incorporate phase to phase and phase to ground MOV protection on the AC input line
  - Utilize gold plated plug-in connections on printed circuit boards
  - Microprocessor based inverter logic shall be isolated from power circuits
  - Utilize latest generation IGBT inverter section
  - Inverter section shall not require commutation capacitors
  - Embedded Ethernet port for direct network cable connections
  - Battery receptacle for Lithium battery power to the Real Time Clock
  - Additional DPI port for handheld and remote HIM options
  - Dedicated Digital Input for hardware enable
  - Conformal coated printed circuit boards
  - Optional onboard 24V DC Auxiliary Control Power Supply
- ii. Control logic
- Ability to operate with motor disconnected
  - Provide a controlled shut down, when properly protected, with no component failure in the event of an output phase to phase or phase to ground short circuit
  - Provide multiple programmable stop modes including Ramp, Coast, DC-Brake, Ramp-to-Hold, Fast Braking, and Current Limit Stop
  - Provide multiple acceleration and deceleration rates
  - Adjustable output frequency up to 650Hz
- iii. Device logic control
- Ability to control outputs and manage status information locally within the VFD
  - Ability to function stand-alone or complimentary to supervisory control
  - Ability to speed reaction time by processing in the VFD
  - Ability to provide scaling, selector switches, or other data manipulations not already built into the VFD
  - Ability to read inputs/write outputs and exclusively control the VFD
  - Ability to provide an option for decision making if communication is lost with main controller
  - Ability to control other VFDs via a peer-to-peer EtherNet/IP network
  - Ability to write programs off-line
- iv. Motor Control Modes
- Selectable Sensorless Vector, Flux Vector, V/Hz, Permanent Magnet Motor, and Adjustable Voltage Control modes selectable through programming
  - The drive shall be supplied with a Start-up and Auto-tune mode
  - The V/Hz mode shall be programmable for fan curve or full custom patterns
  - Capable of Open Loop V/Hz
- v. Current Limit
- Programmable current limit from 20 to 160% of rated output current
  - Current limit shall be active for all drive states: accelerating, constant speed and decelerating
  - The drive shall employ PI regulation with an adjustable gain for smooth transition in and out of current limit
- vi. Acceleration / Deceleration
- Accel/Decel settings shall provide separate adjustments to allow either setting to be adjusted from 0 to 3600 seconds
  - A second set of remotely selectable accel/decel settings shall be accessible through digital inputs
- vii. Speed Profiles
- Programming capability shall allow the user to produce speed profiles with linear acceleration/deceleration or "S Curve" profiles that provide changing accel/decel rates
  - S Curve profiles shall be adjustable
- viii. Adjustments
- A digital interface can be used for all set-up, operation and adjustment settings
  - All adjustments shall be stored in non-volatile memory (EEPROM)



- No potentiometer adjustments shall be required
  - EEPROM memory for factory default values shall be provided
  - Software must be available for trending and diagnostics, as well as online and offline programming functionality
- ix. Process PID Control
- The drive shall incorporate an internal process PI regulator with proportional and integral gain adjustments as well as error inversion and output clamping functions
  - The feedback shall be configurable for normal or square root functions. If the feedback indicates that the process is moving away from the set-point, the regulator shall adjust the drive output until the feedback equals the reference
  - Process control shall be capable of being enabled or disabled with a hardwire input. Transitioning in and out of process control shall be capable of being tuned for faster response by preloading the integrator
  - Protection shall be provided for a loss of feedback or reference signal
- x. Skip Frequencies
- Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance shall be provided
  - The set points shall have a bandwidth adjustable from Maximum Reverse Speed to Maximum Forward Speed
- xi. Fault Reset / Run
- The drive shall provide up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart
  - The automatic mode shall not be applicable to a ground fault, shorted output faults and other internal microprocessor faults
  - The time between restarts shall be adjustable from 0.5 seconds to 30 seconds
- xii. Run on Power Up
- A user programmable restart function shall be provided to allow restart of the equipment after restoration of power after long duration power outages. Restart time dependent on presence of incoming signal
- xiii. Fault Memory
- The last 32 fault codes shall be stored and time stamped in a fault buffer
  - Information about the drive's condition at the time of the last fault such as operating frequency, output current, dc bus voltage and twenty-seven other status conditions shall be stored
  - A power-up marker shall be provided at each power-up time to aid in analyzing fault data
  - The last 32 alarm codes shall be stored and time stamped for additional troubleshooting reference
- xiv. Overload Protection
- The drive shall provide internal class 10 adjustable overload protection
  - Overload protection shall be speed sensitive and adjustable
  - A viewable parameter shall store the overload usage
- xv. Auto Economizer
- An auto economizer feature shall be available to automatically reduce the output voltage when the drive is operating in an idle mode (drive output current less than programmed motor FLA). The voltage shall be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage
  - When the load increases, the drive shall automatically return to normal operation
- xvi. Terminal Blocks
- Separate terminal blocks shall be provided for control and power wiring
  - I/O terminal blocks shall be removable with wiring in place
- xvii. Flying Start



- The drive shall be capable of determining the speed and direction of a spinning motor and adjust its output to "pick-up" the motor at the rotating speed. This feature is disabled by default
- xviii. Inputs and Outputs
- The Input / Output option modules shall consist of both analog and digital I/O
  - No jumpers or switches shall be required to configure digital inputs and outputs
  - All digital input and output functions shall be fully programmable
  - The control terminal blocks shall be rated for 115V AC
  - Inputs shall be optically isolated from the drive control logic
  - The control interface card shall provide input terminals for access to fixed drive functions that include start, stop, external fault, speed, and enable
  - The VFD shall be capable of supporting up to 10 analog inputs, 10 analog outputs, 31 digital inputs, 10 relay outputs, 10 transistor outputs, and 5 positive temperature coefficient (PTC) inputs
  - The Input / Output option modules shall have the following features:
    - Analog Inputs:
      - Quantity two (2) differentially isolated,  $\pm 10V$  (bi-polar), 88k ohm input impedance, 11 bit plus sign
      - Analog inputs shall be user programmable for a variety of uses including frequency command and process loop input. Analog inputs shall be user programmable for function scaling (including invert), offset, signal loss detect and square root
    - Analog Outputs:
      - Quantity two (2)  $\pm 10V$  (bi-polar) / 11 bit & sign,  $2k\Omega$  minimum load, 4-20 mA, 11 bit plus sign,  $400\Omega$  maximum load
      - The analog output shall be user programmable to be proportional to one of fourteen process parameters including output frequency, output current, encoder feedback, output power
      - Programming shall be available to select either absolute or signed values of these parameters
    - Digital Inputs:
      - Quantity of six (6) digital inputs rated 24V DC/115V AC
      - All inputs shall be individually programmable for multiple functions including: Start, Run, Stop, Auxiliary Fault, Speed Select, Jog and Process PI functions
    - Digital Outputs:
      - At least one (1) relay output (N.O. or N.C.)
      - For 240V AC or 24V DC, N.O. contact output ratings shall be 2 amp max., general purpose (inductive)/resistive. N.C. contact output ratings shall be 2 amp max., resistive only
      - Relays shall be programmable to multiple conditions including: Fault, Alarm, At Speed, Drive Ready and PI Excess Error
      - Timers shall be available for each output to control the amount of time, after the occurring event, that the output relay actually changes state
      - At least one (1) transistor output
      - For 24V DC, transistor output rating shall be 1 amp max, Resistive
- xix. Reference Signals
- The drive shall be capable of using the following input reference signals:
    - Analog inputs
    - Preset speeds
    - Remote potentiometer
    - Digital MOP
    - Human Interface Module
    - Communication modules
- xx. Loss of Reference
- The drive shall be capable of sensing reference loss conditions
  - In the event of loss of the reference signal, the drive shall be user programmable to the following:
    - Fault the drive and coast to stop



- Issue a minor fault - allows the drive to continue running while some types of faults are present
    - Alarm and maintain last reference
  - When using a communications network to control the drive, the communications adapter shall have these configurable responses to network disruptions and controller idle (fault or program) conditions:
    - Fault
    - Stop
    - Zero data
    - Hold last date
    - Send fault configuration
- xxi. Metering
  - At a minimum, the following parameters shall be accessible through the Human Interface Module:
    - Output Current in Amps
    - Output Voltage in Volts
    - Output Power in kW
    - Elapsed MWh
    - DC Bus Voltage
    - Frequency
    - Heatsink Temperature
    - Last eight (32) faults
    - Elapsed Run Time
    - IGBT Temperature
- xxii. Faults
  - At a minimum, the following faults shall be accessible through the Human Interface Module:
    - Power Loss
    - Undervoltage
    - Overvoltage
    - Motor Overload
    - Heat Sink Over-temperature
    - Maximum Retries
    - Phase to Phase and Phase to Ground Faults
- xxiii. Predictive Diagnostics
  - At a minimum, the following predictive diagnostic features shall be provided:
    - Relay Output Life Cycles based on load type and amps
    - Hours of Fan Life based on load and ambient temperature
    - Motor Bearing life based on expected hours of use
    - Motor Lubrication schedule based on hours of use
    - Machine Bearing life based on expected hours of use
- xxiv. Real-Time Clock
  - Shall be capable of providing time stamped events
  - Shall have the ability to be set locally or via a remote controller
  - Shall provide the ability to be programmable for month, day, year and local time zones in HH:MM:SS

#### **VFD Packaged System**

- a) Features
  - i. Ratings
    - Voltage
      - Capable of accepting nominal plant power of 480V AC at 50Hz
      - The supply input voltage tolerance shall be  $\pm 10\%$  of nominal line voltage
    - Displacement power factor
      - Six-pulse VFD shall be capable of maintaining a minimum true power factor (Displacement P.F. X Distortion P.F.) of 0.95 or better at rated load and nominal line voltage, over the entire speed range



- Eighteen-pulse VFD shall be capable of maintaining a minimum true power factor (Displacement P.F. X Distortion P.F.) of 0.98 or better at rated load and nominal line voltage, over the entire speed range.
  - Efficiency
    - A minimum of 96.5% (+/- 1%) at 100% speed and 100% motor load at nominal line voltage
    - Control power supplies, control circuits, and cooling fans shall be included in all loss calculations
  - Operating ambient temperature range without derating: 0 °C to 40 °C
  - Operating relative humidity range shall be 5% to 95% non-condensing
  - Operating elevation shall be up to 1000 Meters without derating
- ii. Sizing
- Systems rated at Normal Duty loads shall provide 110% overload capability for up to one minute and 150% for up to 3 seconds
  - Systems rated at Heavy Duty loads shall provide 150% overload capability for up to one minute and 180% for up to 3 seconds
- iii. Auto Reset/Run
- For faults other than those caused by a loss of power or any other non-critical fault, the drive system shall provide a means to automatically clear the fault and resume operation
- iv. Ride-through
- The VFD system shall attempt to ride through power dips up to 20% of nominal. The duration of ride-through shall be inversely proportional to load. For outages greater than 20%, the drive shall stop the motor and issue a power loss alarm signal to a process controller, which may be forwarded to an external alarm signalling device
- v. Run on power up
- The VFD system shall provide circuitry to allow for remote restart of equipment after a power outage. Unless indicated in the contact drawings, faults due to power outages shall be remotely resettable. The VFD system shall indicate a loss of power to a process controller, which may be forwarded to an external alarm signalling device. Upon indication of power restoration the process controller will attempt to clear any faults and issue a run command, if desired
- vi. Communications
- VFD shall provide an embedded EtherNet/IP port
  - VFD shall be capable of communicating on multiple networks
  - VFD shall be capable of supporting the following network options:
    - DeviceNet
    - EtherNet/IP
    - ControlNet Coax
    - ControlNet Fiber
    - Interbus
    - CANopen
    - Modbus/TCP
    - Modbus RTU
    - Profibus DP
    - RS-485 DF1
    - RS-485 HVAC
    - Remote I/O
- vii. Enclosure Door Mounted Human Interface Module (HIM)
- VFD shall provide a HIM with integral LCD display, operating keys and programming keys
  - An enclosure door-mounted HIM, rated NEMA/UL Type 1 or NEMA/UL Type 4/12, shall be provided
  - An optional VFD-mounted HIM, rated NEMA/UL Type 1, may be provided and shall be capable of connecting via a separate cable for use as a handheld terminal
  - The HIM shall have the following features:
    - A seven (7) line by twenty-one (21) character backlit LCD display with graphics capability



- Shall indicate drive operating conditions, adjustments and fault indications
  - Shall be configured to display in the following three distinct zones:
    - The top zone shall display the status of direction, drive condition, fault /alarm conditions and Auto / Manual mode
    - The middle zone shall display drive output frequency
    - The bottom zone shall be configurable as a display for either programming menus / information or as a two-line user display for two additional values utilizing scaled units
  - Shall provide digital speed control
  - The keypad shall include programming keys, drive operating keys (Start, Stop, Direction, Jog and Speed Control), and numeric keys for direct entry
- b) Enclosures
- i. Shall be rated NEMA/UL Type (1) or (12)
  - ii. Shall be painted per the manufacturer's standard
  - iii. Shall provide entry and exit locations for power cables
  - iv. Shall contain a label for UL508
  - v. The drive system nameplate shall be marked with system Short Circuit Current Rating (SCCR)
- c) Drive enclosures input disconnect
- i. Provide an enclosure door interlocked disconnect with fusing, or disconnect, or thermal magnet circuit breaker, or motor circuit protector
  - ii. Operator Handles
    - Provide externally operated main disconnect handle
    - Handles shall be lockable with up to three lockout / tagout padlock positions
- d) Branch circuit protection
- i. Input fusing, motor circuit protector (MCP), or inverse time circuit breaker shall be provided
- e) Bypass
- i. Manual Bypass Option:
    - Shall provide a means to manually switch a single motor from drive control to bypass (across the line operation)
    - Shall provide separate drive output and bypass contactors. The contactors shall be electrically and mechanically interlocked
    - Shall provide a Drive/Off/Bypass selector switch, mounted on the enclosure door, for selection of Drive and Bypass modes of operation
    - Provide a Class 10 overload for motor protection while operating in the bypass mode
  - ii. Automatic Bypass Option:
    - Shall provide a means to automatically (upon a drive fault) switch a single motor from drive control to bypass (across the line operation)
    - Shall provide separate drive output and bypass contactors. The contactors shall be electrically and mechanically interlocked
    - Shall provide a Drive/Off/Bypass selector switch, mounted on the enclosure door, for selection of Drive and Bypass modes of operation
    - Shall provide a Auto Bypass/Off/On selector switch, mounted on the enclosure door, for selection of Auto Bypass mode of operation
    - Provide a Class 10 overload for motor protection while operating in the bypass mode
  - iii. SMC Flex / Pump Option Bypass:
    - Shall provide a means to switch a single motor from drive control to bypass via a soft start (across the line operation)
    - Shall provide separate drive output and bypass contactors. The contactors shall be electrically and mechanically interlocked
    - Shall provide a Drive/Off/Bypass selector switch, mounted on the enclosure door, for selection of Drive and Bypass modes of operation
    - Provide a Class 20/30 overload for motor protection while operating in the bypass mode
    - Shall provide a door-mounted HIM
    - Shall provide bypass fusing on input of RVSS bypass



- f) Control power transformer
  - i. Provide a control power transformer mounted and wired inside of the drive system enclosure
  - ii. The transformer shall be rated for the VFD power requirements
- g) Harmonic mitigation techniques
  - i. Drive Input Line Reactor
    - Provide a drive input line reactor mounted within the drive system enclosure for drives that are less than 100 horsepower
    - The line reactor shall meet the following specifications:
      - The construction shall be iron core with an impedance of 3 or 5 percent
      - The winding shall be copper or aluminium wound
      - The insulation shall be Class H with a 115 °C rise over 50 °C ambient
      - The unit shall be rated for system voltage, ampacity, and frequency
  - ii. 18-pulse VFD (greater than 100 horsepower) with Auto Transformer
    - Provide VFD with a single 18-pulse converter
      - The converter bridge shall be a parallel 18-pulse diode bridge assembly with DC snubber (board or assembly). Diodes shall be rated (devices) with a blocking voltage minimum of 1600V
      - The converter shall incorporate 1000V three phase block style MOV protection rated 85 °C
    - The drive system shall incorporate an 18-pulse phase shifting auto transformer with line reactor as an assembly. The 18-pulse assembly shall be wired into the VFD System enclosure where possible. The auto transformer shall have the following minimum features:
      - Rated for input rectifier duty and matched to VFD overload capability
      - Copper or aluminium wound
      - Class 180 or 220 insulation
      - Power factor of 0.98 or better at rated load and nominal line voltage
      - Open core construction
      - One normally closed thermoswitch contact in each coil wired into a VFD control circuit
    - The drive system shall be compliant with IEEE519-1992 standards at the input VFD terminals based upon the input power phase imbalance within 0.5% of nominal line voltage and under full VFD output current ratings
- h) Auxiliary relays
  - i. Provide relays for Drive Alarm, Drive Fault, Drive Run, and System Status Faults (as required)
  - ii. The relays shall be Allen-Bradley 700-HC (2 N.O. & 2 N.C.). The relay contacts shall be rated for 115V AC/30V DC, 5.0 amp resistive, 2.5 amp inductive
- i) Control interface
  - i. The control terminals shall be rated for 115V AC
  - ii. The control interface shall provide input terminals for access to VFD functions that include start, stop, external fault, speed select, and enable, as required
- j) Motor heater control
  - i. The drive system shall provide the drive control circuitry to energize an existing motor heater whenever the motor is not running via remote power
  - ii. The heater control shall be interlocked with the drive and/or bypass and shall be energized whenever the motor is not running. The source shall be remotely provided
  - iii. A pilot light with LED shall be mounted on the drive system enclosure door for indication of Motor Heater On
- k) Hand/Off/Auto selector switch
  - i. Provide a "Hand/Off/Auto" selector switch, mounted on the enclosure door
  - ii. The "Hand/Off/Auto" selector switch shall start the drive in the "Hand" mode and stop the drive in the "Off" mode
  - iii. In the "Auto" mode the drive shall be started and stopped from a remote "RUN" contact
  - iv. In all modes, Auxiliary and Enable inputs to the drive control interface board must be present before the drive will start



- v. When a HIM is present, the stop function shall always be available to stop the drive regardless of the selected mode ("Hand" or "Auto"). The HIM will be non-functional (except for the display and programming) when the switch is in "Off" mode. The HIM shall stop the drive if the switch is in the "Auto" mode with the remote start contact initiated
  - vi. The drive speed reference shall be controlled from the HIM, unless a separate door mounted potentiometer is provided, when in "Hand" mode (factory default setting)
  - vii. The drive speed reference shall be controlled by a remote 4...20 mA input when in "Auto" mode
  - viii. The device shall be mounted on the drive system enclosure door
- l) Drive disable mushroom push button
- i. Provide a maintained mushroom style push button, mounted on the enclosure door that when pushed, will open the drive enable input
  - ii. The device shall be mounted on the drive system enclosure door
- m) Pilot lights
- i. Provide LED pilot lights, mounted on the enclosure door, for indication of the following status:
    - Run
    - Drive Fault
    - Control Power On
    - Motor Fault
  - ii. The device shall be mounted on the drive system enclosure door
- n) Motor run time meter
- i. Provide a digital, non-resettable, door-mounted elapsed time meter
  - ii. The meter shall be electrically interlocked with the Drive Run relay and Bypass contactor to indicate actual motor operating hours

## EXECUTION

### Examination

- a) Verify that location is ready to receive equipment
- b) Verify that the building environment can be maintained within the service conditions required by the manufacturer of the VFD

### Installation

- a) Installation shall be in compliance with all manufacturer requirements, instructions and drawings

### Start-up service

- a) At a minimum, the start-up service shall include:
  - i. Perform pre-Power Check
  - ii. Megger Motor Resistances: Phase-to-Phase and Phase-to-Ground
  - iii. Verify system grounding per manufacturer's specifications
  - iv. Verify power and signal grounds
  - v. Check connections
  - vi. Check environment
- b) Drive Power-up and Commissioning:
  - i. Measure Incoming Power Phase-to-Phase and Phase-to-Ground
  - ii. Measure DC Bus Voltage
  - iii. Measure AC Current Unloaded and Loaded
  - iv. Measure Output Voltage Phase-to-Phase and Phase-to-Ground
  - v. Verify input reference signal
- c) All measurements shall be recorded
- d) Drive shall be tuned for system operation
- e) Drive parameter listing shall be provided



### Training

- a) Manufacturer to provide on-site instruction
- b) The instruction shall include the operational and maintenance requirements of the variable frequency drive
- c) The basis of the training shall be the variable frequency drive, the engineered drawings and the user manual. At a minimum, the training shall:
  - i. Review the engineered drawings identifying the components shown on the drawings
  - ii. Review starting / stopping and speed control options for the controller
  - iii. Review operation of the Human Interface Module for programming and monitoring of the variable frequency drive
  - iv. Review the maintenance requirements of the variable frequency drive
  - v. Review safety concerns with operating the variable frequency drive

## 28. LOW VOLTAGE ELECTRIC MOTORS

All electric motors shall fully comply with the following relevant standards:

SABS 1189, SABS 948, BS 4999 and BS 5000 or IEC 34 and IEC 72.

When ordering electric motors for a specific application the Contractor shall ensure that the orientation of the terminal boxes on the motors are suitable for vertical cable entry from below with the motor installed in position and provided with suitable cable entry holes to accommodate the specific cable glands (Holes to be tapped in case of cast boxes).

All three phase low voltage motors shall be of the squirrel cage induction type.

Unless a power rating for a motor is specified, all motors shall be rated for continuous operation (Duty Class S1) at an output of 15% in excess of the maximum power requirements of the associated driven plant when operating at the maximum specified duty at an ambient temperature of 40 °C and an altitude of 1300 m.a.s.l. The minimum class of insulation shall be class F according to SABS 948.

The motors shall be of a recommended standard rating and if the requirements given above fall between two standard ratings, motors of the next higher standard rating must be provided. The motors shall be either fixed speed, dual speed or speed control units, as required. All motors shall, where possible, be from the same manufacturer to prevent stocking a variety of spares.

The motor speed shall match that of the driven plant but shall not be in excess of 1500 rpm unless otherwise required.

All motors shall be suitable for "direct-on-line" starting unless "star/delta" or other starting methods are prescribed by the supply authority.

The maximum starting current of these motors under locked rotor conditions with specified voltage applied to the motor terminals shall not exceed six times normal full load current.

The motors shall be suitably rated for 15 starts per hour at an ambient temperature of 40 °C and an altitude of 1300 m.a.s.l.

All submersible motors shall be of the IP 68 type and all other motors shall be of the IP 55 IC 01 41 type.

Motors rated at 22kW and above shall each be equipped with three thermostats with a positive temperature coefficient of resistance embedded in the overhang of the stator windings (one per phase) to facilitate the operation of protective devices on overheating of the relevant motor. These thermostat and heaters shall be wired to suitable separate terminal boxes on the outside of the motor.

All submersible motors shall be supplied complete with adequately rated underwater cables factory connected onto the motor, for power supply as well as sensing where applicable. These



cables shall be sufficient length to reach the connection points, i.e. the nearest readily accessible dry area, without straining the cable and shall have watertight connections onto the motor. Exact lengths of cable required shall be verified on site before finalizing orders.

Motor selection for frequency converter speed applications shall allow for the following:

- (a) The rated motor power shall be in excess of 35% of the maximum power required by the driven machine and shall have the written consent of the manufacturer that the motor rating will suit the application. Motors shall be suitable for continuous operation over the variable speed range of between 50% and 100% of the specified motor speed.
- (b) The ratio between the maximum torque and the rated torque of the motor must be less than 2.5.
- (c) The method of cooling of the motor shall be efficient for continuous operation over the abovementioned speed range of the motor and shall either be self-ventilated or separately ventilated type of motor.
- (d) The rated speed of the motor shall be as close as possible to the nominal speed of the driven plant.
- (e) Four-pole motors will be preferred but more pole motors will be acceptable if direct-on-line starting will adversely be affected by the four-pole motor.
- (f) Motor winding insulation must be compatible with frequency converter variable speed operation.
- (g) Noise levels of the motor shall not exceed the value given in SABS 948 appropriated to the rated output and speed range of the motor.
- (h) Variation levels of the motor shall not exceed acceptable vibration amplitudes through the speed range when operating in conjunction with frequency converter variable speed applications.

Dual speed motors shall have separate windings each with differing number of poles. Motor ventilation shall be efficient at the required load torque of the driven plant at both speed settings.

Vibration and noise levels shall not exceed values given in SABS 948 appropriated to the rated output and speed of the motor.

Each motor shall be provided with a grade 304 stainless steel or brass nameplate.

**The following information shall be submitted with each Tender** in respect of all the three phase low voltage motors offered:

- (a) Two copies of an outline drawing showing main overall dimensions.
- (b) Guaranteed continuous rating under site conditions.
- (c) Guaranteed number of starts per hour at an ambient temperature of 40 °C.
- (d) Guaranteed maximum starting current under locked rotor conditions with the normal voltage connected to the incoming terminals.
- (e) Guaranteed efficiency of the motor at 50% and 100% normal full load with motor windings connected in delta.
- (f) Guaranteed power factor of the motor at 50% and 100% normal full load with the motor windings connected in delta.
- (g) The mass of each motor.



- (h) Copies of SABS test reports if these motors carry the SABS mark.

The following tests shall be carried out at the Manufacturer's Works on these motors after manufacture:

- (a) If the motor do not carry the SABS mark, performance and efficiency tests shall be carried out to prove the guaranteed information submitted with the successful Tender. These tests must be performed by the South African Bureau of Standards and a certificate of approval must be submitted stating that the motors comply with the requirements of SABS 948.
- (b) All motors shall be subjected to routine tests as prescribed in Appendix D to SABS 948.

The manufacturer **must submit** to the Engineer two certified copies of test certificates reflecting the conditions and results of the tests carried out on each motor.

After installation on Site, but prior to commissioning, the following test shall be carried out:

- (a) Ensure that the bearings are properly lubricated.
- (b) Ensure that all power and earth connections are properly made.
- (c) Check all ventilation openings for obstruction.
- (d) Measure the insulation resistance between phases mutually and between each phase and earth to ensure that the windings are dry.
- (e) Spin the motor by briefly switching the supply on to check the correctness of the direction of rotation. After the motor has been started the following shall be observed:
- (f) Smoothness and period of acceleration up to maximum speed.
- (g) Noise, vibration and temperatures of motor and bearings.

Seal leak detectors for submersible pump and motor sets

All submersible pump motor sets shall be provided complete with humidity sensors to facilitate seal leak detection as well as an underwater cable connection for each detector as specified for submersible motors.

## 29. SUBSTATION / MOTOR CONTROL CENTRE BUILDINGS

### Regulations and Approval

Building work shall be to the approval of the Employer and appropriate Building Inspector and shall comply with local building regulations.

Dimensions of cable trenches, ceiling height, width of door opening, ventilation requirements, etc. must be verified with the switchgear supplier before construction commences.

Any cost resulting from Contractor failing to verify this information and advise the Builder of any changes shall be for his own account.

### Foundations

Upper surface of foundations are to be  $\pm 1000\text{mm}$  below ground level, depending on ground conditions. Actual depth is to be decided on site.

Concrete mix: 5 parts 19mm stone; 3 parts sand; 1 part cement.

### Brickwork



Bricks are to be laid stretcher bond with "Brickforce" every fifth course.

All walls are to be 230mm thick.

Outer skin is to be of approved facebrick, samples of which must be submitted for approval before ordering.

Horizontal and vertical joints of outer skin are to be raked out 12mm. Inner skin jointing is to be flush.

External walls are to have a 12mm overlap at damp course level.

Vermin proof air bricks shall be provided to the extent shown.

#### **Floor**

Sub-floor is to be a 100mm thick concrete slab reinforced with 152 x 152-gauge mild steel mesh.

Base, and fill if any, is to be well compacted before casting floor slab. Concrete mix shall be 4 parts 19mm stone; 2 parts sand; 1 part cement.

Floor is to be finished with 25mm cement screed, steel trowelled and level to within 3mm, screed being coloured with an oxide of a selected colour.

Brass weather strip shall be set in floor immediately inside the doors.

Cable ducts are to have 100mm thick concrete mat and are to be lined with 144mm brickwork, unless otherwise specified. Concrete mix shall be as for foundations.

#### **Roof**

Roof shall be tile on timber construction as shown with PVC weather sheet beneath tiles.

Tile colour will be as specified by Architect / Engineer. Samples shall be submitted for approval before ordering. All ridge tiles are to be cement grouted.

Roofing timber shall be seasoned and suitably treated against termites. Gang-nailing of rafters, trusses and posts is acceptable. Roofing timber is to be rough sawn.

Tie straps of 8-gauge galvanised wire or 32mm x min. 18-gauge galvanised hoop iron for fixing of wall plates shall be provided between tile battens and rafters. Tiles shall be nailed to these battens.

Fascia and barge boards shall be of selected hardwood. "Flexit" board or similar is to be installed below eaves. All other timber shall be of SA Pine or similar.

Gutters and downpipes shall be uPVC or aluminium, gutters being half-round. Downpipes shall discharge onto a concrete rainwater trap.

#### **Ceiling**

Ceiling shall be Rhinoboard on SA Pine bracking with standard cornices.

#### **Doors**

Doors shall be fabricated of selected hardwood as detailed, vermin proof louvers being fitted as shown.

Doors shall be hung with brass or bronze "parliament" type hinges, unless otherwise specified. Brass tower bolts shall be fitted to the normally closed door with brass barrel keeps set in floor and frame. 230mm Brass or bronze swivel type locking bar shall be provided on external face of doors. Padlocks will be provided by Contractor. 230mm Brass or bronze cabin hooks and eyes shall be



provided to retain each door in the fully open position. Eyes shall be fixed to outside of door and the hook screwed into the facebrick at 1,0m above floor level. All screws for fabrication of doors and louvres and for fixing of all accessories shall be brass.

#### **Chequered Plate**

All cable trenches within building shall be provided with galvanised chequered plates or an alternative material with equivalent strength.

Angle iron supports shall be fixed to trench walls to support chequered / equivalent plates flush with floor.

Plates shall comprise lengths which can be conveniently handled and where pieces are odd shaped to cover trenches diverting and changing direction, odd shapes pieces may be neatly welded together to form a single section.

Chequered / equivalent plates shall putt square against each other along the full run of the trenches and shall neither overlap nor have gaps between them.

#### **Finishes**

Internal walls and duct walls shall be smooth plastered. Internal walls and ceiling are to be painted with two coats of white Acrylic PVA.

Timber facias and barge boards are to be treated with one coat of wood primer, one coat of undercoating, and finished with two coats of best quality white oil based hard gloss enamel.

Doors and louvres are to be given two coats internally and three coats externally of clear wood sealer.

### **30. ELECTRICAL ACTUATORS FOR VALVE CONTROL**

Electrical actuator motors for valve and sluice gate control shall be rated in excess of 50% of the maximum power required to open and close the valve or sluice gate.

The actuators shall be complete with continuous local position indication providing a 4-20mA signal for remote position indication and suitable for remote control by means of a 4-20ma signal if required as indicated in the detail technical specification.

Electric actuators for plug valve control shall be suitable for valve position selection by means of a local as well as remote non-maintainable signal and limit switches built into the actuator to facilitate positive positioning of the plug valve in any of the positions selected. The actuator shall be provided with local valve position indication as well as facilities for remote indication.

NB: Gears of synthetic materials will not be acceptable in these units.

### **31. Programmable Logic Controller**

This Specification defines the requirements for the design, construction, supply, delivery, programming, configuration, testing, installation and commissioning of Programmable Logic Controllers (PLC) as well as their interfaces to equipment and instrumentation such as HMI and Supervisory Control and Data Acquisition (SCADA).

Applicable standards are:

- IEC 61131 (Parts 1-8) Programmable Logic Controllers
- IEC 61499-1 Function blocks
- Occupational Health and Safety Act of 1993



*Hardware: General*

PLC and PCS hardware shall be of a recognised reputable type, approved by the Engineer; from a major international supplier, with a comprehensive and established South African based technical and logistical support operation.

The PLC / PCS shall comprise of the following:

- a) Central Processing Unit (CPU)
- b) dedicated Power Supply Unit (PSU)
- c) digital and analogue hard-wired input / output (I/O) cards
- d) remotely connected digital and analogue I/O cards (if and where specified)
- e) data communications cards and/or ports on the CPU

The PLC / PCS shall interface with other devices and systems as follows:

- a) control circuit components, equipment, instrumentation and plant devices
- b) industrial Ethernet communications to Level 2 visualization and operation equipment
- c) an open fieldbus communications to Level 0 equipment (if and where specified)
- d) other process controllers (e.g. variable speed drives, electronic controllers, dedicated equipment control systems or other PLCs)
- e) remote terminal units (RTUs), and telemetry systems

The hardwired I/O and network communication cards, together with the processor and power supply cards, shall all be housed in racks of one or more chassis units. Where chassis units are provided with spare slots for hardware expansion, these shall be protected by proprietary blanking plates. Any spare communications ports shall likewise be protected with dust covers or plugs.

The processor memory shall be sufficient to operate the as-installed programme with 20% spare capacity, and the installed I/O cards shall be sufficient to operate the as-installed programme plus 10% spare capacity of each I/O type used.

Once the program has been entered into the processor memory, it shall remain resident and unaltered, including under power down conditions, until it is deliberately modified by use of a programming unit. The processor shall contain a readily replaceable memory backup battery and indication of battery status.

The PLC / PCS shall be programmable using a standard portable notebook computer with suitable software as its programming device. The PLC / PCS shall be provided with all interfacing hardware and software; ready loaded and configured, to permit full access to the programme (including re-programming) via the standard serial communications port of a PC.

The processor shall incorporate the following indications as a minimum:

- a) running
- b) processor watchdog healthy
- c) and I/O manipulation status

The processor watchdog signal shall be configured to raise an alarm upon CPU failure which shall be displayed on the associated HMI / SCADA or telemetry (where applicable). The PLC / PCS CPU shall allow programme changes "on the fly". In other words, minor changes to the control logic shall not require the CPU to be reset thereby causing the plant or works to be shut-down.

The PLC range shall offer various CPU memory, capacity, speed and I/O count sizes to suit the plant or works including "hot-standby"/ redundant CPU possibilities all as called for in the Project Specification.

*Hardware: PLC I/O*

I/O cards shall be provided with voltages and signal loop currents (or voltages) as called for in the Project Specification.

The I/O cards shall be keyed or otherwise configured to prevent maloperation if placed in the wrong position in a PLC / PCS rack, and each I/O card shall be capable of being individually removed or replaced without disturbing the wiring to adjacent cards.

Each I/O card shall be provided with an individually fused power supply feed, and an I/O card malfunction or power supply failure shall be recognised by the PLC hardware and software and raise an alarm on the CPU, relevant HMI or SCADA.



Conventional PLC I/O cards shall be limited to a maximum of 16 channels per card, and each I/O point shall be provided with an I/O status indicator. The use of 32 channel digital input cards will be subject to the card's cable termination concept and approval of the Engineer.

The I/O wiring shall be segregated between input and output cards, and all I/O (including spare I/O) shall be loomed from the PLC card down to knife-edge ('swinging blade') disconnect type marshalling terminals from where these shall be marshalled to the field wiring. Where available, proprietary "looms" (connector / termination assemblies) shall be used to connect between the I/O card and the marshalling section.

Where it is necessary to maximise plant availability; e.g. with a duty / standby plant configuration, and more than one input card is available, the duty plant inputs shall be assigned to a separate card from the standby plant inputs. The same shall apply to the assignment of outputs to the plant.

Where mission critical applications require redundant IO these shall be accommodated by the choice of the PLC and appropriate CPU, and the circuitry shall be equally segregated as described above.

*Hardware: PLC Remote I/O*

Where Remote I/O is called for in the Project Specification the I/O cards shall preferably be of the same type and range as those offered for the main PLC with centralised I/O.

Data communications from the PLC / PCS to Remote I/O shall be via a dedicated data communications medium and protocol specifically design for Remote I/O and the Data Communications medium from the PLC to HMI, SCADA or Field instrumentation may not be used for this purpose.

*Hardware: PLC I/O circuits*

Digital input circuits, whether hard-wired to conventional I/O or connected via remote I/O, shall consist of volt-free contacts from control circuit components, equipment, and plant devices. These circuits shall be energised from the PLC end, and shall be "fail safe" in design, i.e. contacts shall open on PLC failure or alarm conditions and normal plant status conditions shall provide normally open contacts.

Digital outputs shall be provided with integral changeover relay contact suitably rated for the required switching duty and shall be provided with suppression devices when switching DC loads. Alternatively, transistor output cards may be used in which case suitably rated interposing relays shall be included for each digital output in the Assembly.

Analogue input and output cards be capable of a minimum analogue to digital conversion resolution of 12 bits and shall include open circuit and short circuit monitoring.

Analogue inputs shall be powered either from the field instrument they connect to (where the instrument is separately powered with 230 V AC or 24 V DC), or from a fused 24 V DC power supply at the PLC side where the instrument is loop powered. Each instrument loop circuit shall be designed for a loop impedance not exceeding 250 ohms.

Analogue outputs shall be powered from a fused 24 V DC supply via the analogue output card, and shall be able to drive into an impedance of up to 750 ohms. Analogue outputs shall provide a direct connection to the load (i.e. the whole primary loop).

Digital Inputs and Outputs shall be galvanically isolated in groups on no more than eight.

Analog Inputs and Outputs shall be individually galvanically isolated.

*Software: General*

PLC application software shall be written to meet the requirements of the plant or works Control Philosophy and the PLC processor shall be capable of being programmed using ladder logic, control system flow chart or statement list in accordance with SANS 61131-3. The software shall be laid out in a modular manner and structured in program and function blocks, such that similar tasks are of a similar structure and functionality to facilitate efficiency and ease of programming and maintenance.

Standard software Function Blocks shall be built up using the Client's standard suite of function (when available), or the PLC manufacturer's recommended standard Function Blocks.



Each line of code shall be fully documented and annotated, using mnemonics directly related to the associated item of plant. Function blocks shall be provided with descriptors e.g. analogue handling block, PID block, motor start block, etc. All data areas used shall be documented and a full memory map provided.

The PLC application software and operating data shall be held in appropriate memory locations; secured against power failure and shall be provided with the facility for password protection against unauthorised access.

A sudden interruption of the power supply to the PLC shall result in the programme failing to a safe condition, and the PLC system shall not require manual attendance following a supply failure or restoration. The software control routines shall provide safe power-on and power off sequences to ensure that the process is always in a safe and controlled condition.

Where a PLC forms part of a networked plant control system, it shall have a standalone operating capability such that in the event of a network failure it shall be able to continue monitoring and controlling its associated plant; using any set-points and parameters available prior to any network failure, including the ability for operators to change duties, monitor alarms, etc. via any associated local operator interface such as an HMI as called for in the Project Specification.

All software necessary to programme, operate, or maintain any equipment or component within the Assembly, including any network connectivity software, shall be provided, and shall be licensed in the Client's name.

*Software: PLC software structure*

The PLC application software controlling the plant shall be structured so as to provide, as a minimum requirement, the software routines for each key functional area as detailed below:

**Plant initiation**

This key functional area shall contain routines developed to control plant start-up and restart, plant reset, and phased plant starting, after a power supply re-energisation; including a return to the control mode selected prior to powering down. Plant trips, when reset by the operator, shall reinstate normal automatic operation without the need for further operator intervention.

**Plant automatic control**

This key functional area shall contain all software necessary to provide automatic control of the plant process(es) and shall include alarm generation and exception handling, together with the starting-up and scheduling of any associated standby plant.

**Plant shutdown**

This key functional area shall contain routines developed to control plant shutdown, including under operational, power failure, and unplanned / emergency conditions.

**Operator and remote interface(s)**

This key functional area shall contain all software necessary to provide interfaces to the local HMI, and to SCADA or telemetry (where required). All digital points to / from the HMI, to / from the SCADA system, or to the telemetry system, shall be held within separate integer registers or memory areas, and all analogue points to / from the HMI, to / from the SCADA system, or to the telemetry system, shall be held within separate floating-point registers or memory areas.

**Interlocks**

The PLC / PCS programming shall provide for two types of interlocks namely process and safety interlocks.

**a) Process Interlocks:**

- i) These are dictated by the physical flow of material through the plant and are typically programmed between motor, valve, actuator and controller software blocks.
- ii) Equipment being prevented from start-up by a process interlock shall clearly indicate this condition on the SCADA system.

**b) Safety Interlocks:**

- i) These are typically hardwired into the motor, valve or actuators control circuit, latched and reset in the MCC whilst monitored by the PLC and shall indicate as faults on the HMI or SCADA system.



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*Software: PLC software control routines*

The development of the PLC application software shall include as a minimum, the routines as detailed below.

For all plant items, the selection of automatic control via the auto-available input signal shall be recognised by the PLC and displayed at the associated HMI, SCADA (and where appropriate, at a remote telemetry SCADA terminal). When an item of plant is selected for hand control, facilities for the rescheduling of any standby plant shall be provided.

Direct operator control via the PLC of each plant item (where that plant item is selected for automatic control) shall be provided from the associated HMI (and where appropriate, at a remote SCADA terminal). The selection of direct control shall leave the plant item state unchanged until a new control command is issued, at which time the rescheduling of any standby plant item shall take place.

Where duty / standby (or assist) plant is provided, the software control regime shall provide scheduling of these plant items through rotation of the duty / standby (or assist) functions. The duty rotation shall be dependent either upon the hours run for that item of plant selected for duty, or upon the issue of a manual duty rotate command. The required duty hours (between zero and 999) shall be entered by the operator at the associated HMI (or where appropriate, at a remote SCADA terminal). An entered value of zero duty hours shall inhibit the duty function within the associated plant item's duty rotation cycle. For those areas of plant where an apportioned wear pattern is required, an operator warning message shall be issued if the duty cycle hours entered for each item does not provide an uneven wear pattern. Where the operation of plant items is determined by upper and lower process limits, the automatic changeover of duty status shall be delayed until an appropriate point within the operating cycle.

*Software: PLC monitoring software*

Monitoring software shall be provided to confirm the running of plant items in response to any start command, and shall use separately configurable time delays for each item of plant. If an item of plant fails to start within its configured time, the item of plant shall be deemed to have failed and an alarm shall be generated. The monitoring software shall also provide the accumulated run hours for all motor driven and proprietary items of plant.

When an item of plant fails, the control system shall automatically reschedule any standby plant item in place of the duty plant, and execute the appropriate shut-down sequence for the failed plant item. The standby plant item shall continue to operate in place of the failed duty plant item, until the plant item failure condition has been reset by the operator. Once the plant item failure condition has been cleared by the operator, the restored duty plant item shall operate and the standby plant item shall return to its standby status.

Monitoring software shall be provided to confirm the position of all valve(s) and penstock(s) in response to any open or close request, and shall use separately configurable time delays for each valve or penstock. If a valve or penstock fails to achieve the requested position, within its configured time, the valve or penstock shall be deemed to have failed and an alarm shall be generated.

Monitoring software shall be provided for the associated HMI, SCADA (and where appropriate, at a remote telemetry SCADA terminal), to generate operator message prompts where there is a need to manually exercise control over items of plant which remain in a static operating position or dormant state for extended periods of time. Where applicable, such plant will be identified in the Project Specification and / or Control Philosophy.

The PLC application software shall check all analogue input signals for validity. An analogue input signal shall be converted to a digital value at the I/O card, i.e. the current loop signal shall be converted to 0 - 4095 bits. The PLC software shall periodically check for a conversion which indicates under-range or over-range. If either of these two states is set, the software shall initiate an 'out of range' alarm.

In order to prevent the operator being presented with excessive spurious alarm messages, the PLC application software shall include routines, that on the initiation of a specific event alarm, shall prevent cascade alarms from being raised i.e. a 'mains failure' alarm will mask the 'not available' alarms from individual motor starters, valves, etc.



The PLC application software shall generate totalized quantities for individual items of equipment and instrumentation, whereby a pulsed digital signal shall be received and a set amount added to a totalizer register. The set amount used to increment the totalizer shall be adjustable and stored in a register. The totalizer shall be capable of the range 0 to 999999, and the totalizer shall automatically rolling over to zero when the maximum figure has been reached. The totalizer figures shall be displayed on the associated HMI display, SCADA (and where appropriate, at a remote telemetry SCADA terminal).

#### *Functional Specification*

Prior to programming the PLC, the Contractor shall provide the Engineer with a Control System Functional Design Specification describing how the Plant or Works Control Philosophy will be implemented in the Control System Software (PLC).

The Functional Specification shall include at least the following:

- a) Control System Overview
- b) Final Approved plant or works Control Philosophy
- c) Equipment, Motor and Instrumentation Lists
- d) PLC IO lists
- e) List of Interlock signals
- f) List of Alarms
- g) List of all PID control Loops
- h) List of all Sequence and / or Duty/ Standby control
- i) Detail description of PLC configuration and software building blocks (Function Blocks)
- j) Function Block Parameters tables

The Functional Specification shall be issued to the Engineer for approval.

On completion of the contract the Functional Specification shall be converted into a Control System Functional Description and incorporated into the Operations and Maintenance Manuals.

## **32. MULTICORE CABLES AND EARTHWIRES**

### *Low and Medium Voltage Cables*

All multi core-cables used on this contract shall comply with the requirements laid down in SABS 1507 – 1990 as amended to date for PVC PVC SWA PVC cables with copper conductors and insulated for 500/3300 volt grade.

Cables for status and analog signals shall consist of the requisite size and number of copper twisted pairs, individually and overall screened, PVC sheathed, steel wire armored and PVC covered, complying with the requirements of SABS 1507 where applicable.

Cable and earth wires for a specific application shall be selected strictly in accordance with the requirements laid down in SABS 0142 in respect of current rating and voltage drop. Where practicable the earth continuity conductor shall form an integral part of the cable.

### *Fiber Optic Cables*

The cable shall have a GRP centre strengthening member, color coded fibers in gel filled loose tubes, surrounded by interstitial water blocking gel, aramid strengthening member, paper binder, polyethylene bedding sheath, plastic coated corrugated steel type armor and polyethylene water resistant outer sheath.

The steel armor shall be polymer coated and bonded to the sheath.

The fiber shall be manufactured from pure silica cladding, minimally doped with Phosphorous and Fluorine to achieve a matched cladding and a graded Germanium doped silica core. The primary coating shall consist of two layers of UV curable acryline resin.



Attenuation uniformity shall be checked at both 850nm and 1300nm with a pulse width not exceeding 1 micro's. Fibers with points or steps of discontinuity greater than 0,3dB shall be rejected. For fiber lengths in excess of 1km the attenuation coefficient over the length of fiber shall not vary by more than 0,3dB/km.

The fiber shall withstand a mechanical strain of at least 8N for 1 second and shall have an attenuation increase of less than 0.005dB/turn under a bend resistance test using 100 turns around a 75mm diameter mandrel.

### **33. JOINTING OF CABLES**

Joints will only be allowed where more than one full drum length of cable is necessary to complete a specific circuit and must be restricted to the absolute minimum. All joints shall be made to the best practice by competent cable jointers using first class material. The contractor shall maintain the electrical continuity of the armoring in an approved manner at all straight through joints.

#### *Low voltage power and control cables*

Joints shall only be allowed where more than one drum length of cable is necessary to complete a specific circuit.

The jointing kit shall be equal and similar to Raychem heat-shrinkable joints for cables up to 1 kV.

The joints shall be made to the manufacturer's instructions and with materials stipulated in such instructions.

### **34. TERMINATION OF MULTICORE CABLES**

#### *Low voltage multi core power and control cables*

Cables are to be terminated with glands manufactured of bronze and comprising a barrel with sealing washer and bush nut screwed into one end and a compression nipple with wire clamping ring screwed onto the other end. The opposite end of the compression nipple must have a male electrical thread with locknut. The glands shall be suitably sized for the relevant cables, be of the adjustable type complete with armor clamps and with watertight neoprene shrouds.

Cable terminating glands for outdoor use shall be provided with waterproofing inner seals as well as waterproofing seals on nipples. Cable armoring shall be earthed at each end but may not be used as earth continuity conductor.

#### *Fiber Optic Cables*

Fiber optic cables shall be terminated by means of suitable glands, ST connections and bus terminals capable of direct connection to the bus interfaces on the bus stations. These bus stations will be housed in separate panels of various control centers.

### **35. DISTRIBUTION AND MOTOR CONTROL BOARDS**

#### *Indoor floor standing distribution and motor control boards Construction*

The board shall be designed for front access only unless stated otherwise in the schedules.

The boards shall be of the free-standing floor mounted cubicle type with IP 55 insert proofed enclosure, constructed of at least 2mm 3CR12 steel or mild steel powder coated on a rigid channel iron or similar frame, and shall be bolted down in position by means of M16 high tensile stainless steel bolts grouted into the concrete floor.

The bolts shall be inside the board.

The overall height of the board shall not exceed 2,00m and the overall depth shall not be less than 450mm and shall not exceed 0,6m. The construction of the board shall be such that future



extension panels may be fitted on both sides and alterations can be done without major changes to the board. (Modular construction will be preferred.)

The board shall be provided with readily removable covers on the side and hinged panels on the front.

All removable covers shall be provided with pre-approved handles or similar approved to facilitate removal. These covers shall be suitably braced and reinforced to ensure rigidity.

All hinged panels shall be reinforced to ensure rigidity and shall be provided with heavy duty rust proof hinges.

These panels shall also be provided with approved knobs or handles.

Each door shall be supplied with completely concealed hinges, each fastened with not less than four (two on each side) brass bolts and nuts. In the case of double doors the first door shall be locked with two slides on the inside, onto the kiosk shell. The second door shall close over a lip on the first one.

The doors shall be provided with a locking system suitable for padlocking. The locking system shall consist of a 3-way locking mechanism locking the door at the top, middle and bottom. The padlock shall be enclosed in a tamper proof enclosure as part of the door construction.

All switch gear, instruments and equipment for the control of any specific motor or other electrical device, shall be mounted flush behind a common hinged panel, with only operating handles, push buttons and instrument faces protruding through neatly machine punched holes in the panel.

The board shall be provided with a readily removable, rigidly supported unpainted 3CR12 or HDG cable end support gland plate along the entire length of the board and at least 230mm above floor level.

Space shall be provided for future switchgear and equipment where specified.

The board shall be suitably sized to accommodate without cramping, all the switchgear and equipment specified.

Screwed-on engraved labels in English shall be provided below all switchgear and equipment on the panels, to facilitate identification.

The board shall be provided with one set of four solid, copper bus bars in the top section and extending over the entire length of the board. Provision shall be made at the end of each bus bar for future extensions.

Bus bars shall comply with the requirements of BSS 1433 and the relevant clauses of BSS 159.

Bus bars shall be rigidly supported at suitable intervals to prevent undue damage resulting under short circuit conditions. Ceramic or other approved bus bar insulators shall be used. The bus bars shall be arranged horizontally with the longer sides of the cross-sections in the vertical plane and one behind the other, in the horizontal plane, at 90 mm centers.

Bus bars shall be clearly and indelibly marked Red, White and Blue for the three phases and Black for Neutral.

Connections to bus bars shall be achieved by means of cable lugs and suitable sized cadmium-plated, high tensile steel bolts and nuts with cadmium-plated cup washers or lock washers.

All screws, studs, bolts, nuts and washers used for these boards shall be Grade 304 Stainless Steel. The use of self-tapping screws will not be permissible. A solid copper earth bar shall be provided inside the board at the back and along the entire length, at a height of approximately 0.6m above floor level.



The earth bar shall have a cross-section of 150 mm<sup>2</sup>.

The earth bars shall be drilled and provided with the required number of 6 mm dia and 10 mm dia cadmium plated, high tensile steel bolts and nuts, complete with cadmium-plated washers and cup washers or lock washers, for making the earth connection. The earth positions shall be evenly spaced along the entire length of each bus bar.

#### Paint finishes for electrical materials and equipment

The paint finishes for electrical materials and equipment where applicable shall strictly comply with the quality specification.

#### Internal wiring

The internal wiring of the boards shall consist of colored PVC-installed conductors of adequate copper cross-section, which shall be neatly installed horizontally and vertically installed in PVC trunking. Numbered ferrules of an approved type (clip on type not acceptable), shall be provided on each end of each wire, to facilitate the tracing of circuits.

#### Electronic Equipment

Where electronic equipment such as transmitting I/O units are incorporated in a distribution- and motor control board, this equipment shall be installed in a separate and special compartment.

Sufficient room shall be provided for the rail mounted terminal strips, equal and similar to Klippon Type SAKR, which will be supplied and installed by the monitor and control system contractor.

The door must be labeled: "ELECTRONIC EQUIPMENT".

#### Labeling of Switchboards and Motor Control Boards

A screwed on engraved label of the black on white "trefolite" type shall be provided below each item of equipment on the front panel of each board as well as on the chassis in close proximity to the relevant equipment to identify such equipment in the English language in 6 mm high lettering.

Each board shall further be provided with a screwed-on reverse engraved yellow Perspex nameplate with black 20 mm high lettering to identify the board in the English language on the outside of the door at the top thereof.

#### Outdoor distribution- and motor control boards

The outdoor motor control boards shall be of the grade 304 stainless steel or mild steel powder coated cubicle type complying with the specification for indoor boards, but shall be not more than 2000 mm high.

Where electronic equipment such as transmitting I/O units are incorporated in a distribution- and motor control board, this equipment shall be installed in a separate and special compartment.

Sufficient room shall be provided for the rail mounted terminal strips, equal and similar to Klippon Type SAKR, which will be supplied and installed by the monitor and control system contractor.

This compartment shall consist of an outer and inner shell with at least 10 mm insulation or polystyrene between the inner and outer shell all round to keep the temperature inside the compartment at least 5° C below the temperature surrounding the compartment in summer. If necessary, ventilation fans shall be installed.

The doors of this compartment must also be of a double wall construction with insulation or polystyrene between the two walls. The door must be labeled:

"Electronic Equipment"



Sufficient provision for breathing and heat dissipation must be made in this compartment.

Control board components

Isolators

All isolators shall be of the "Load-breaking" and "fault-making" type and shall comply with the requirements of BS 5419-1977 where applicable. Where relevant, isolators shall be provided with auxiliary contacts for signal purposes.

Fused switches

All fused switches shall be of the "load-breaking" and "fault-making" type complying with BS-5419 where applicable and fitted with HRC cartridge fused links to BSS-88. Auxiliary contacts shall be provided where relevant for signal purposes.

Moulded case circuit breaker

All molded case circuit breakers shall comply with the requirements of SABS specification No 156-1977 and shall be equal and similar to Heinemann manufacture.

These circuit breakers shall be fitted with copper terminal collector bars where more than one cable tail has to be terminated on the same terminal.

400 Volt air-break contactors

All contactors shall be of the totally enclosed, three pole, double airbreak per pole, automatic magnetic type complying with the requirements of IEC 158-1 for Class AC3 contactors of Intermittent Duty Class 0, 3.

All contactors shall be provided with arc extinguisher and readily replaceable silver or silver-alloy contacts rated for at least 2-million "on" and "off" switching operations at rated current.

Each contactor shall be provided with a 240 Volt, 50 Hz closing coil suitable for continuous operation and at least 15 closing operations per hour.

An adequate number of auxiliary contacts shall be fitted.

The contactor may not hum or chatter in service and the contacts may not bounce on closing.

Current Limiting Circuit Breakers

The current limiting circuit breakers shall be capable of remaining in service and of carrying their normal rated current after having interrupted the maximum rated short circuit current at least three times.

The current limiting circuit breaker shall be equal and similar to the Merlin and Gerin or Unelec type for air circuit breakers and Merlin and Gerin or CBI for molded case circuit breakers.

Direct-on-Line starters (400V motors)

These starters shall be of the manually operated (locally and remotely) type and each starter shall be contained in its own separate compartment on the relevant motor control board.

Each of these units shall comprise amongst other the following components:

1 Only mains fused switch connected to the bus bars of the board and interlocked with the door of the compartment to prevent opening of the door with the switch closed and to prevent closing of the switch with the door open.

1 Set of HRC control fused links with carriers and basis;



All necessary relays as required;

1 Only mains contactor;

1 Set of START and STOP push buttons;

1 Only mains operated timing device to limit starts to 15 starts per hour; and

1 Only power factor correction capacitor unit for motors of 5 kW and more.

The following protective and indicating devices complete with necessary suitable rated potential fuses, current transformers, test blocks and auxiliary relays;

1 Only motor protection relay (Electronic type equal and similar to Newelec KC) for motors of 11kW or more or as specified;

1 Only motor under current relay (Where specified)

1 Only instantaneous indicating ammeter for motor current;

1 Only ammeter selector switch for motors of 5kW or more;

3 Current transformers for motors of 5 kW or more;

1 Only running hour meter;

1 Only anti-dither circuit;

1 Only anti-cycle timer; and

1 Only themister relay for motors of 22 kW or more

1 Only blue LED type indicator light to indicate the time delayed starting period

3 Only LED type indicator lights as follows:

Green – 'Supply on'; Amber – 'Motor Running'; and Red – 'Motor Tripped';

It shall further be possible to trip and lock-out the starter by means of a remote stop button to be provided at the relevant motor.

Provision shall also be made for locking the mains fused switch handle in the OFF position.

#### Star/Delta Starters (400V motors)

These starters shall be of the automatic star/delta type and each starter shall be contained in its own separate compartment on the relevant motor control board.

Each of these units shall comprise amongst others provided for direct-on –line starters the following components as:

1 Only Main Isolator connected to the bus bars of the board and interlocked with the door of the compartment to prevent opening of the door with the switch closed and to prevent closing of the switch with the door open;

3 Only HRC fuses rigidly attached to the load side of the abovementioned Mains Isolator and the rating of which shall be carefully selected for back-up protection for the relevant motor;

1 set of HRC control fused links with carriers and bases;

1 only Mains Contactor;



- 1 only Star Contactor;
- 1 only Delta Contactor;
- 1 only Star to Delta timer of the clockwork or electromagnetic type;
- 1 only Mains operated timing device to limit the starts to 15 starts per hour;
- 1 set START and STOP pushbuttons;
- 1 only three phase Factor Correction Capacitator unit for motors of 5kW or more
- All necessary relays.

#### Variable Speed Drives

These variable speed drives shall each be contained in its own separate panel, manufactured and equipped to the satisfaction of the variable speed drive manufacturer to suit their own requirements with regard to ventilation of the variable speed drive.

The variable speed drive panel shall be equipped with air filters.

The frequency converter shall make use of flux vector control without encoder or tachogenerator feedback and shall incorporate direct torque control technology so that the overall effectiveness of the drive shall only be limited by the performance of the motor.

Semi-conductor shall be determined by the values of flux and torque and shall not have a predetermined pattern as in conventional pulse width modulation flux vector drives.

Each of these drives shall comprise amongst others the following components:

1 Only main isolator that shall be interlocked with the door of the panel to prevent opening of the door with the switch closed and to prevent closing of the switch with the door open.

3 Only ultra rapid fuses rigid connected to the load side of the above-mentioned mains isolator and the rating of which shall comply with the manufacturer's specifications for the drive.

1 Only direct torque control frequency converter.

1 Only door mounted control panel complete with cable connections.

1 Only Thermister relay for motors of 22 kW or more.

1 Only external EMC line filter.

All equipment necessary for remote emergency stop device.

All equipment necessary for remote speed control via a monitoring and control SCADA system as well as PLC control.

All equipment necessary for remote motor status and speed monitoring.

A hot dipped galvanized gland plate must be provided at least 250mm above floor level for cable connection.

- (a) The control panel shall be the user interface for monitoring, adjusting parameters and controlling the drive operation. It shall be possible to:



- i) Enter start-up data into the drive.
- ii) Control the drive with start, stop and reference signals.
- iii) Display actual values of motor performance.

4. Display information on at least the five most recent faults.

- (b) The drives shall satisfy the following technical requirements.
  - i) The static speed control error shall not exceed  $\pm 0.5\%$  of motor nominal speed.
  - ii) Fundamental power factor shall be at least 0.97 at nominal load.
  - iii) Efficiency shall be at least 98% at nominal power level.
  - iv) The drive shall operate satisfactorily under all ambient temperature conditions between  $-5^{\circ}\text{C}$  and  $+40^{\circ}\text{C}$  at an altitude of 1260m above sea level and humidity up to saturation point.
  - v) The drive shall provide output protection of motor overload, over current, short circuit at start, earth fault, missing motor phase and over frequency.
  - vi) The drive shall satisfy the following minimum harmonic voltage limits. Total harmonic distortion of 6%, odd harmonic distortion of 4% and even harmonic distortion of 2%. These harmonic distortion parameters shall be measured by the Contractor after commissioning of the system and if the equipment fail to comply with this requirement, the Contractor will have to rectify the same to the satisfaction of the Engineer.
  - vii) The drive shall be equipped with an AC choke for harmonic current reduction and shall be placed on the AC side of the rectifier bridge in order to protect the rectifier semiconductors against power line transients.
  - viii) Torque step rise time shall typically be less than 5ms.
  - ix) Stringent precautions must be taken in the design of the protection equipment to assure adequate lightning and surge protection.

#### Current transformers

All current transformers shall be of the air insulated type complying in all respects with the requirements laid down in BS 3938: 1973.

The contractor shall carefully select the ratio, burden and accuracy class to suit its application in accordance with the recommendations and requirements of BS 3938.

#### Indicating instruments

All indicating instruments shall comply with the requirements laid down in BS 89: Part 1:

1970 for instruments of a 2, 5 Accuracy Class. All indicating instruments shall have 96 mm square dials.

The maximum demand ammeters shall be of the 6-amp combined maximum demand registering and instantaneous type having MISC movement and thermal demand indication with an integrating time lag of 15 minutes. The ammeter scales shall be direct reading with a full-scale deflection corresponding to 120% of the rated primary current of the relevant current transformer. Each ammeter shall be clearly and indelibly marked to indicate the color of the phase to which it is connected.



The ammeter for motor starters shall be 5 amp instantaneous indicating meters with MICSC movement and direct reading scales. The meter shall be able to withstand over currents resulting under starting conditions and the full load current of the relevant motor shall be clearly marked in red on the face of the meter.

Voltmeter shall be of the direct reading moving iron suppressed zero type.

The power factor meters shall indicate from 0,7 lagging to 0,7 leading.

The running hour meters shall have cyclometer dials indicating up to 5 digits and two decimals.

#### Instrument selector switch

A four-position rotary type instrument selector switch shall be mounted directly below the relevant instrument in such a way that only the selector knob and indicator plate are on the panel, and the switch itself is behind the panel.

The selector knob shall consist of bakelite, and shall have an arrow engraved on it, indicating the switch position.

The switch shall have a positively driven switching mechanism.

The indicator plate shall consist of bakelite and shall have the positions of the three phases and "OFF", engraved on it in 5 mm high lettering.

#### Power factor correction capacitors for 400 Volt motors

Each of these capacitors shall be the indoor switchboard mounting 400 Volt 50 cps three phase self-contained type with a dead casing and shall fully comply with the requirements laid down in BS 1650-1971.

Each capacitor unit shall be of carefully selected rating to correct the power factor of its associated motor to 0,95 at full load and should not exceed a value which compensates for 85% of the no-load magnetizing current.

The dielectric shall consist of plastic film and low-loss paper situated between aluminum foil and impregnated with a synthetic liquid agent with scavenger additive.

The capacitor losses shall not exceed 1 Watt/kVAr.

The capacitor units shall have the following admissible overload at an ambient temperature of 40°C and an altitude 1260 m above sea level.

10% excess volts continuously;

50% excess current continuously; and

30% excess kVAr continuously.

Each of these capacitor units shall be provided with discharge resistors and a fuse each winding element that will disconnect the affected element in event of a de-electric breakdown.

*Information to be submitted with Tenders in respect of the 400 Volt distribution boards and motor control boards. The following information shall be submitted with each Tender in respect of all boards offered:*

- (a) Full technical details and descriptive literature regarding all equipment and instruments offered;
- (b) Three paper prints of an outline drawing of each board indicating the main overall dimensions and general lay-out of the boards; and



- (c) Three paper prints of an outline drawing of the front-end processor cabinet indicating the main overall dimensions, general layout and type of material employed on the face of the panel.

*Information to be submitted by the successful Tenderer in respect of all boards. The successful Tenderer shall submit three paper prints of each of the following drawings, in respect of each of the boards to the Engineer for approved prior to manufacture:*

- (a) Outline and general arrangement drawings, showing main overall dimensions and construction details;
- (b) A wiring diagram; and
- (c) A single line diagram.
- (d) Plastic transparent prints of the following drawings shall be supplied to the successful Tenderer in respect of each of the final layout of the boards.
  - i) Outline and general arrangement drawing of each board;
  - ii) A wiring diagram of each board and mimic panel;
  - iii) A single line diagram of each board;
  - iv) A paper print of the single line diagram for that specific distribution board, shall be framed and installed behind glass in each of the switch rooms. These drawings shall be furnished on A2 prints; and
  - v) A paper print of the single line diagram for each LT starter panel shall be installed behind Perspex inside the door of each starter panel.

*Testing of distribution/motor control boards at the manufacturer's works*

Each distribution/motor control board shall be subjected to the following tests in the manufacturer's works after manufacture:

- (a) A thorough inspection shall be carried out to ensure compliance with the specification and approved drawings and wiring diagrams and to ascertain that all connections are properly made.
- (b) A high voltage test on all primary connections to check the insulation between phases manually and between each phase and earth.
- (c) The polarities and ratios of all potential and current transformer shall be checked.
- (d) Primary and secondary injection tests shall be carried out on all switching, protection, metering interlocking and indication circuits.

The manufacturer shall submit three copies of test certificates giving details of conditions and results of tests carried out to the Engineer.

**36. CONCRETE PLINTH FOR STARTER PANELS AND PEDESTALS**

The plinth shall be cast 150 mm below as well as 150 mm above the ground level. It shall have neatly beveled edges and shall be 75 mm wider than the panels all round.

An opening of sufficient width to allow for cable entry, shall be provided under the starter panels.

The grade 304 stainless steel foundation bolts for mounting of the panels be cast or grouted into the plinth. The plinth shall be in Class 20/19 concrete and shall be suitably reinforced if necessary.



It is recommended that the casting of these foundations must be carried out by the Civil Contractor at the cost of the Contractor under this contract in accordance with his instructions and under his supervision.

**37. ELECTRONIC LEVEL CONTROL**

The micro based electronic controllers which will be mounted in the starter shall be easy to calibrate and reliable in service.

The power units for all the pumps in a specific pump station shall be installed in a separate compartment of the starter and clearly labeled in accordance with the pumps it controls.

These level controls shall be designed to automatically select the pump sequence to ensure that all the pumps will at random be a duty pump.

Where a controller controls only two pumps and one pump is always a standby pump, the standby pump shall automatically become the next duty pump after each duty cycle, unless one pump is taken down for service. When that occurs, the duty pump shall remain on duty until the normal operation is restored.

When a pump selected for duty fails to respond to the start signal from the control, and then the next duty pump shall automatically start-up after five minutes.

The level control must also stop all the pumps, whether on manual or automatic selection, when the pump has reached a predetermined low level.

The transducers shall be designed to operate in air, been capsulated, of rugged construction and impervious to submergence.

The transducers shall, where possible, be installed at a point 500 mm away from a wall or pipe, which may cause a false signal, and at least 500 mm above maximum water level.

The coaxial cable between the transducer and power unit shall be of sufficient length to avoid any joints in this cable, as no joints will be permissible.

The grade 304 stainless steel brackets must be provided and installed under this contract.

**38. EMERGENCY STOP PUSH BUTTONS AND WEATHERPROOF ISOLATORS**

Each of these units shall consist of a totally enclosed outdoor type heavy duty "push and turn to lock" stop push button station with a cable gland entry at the bottom to accommodate a 3 core 1,5 mm<sup>2</sup> LT PVC SWA PVC cable.

This push button station and weatherproof isolator shall be mounted on a rigid 1 meter high-grade 304 stainless steel pedestal with 2 mm radius rounded edges, designed to be bolted to a concrete floor.  
(Refer to the relevant drawing.)

An emergency stop push button shall be installed where indicated near the coupling between each motor and its associated pump and shall be connected to the relevant starter panel via the specified cable to stop the motor.

The pedestal shall be securely bolted to the floor by means of stainless steel foundation bolts grouted into the concrete and care shall be taken to ensure that it is installed plumb.

**39. CABLE LADDERS**

Cable ladders shall be of the heavy-duty type, equal and similar to O-Line.

Cable ladders shall be hot dipped galvanized or as specified on the drawings the height of the sides shall be 76 mm with the width to suit the number and size of cables to be installed.



The cable ladders shall be secured on suitable lengths, which shall be suspended from the roof slab by means of suitable lengths 8 mm dia. threaded hot, dipped galvanized steel rods.

The threaded rods shall be secured to the roof slab with suitable sized hot dipped galvanized steel raw bolts and shall be secured to the channel sections by means of two hot dipped galvanized nuts and washers.

Clamps of the "K" series, suitable for the specific cable shall be employed to secure the cable onto the tray.

The cable trays shall be capable of carrying a distributed load of 140kgm<sup>-2</sup> and a point load of 90kg at the centre of an unsupported span of 2.5m with a maximum deflection of 15mm and without permanent deformation after removal of the design loads. A factor of safety of 2 shall apply.

The cable trays shall be slotted to accept cable ties.

Where cable trays pass through any fire barrier or walls, the tray must be filled with 50mmΦ PVC sleeves passing through the wall and protrude min 250mm on either side. The sleeves must be filled with fire resistant foam after cable installation.

The tray and all cables shall be coated for a min length of 600mm on either side with an approved fire retardant similar or equivalent to Prosafe WB with a final coat of Prosafe Topcoat of matching colour to the Engineer's or Architect's approval. All products shall be handled and applied to manufacturer's recommendations.

#### **40. LIGHTNING PROTECTION**

##### *Plant*

The lightning protection of the lightning structures, poles and plant of the works, including all the buildings and handrails on the new plant, form part of this contract.

The lightning protection must be a SABS approved scheme and SABS approved drawing of the scheme must be submitted to the Engineer.

##### *Lightning arrestors*

Tenderers shall allow in their Tender prices for adequate protection of the equipment supplied and installed under this contract against direct as well as induced voltage surges and spikes which may be experienced on the system.

Surge arrestors shall be provided on each phase as well as neutral on the incoming power supply terminals of each board.

Electronic equipment shall be adequately protected on both the incoming and outgoing terminals by means of suitable arrestors compatible with the relevant equipment. 4-20mA signal cables shall be protected on both sides of the cable against surges.

Arrestors shall be of DEHN manufacture (as supplied by Surgetech (Pty) Ltd. or equal and similar thereto).

All arrestors shall be connected directly to earth along the shortest possible route and only conductors of adequate rating for the discharge currents catered for shall be used for connections to arrestors.

Tenderers shall submit full particulars of the arrestors offered as well as written confirmation that it will provide adequate protection for the relevant equipment against possible voltage surges and spikes on the system.

#### **41. EARTH CLAMPS**



Earth clamps shall consist of 12 mm x 1,5 mm thick copper strap provided with a 25 mm<sup>2</sup> x 3 mm dia, brass bolt, nut and washers. The design of the clamp shall be such that it will fit snugly around the conduit without necessitating any extra packing.

#### 42. FIRE DETECTION SYSTEM

The specialist sub-contractor shall be a registered South African Qualification & Certification Committee (SAQCC) Fire and FDIA (Fire Detection Installers Association) contractor responsible for the detail design, supply, installation, commissioning and testing of the Fire Detection System. A fully addressable closed circuit fire detection system shall be installed (max 126 units per loop). The design and installation of the Fire Detection System shall be done in accordance with SANS 322, 10139 20012 and 10400 (as amended) and the installation shall be done by a reputable and approved Sub Contractor.

The Contractor shall be responsible for providing a link to the existing Main Fire panel (where applicable).

The Contractor shall be responsible for providing a link to the nearest Fire Department. The link shall be compatible to communicate with the applicable Fire Department's system. In areas where cellular reception is poor or not available, suitable measures shall be taken to either boost the signal or to revert to VHF technology. The Contractor shall present his proposal to the Engineer for approval before procuring the said system.

The fire and smoke detection system will comprise of various detectors to cover each area. A multi-zone fire detection control panel of the type ZITON, ARITECH, AST or similar approved shall be installed. The panel shall be supplied with back up battery. The panel shall be fed from the Emergency Power distribution board by means of a 10A circuit breaker located in a glass fronted, lockable box positioned next to the distribution board. The Addressable Call Point Fire Alarm Break Glass shall be surface mounted type ZITON, ARITECH, AST or similar approved with a clear polycarbonate front cover.

The audible and visual siren shall have strobe light and shall be of the ROSHNEE type or similar approved.

Audio and visual alarms for gas suppression systems must conform to the following sequence of operation:

| ▪ AUDIBLE AND VISUAL WARNINGS FOR GAS PROTECTED AREAS |                   |              |               |               |                |                     |
|-------------------------------------------------------|-------------------|--------------|---------------|---------------|----------------|---------------------|
|                                                       | Bell inside       | Siren inside | Strobe inside | Siren outside | Strobe outside |                     |
| First detector activates                              |                   | ON           | ON            | ON            | ON             | Standard fire alarm |
| Second detector activates & timer starts              | ON (intermittent) | ON           | ON            | ON            | ON             | Intermittent sound  |
| Timer expires / Discharge                             | ON (solid)        | ON           | ON            | ON            | ON             | Solid sound         |

The smoke and heat detectors shall be of the APPOLO or ZITON type.

The manual call point shall be of the ZITON, ARITECH, AST type or similar approved.

All fire signal or control cables shall be Halogen-Free fire-retardant Polymer with min of 1.0mm<sup>2</sup> PH120 type fire resistant alarm cable installed in galvanised conduit & trunking to comply with SANS 14115 throughout the installation. Type test certificate shall be submitted for cables being tested in accordance with EN 50200 test requirements to ensure cables remain operational in fire conditions for the rated period or longer and complies with SANS 10139.

The cable shall be installed in a 25mm conduit or trunking.

An easy readable layout drawing clearly identifying the various zones shall be laminated and be wall mounted next to the Fire Panel in a suitably sized aluminium clip board.



A step-by-step operating procedure shall be laminated and be wall mounted in in a suitably sized aluminium clip board complete with the Fire Zones simplified drawing next to the Fire Panel.

The Contractor shall on completion of the Fire Detection System installation:

- Fully test the system in the presence of the Engineer, Client representative and Local Fire Department.
- Ensure for the fire condition that all the air handling units (AHU) and HVAC will shut down, all Access Control doors are released and the grounding of all the lifts.
- Provide a laminated A4 size Step-by-Step procedure for operating and effective use of the Fire Panel next to the panel.
- Provide training on the effective use of the Fire Panel to client representatives and keep an attendance register of such training which must be submitted as part of the compliance certification with the As-Built documentation.
- Provide a Compliance Certificate.

#### 43. LIGHTING

Lighting shall comply with the SABS standards where applicable. The luminaires specified are detailed in the Bill of Quantities and drawings.

Where alternative luminaires and lamps are offered, complete details shall be submitted with the tender. All alternatives shall be subject to the approval of the Engineer.

All luminaires shall be supplied complete with all control gear and an appropriate lamp in each lamp holder.

Where battery backup and "normal" luminaires are indicated in the same room / building, the type of luminaires shall be similar in all aspects (i.e. aesthetics shall be the same.)

Earth conductors shall be connected to the earthing terminal of all luminaires and in accordance with SANS 10142-1.

Each lighting circuit on the Distribution Board shall consist of a 16A single pole MCB of 2.5kA rupturing capacity, unless specified otherwise on the single line diagram.

Unless otherwise specified in the Bill of Quantities or the drawings, the light switches shall be of Clipsal Series 2000, Crabtree Diamond or other similar approved. The correct corrosion resistant cover plate shall be provided with the light switch and included in the rate for the light switch.

The colour coding of light switches shall be in accordance with the details as specified below:

|                         | Normal Supply                                                                                   | Essential/Emergency Supply                                                                  | UPS Supply                                                                                    |
|-------------------------|-------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Colour of Cover Plate   | White                                                                                           |                                                                                             |                                                                                               |
| Colour of Switch Toggle | White                                                                                           | Red                                                                                         | Blue                                                                                          |
| Label Type              | Black letters on White Ivorene label or engraved directly on the cover plate with Black infill. | Red letters on White Ivorene label or engraved directly on the cover plate with Red infill. | Blue letters on White Ivorene label or engraved directly on the cover plate with Blue infill. |
| Label Fixing            | Ivorene label to be glued with super glue or pop riveted to cover plate.                        |                                                                                             |                                                                                               |



|                           | Normal Supply                                                             | Essential/Emergency Supply                                                  | UPS Supply                                                                  |
|---------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Cover Plate Label Details | Distribution Board name and circuit number feeding the switch e.g. DBA/L1 | Distribution Board name and circuit number feeding the switch e.g. DBAE/L1E | Distribution Board name and circuit number feeding the switch e.g. DBAU/L1U |
| Letter Font               | Arial                                                                     |                                                                             |                                                                             |
| Letter Size               | 3mm                                                                       |                                                                             |                                                                             |

#### **Tubular Luminaires**

Tubular luminaires shall comply fully with SANS 1119 and all amendments as well as the additional requirements of this specification. Luminaires shall also bear the SANS mark of approval and the SANS 1464 safety mark.

Tubular lamps light colour shall correspond to cool white i.e. colour 2 (4 300°K) as defined in SABS 1041. Lamps shall comply with SABS 1041 and shall bear the SABS mark. Lamps shall be devoid of flicker. The Contractor is to hand over a fully operational system with all lamps in working order.

Lamps are to be of the T8 type LED similar approved.

Luminaires to be mounted on roof trusses shall be secured by means of two 40mm no.10 round head brass screws and washers. The luminaires shall be bonded to the conduit as defined previously.

#### **Lamp holders**

Lamp holders shall be of the type suitable for the relevant compact fluorescent or general lighting service lamp.

#### **Flood lights**

Flood lights shall be connected to the circuitry by means of cable complete with weatherproof cable glands.

#### **LED luminaires**

LED luminaires shall bear the SANS performance mark and safety marks and a guaranteed minimum 50 000hrs useful lifetime.

Luminaires shall have an IP 65 degree of protection that complies with SANS 60598-2-1.

LED lights shall have light colour that corresponds to cool white i.e. colour 2 (4000°K) as defined in SABS 1041. The light distribution shall be symmetric.

The luminous efficiency of all LED lights offered shall have guaranteed lifetime of 50,000 hrs L70 @ Ta =35°C.

Light fittings shall be standard with different drivers for dimming and emergency lighting with battery for min 3hr operation. Drivers and electronic control gear shall be suitable for operation on a 230V +5%/-10% at 50Hz and dimming drivers shall be DALI compatible.

LED Panel light fittings shall be housed in a high-quality aluminium body.

#### **Lighting designs**

Photometric IES files for all fittings offered shall be submitted on CD with comprehensive specification and brochures together with the tender.

## **44. NON-LETHAL ELECTRIC FENCE**

#### **Introduction**

All work carried out on the electric fence system shall be under the direct supervision of a registered person defined in OHSA Electrical Machinery Regulation 14.



Only the latest generation of non-Lethal electrified free-standing fence of the dual return system type are acceptable that is certified to comply with all legal and to the International Electro-technical Committee (IEC) Specification TEC 336-2-76 requirements. All electric fence energizers shall comply with the EMC requirements for electric fence supply units as given in SANS 214-1.

The construction shall be weather resistant for coastal conditions and robust construction.

The system must operate on a pulse energizer for each adjacent conductor wire to operate at a different potential.

An alarm condition is required to signal when a wire is conducted to ground, a wire is cut, or when any adjacent conductor wires touch. The system will use the latest technology for locating an alarm activity. The Balanced Current System (BCS) are preferred to provide the control station the capability to identify an alarm condition to within 50 meters of its occurrence.

Electric fencing shall be installed clear of any obstructions (including vegetation) that could under normal or wet conditions come into contact or come into close proximity with the electric fence resulting in interference with a communication system.

Vegetation shall be cleared from the electric fencing structure during its installation (thereafter this requirement will be maintained by the user) and shall be cleared as follows:

- a. Urban areas, care must be taken that no vegetation could in anyway get nearer than 1m above and 200mm below the lowest electric fence wire in the case of the electric fence being installed on top of a structure, such as a building element. In the case of the lowest electric fence wire being less than 200mm above ground level, no vegetation may be below the fence. Vegetation may not be closer than 200mm on either side of the electric fence.
- b. Rural areas, care must be taken that no vegetation could in anyway get nearer than 1m above and 1m on either side of the electric fence. In the case of the electric fence being installed on top of a structure, such as a building element, the fence must be clear of vegetation 200 mm below the lowest electric fence wire. In the case of the lowest electric fence wire being less than 200mm above ground level, no vegetation may be below the fence.

The electric fence energizer shall not be earthed to the same earthing system as used by the local electricity supplier or communications provider (or both). The minimum distance between the electric fence earth electrode and any alternating current electric or communications system earthing system shall be 2m. Special precautions must be taken if the electric fence system is connected to any communications device, such as a radio transmitter.

#### **Operation**

The system will be required to operate on a 230V AC supply.

System high tension cables and conductors shall only be buried if they are run in Polyethylene tubing, pipe, trunking or in similar protection. No HV cables shall be separated from normal or other conductors and not be installed in the same trench or duct as the supply or other services to prevent any possible accidental connection or contact.

The monitor will normally operate in non-Lethal stun alarm surveillance mode. This mode provides a highly effective strike that activates an alarm condition. On alarm detection, the system must indicate within 50 meters along the fence line where the alarm occurred. The must also be able to operate by selection in either a full-time monitor mode or a full time non-Lethal mode. This provides flexibility for changes in the legal climate or circumstances at the facility.

The peak value of voltage shall be 10kV. The maximum duration of the electrical impulse shall be 50ms. The minimum interval between impulses shall not be less than 0.75s.

#### **Energizers**

Energizers shall comply with SANS 60335-2-76 with the maximum energy discharge per impulse measured at the load range shall not exceed 0,5Joules, maximum stored energy shall be 0,75 Joules



and the energizer can only operate from a maximum supply of 30 volts dc or ac (r.m.s.), unless the energizer is connected within 1 metre to a mains alternating current supply. (i.e. a 230V plug).

In the event of the mains alternating current supply being used, as its primary supply, the energizers power supply transformer shall have its primary and secondary windings isolated from each other.

The Non-Lethal energizer supply voltage is connected to every second wire and the adjacent wires are connected to ground.

In the Non-Lethal mode, the energizer's output is a pulsating DC voltage adjustable up to 10kV and ground. The maximum loop length that can operate in this mode with an energizer delivering 8 Joules measured into a 500-ohm non-inductive load is 30km. One energizer must be able to energize a 5km, 12-wire fence. In both Monitor and Non-Lethal modes, alarms will be reported if the wires are cut, grounded, or earthed. The system operates in one mode at a time and must have that option to be programmed to switch between the modes automatically.

Electric fence energizers and their ancillary equipment shall be installed, operated and maintained in a way that minimizes danger to persons and reduces the risk of persons receiving electric shocks unless they come into contact with the physical bare conductors of the electric fence.

Electric fence energizers and their ancillary equipment shall be installed, operated and maintained in a way that minimizes interference with other devices.

Electric fence energizers shall be installed a safe distance from any flammable and other hazardous substances.

#### **Controller Module**

The controller constantly monitors every wire along the entire loop length for an alarm condition. The module must have full graphic panel display and control of the location of the incident or alarm within 50m by either providing and indications of the distance the alarm comes from the energizer or by providing a predetermined zone indication. The module will transmit this data via a RS 232 or USB port on a plug-and-play method to a standard PC to record and date-stamp incidents. The controller module will be required to directly interface with existing alarm / CCTV systems via standard available interface requirements. The controller module will have the capability for remote monitoring via PC (Windows / Linux) or Smartphone (Android / iPhone) on a secure interface.

#### **Earthing and Lightning Protection**

The system will use the latest technology available for earthing and lightning protection. Silicon MOV's rated at 0.1kV higher than the maximum system voltage with a maximum residual voltage of more than 48kV are required. The MOV's will protect the energizer from transient surges.

Fence wires (also the earth wire) should be first connected to the lightning diverters and then to the energizer.

The fence will be earthed at every 50m distance to reduce risk of raising touch potential. A maximum earth resistance of 300Ω, should be maintained between electric fence earth electrodes.

A distance of at least 2 metres shall be maintained between the energizer earth electrode and any other earthing system connected parts such as the power supply system protective earth or the telecommunication system earth.

#### **Battery Backup**

The system shall be supplied with a battery backup that can provide backup for up to 12 hours. The batteries shall be able to operate at 80% depth of discharge for at least 3500 cycles. The batteries shall have a built-in battery management system that provides protection from overheating, short-circuit and over / under voltage. A high-quality battery charger with over charge protection and battery conditioning algorithms shall be included in the system.



#### **Insulators**

UV stabilised Polyurethane, glass or porcelain insulators are required to be mounted on the support post for each wire. These high-quality insulators are used to eliminate nuisance alarms from environmental contamination.

#### **Support poles and Wires**

All steel support poles of 75 mm diameter with a wall thickness of 2mm, hot dip galvanised and anchored into the ground with a concrete foundation.

All wires shall be 304 grade stainless steel or better. All wires shall have means to assure a relatively constant tension. Tensioners and springs can be used in the fixing and tensioning of bare conductors between fence insulators but shall not adversely affect the current-carrying capacity of the conductors, fixing thereto shall be in accordance with the manufacturer's instructions.

All bolts, nuts, washers, clamps, etc. shall be stainless steel.

The height of the supports, or fence, shall be at least 1.5m above natural ground level. The maximum spacing between wires on brackets must be 100mm.

#### **Warning signs**

All electric fences shall be identified by prominently displaying warning signs.

Such signs shall be securely fixed to the fence posts, the fence itself, a fence element or to a building element not more than 200mm from the electric fence.

The minimum warning sign dimensions shall be 200mm × 100mm and the lettering and symbols shall be in terms of SANS 60335-2-76.

Sign boards shall be fixed between 1.5 to 2m above ground level.

Sign boards shall be displayed not more than 200mm from each corner or bend in a straight length of an electric fence.

Sign boards shall be displayed on an access gate if present and not more than 200mm on either side of an access area on which an electric fence is erected.

In urban areas sign boards shall not be more than 10m apart and not be more than 100m apart rural areas.

Sign boards shall be placed in clearly visible positions.

#### **Electric Fence System Certificate (EFSC)**

At final testing and commissioning of the system, the specialist contractor has to adhere to SANS 10222-3 (or equivalent) specifications and issue a certificate of compliance for the installation. This shall be done by a registered Electric Fence System Installer (EFSI) in terms of OHSA Electrical Machinery Regulation 13.

An electrical COC in terms of SANS10142 shall also be issued.

#### **As-built information, manuals and training**

Upon completion of the project, the contractor shall provide 2 x hard copies and 1 x soft copy of as-built drawings, equipment manuals and certificates. Drawings shall be in CAD and PDF format. Training on the use of the system shall be provided at the customer's premises to all users / operators of the system.



## 45. UNINTERRUPTABLE POWER SUPPLY (UPS)

### Introduction

Tenderers are to include for the supply, delivery and commissioning of a [6] kVA; [230/400] volt UPS complete with 6 hours autonomy at full load batteries. Others will provide the final connection of input and output cable supplies. The Unit shall be of the floor standing type and the colour shall be Beige.

### Alarm functions on unit

|       |                          |                          |       |
|-------|--------------------------|--------------------------|-------|
| i)    | "Mains off":             | Visual, Audible and Mute | ..... |
| ii)   | "Battery low":           | Visual, Audible and Mute | ..... |
| iii)  | "Inverter off":          | Visual, Audible and Mute | ..... |
| iv)   | "Short circuit":         | Visual, Audible and Mute | ..... |
| v)    | "Over load":             | Visual, Audible and Mute | ..... |
| vi)   | "Bypass";                | Visual, Audible and Mute | ..... |
| vii)  | "Charger off":           | Visual, Audible and Mute | ..... |
| viii) | "Battery under voltage": | Visual, Audible and Mute | ..... |
| ix)   | "Over temperature":      | Visual, Audible and Mute | ..... |
| x)    | "No sync":               | Visual                   | ..... |

### Remote alarm panel

|      |                   |                          |       |
|------|-------------------|--------------------------|-------|
| i)   | Normal Operation: | Visual                   | ..... |
| ii)  | Mains Failure:    | Visual, Audible and Mute | ..... |
| iii) | UPS Failure:      | Visual, Audible and Mute | ..... |
| iv)  | Output to PLC:    | All Alarms (intelligent) | ..... |

### Cabinet

Steel cabinet (preferably neutral beige colour): .....

### General

- i) At commissioning, a discharge test will be done to agitate and equalise the batteries.
- ii) The Tenderer shall perform an on-site full load test of the unit for a standby time duration of at least 80%. The Tenderer shall document the test and the test shall be witnessed and signed-off by the institutional maintenance staff.
- iii) The Tenderer shall provide on-site operator instruction during normal working hours to the Hospital operating personnel.
- iv) The unit shall comply in all respects with the Occupational Health and Safety Act and Regulations 85/1993.



- v) The unit must be guaranteed against faulty workmanship, material and mechanical defects for a period of 12 months.
- vi) Two complete sets of operating manuals shall be supplied with the unit. The manuals shall include both literature and schematic wiring diagrams of the unit.
- vii) After each period of six months operation during the guarantee period the Tenderer shall allow for a complete maintenance service of the unit (i.e. Two services).
- viii) The Tenderer shall allow for the supply, delivery and installation of a By-pass switch arrangement independent of the UPS as per Item Code EC03005P/UPS/DOH

ix) Deviation from Specification:

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x) Additional Features Not Specified

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.....

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xi) Delivery Period: .....

xii) Nearest Service and Spares Centre: .....

#### 34. UNDERGROUND CABLE SLEEVES

All cable sleeves shall be of the Kabelflex type, manufactured and supplied by Nextube (Pty) Ltd. Unused sleeve ends shall be sealed by means of Nextube Closure Caps.

Cable sleeves to be installed across roads shall extend at least 450 mm beyond the edge of the road on each side. Each run of cable sleeve shall be laid straight and without any projections on the side, which may cause damage to or obstruct the threading through of cables.

#### 35. 11 kV SWITCHGEAR

##### o SCOPE OF WORK

This portion of the Project Specification provides for the design, supply, delivery, installation, testing, commissioning and training of 11 kV switchgear.

##### o NORMATIVE REFERENCES

The most recent editions of the national and international standards and specifications listed below are applicable to the Project Specification:

NRS 003:1191, Metal-clad switchgear

NRS 006:1191, Metal enclosed ring main units

NRS 008:1191, Enclosure of cable termination in air



○ **GENERAL REQUIREMENTS**

(a) **Conditions**

The switchgear supplied shall be manufactured to comply with the following:

- |       |                         |   |                                                   |
|-------|-------------------------|---|---------------------------------------------------|
| (i)   | Ambient air temperature | - | -5°C to 40°C<br>24 hour average not exceeding 35° |
| (ii)  | Altitude                | - | 1 800 m                                           |
| (iii) | Polluted ambient air    | - | Above normal dust<br>Above normal smoke           |

(b) **Factory tests**

The Supply Authority and the Engineer must be present on a final factory inspection and testing before shipment. A notice of at least 14 days is required for this factory test. The equipment may be delivered after the approval of the Engineer and the Supply Authority.

(c) **Drawings for approval**

The Contractor shall submit 2 sets of fully detailed manufacturing drawings before purchasing of material and manufacturing commences for approval. The Contractor shall give the Engineer a maximum of 10 working days for this approval. The Contractor shall make provision for all these times in his programme since no application for a delay shall be considered for the preparing of detailed drawings and approval before manufacturing commences.

(d) **Notices**

The following notices in three official languages, and in accordance with the OHS Act, shall be exhibited at all entrances to the switching substations.

- (i) A notice prohibiting unauthorised persons from entering such premises.
- (ii) A notice prohibiting any unauthorised persons from handling or interfering with electrical apparatus.
- (iii) A notice detailing procedure in case of fire.
- (iv) A notice containing directions for resuscitation of persons suffering from the effects of electric shock.

(e) **Paint specification**

(i) **Finish required**

Metalwork of switchboards, and associated equipment 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.

(ii) **Corrosion Resistance**

Painted metal shall be corrosion resistant for a period of at least 168 hours when tested in accordance with SABS Method 155.

(iii) **Edges**

Care shall be taken to ensure that all edges and corners are properly covered.

(iv) **Surface Preparation**



Surface preparation shall comply with SABS 064. Prior to painting, all metal parts shall be thoroughly cleaned of rust, millscale, grease and foreign matter to a continuous metallic finish. Sand or shot blasting or acid pickling and washing shall be employed for this purpose.

(v) **Baked enamel finish**

- Immediately after cleaning all surfaces shall be covered by a rust inhibiting, tough unbroken metal-phosphate film and then thoroughly dried.
- Within forty-eight (48) hours after phosphating, a passivating layer consisting of a high-quality zinc chromate primer shall be applied, followed by two coats of high-quality alkyd-based baked enamel.
- The enamel finish on metal luminaire components shall comply with SABS 783, Type III.
- Other metal parts e.g. switchboard panels, etc. shall comply with SABS 783, Type IV with a minimum paint thickness after painting of 0,06 mm. In coastal areas, the dry film thickness shall be increased to at least 0.1 mm.
- The paint shall have an impact resistance of 5,65 J on cold-rolled steel plate and a scratch resistance of 2 kg.

(vi) **Powder Coated Finish**

- Immediately after cleaning the metal parts shall be pre-heated and then covered by a micro structured paint powder applied electrostatically.
- The paint shall be baked on and shall harden within 10 minutes at a temperature of 190° C.
- The minimum paint thickness after baking shall be 0,05 mm. The dry film thickness shall be increased in coastal areas. The paint cover shall have an impact resistance of 5, 65 J on cold-rolled steel plate and a scratch resistance of 2 kg.

g) **Touch-up Paint**

In the case of switchboards and larger equipment enclosures, a tin of matching touch-up paint not smaller than 1 litre per substation shall be provided.

h) **Colour**

The colour of the switchgear shall be confirmed by the Engineer.

○ **GENERAL SPECIFICATIONS**

(a) **Standards**

All materials and apparatus shall be new and of the best quality and shall comply with the relevant current specifications of the SABS, 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.

| <u>DESCRIPTION</u> | <u>SABS</u> | <u>BSI</u> | <u>IEC</u> |
|--------------------|-------------|------------|------------|
| Air & Oil Switches |             | 5463       | 265-A-C    |



|                                 |      |           |       |
|---------------------------------|------|-----------|-------|
| Busbar & Busbar Connections     | 1195 | 159       |       |
| Bushings                        |      | 222       | 137   |
| Cable Glands & Sealing boxes    |      | 542, 2562 |       |
| Circuit-breakers                |      | 5311      | 56    |
| Current Transformers            |      | 3938      | 185   |
| Voltage Transformers            |      | 3941      | 186   |
| HV Fuses                        |      | 2692      | 282-1 |
| LV Fuses                        | 172  | 88        | 269-1 |
| Electrical Power Switchgear     |      | 5227      | 298   |
| Galvanizing                     | 763  | 729       |       |
| Indicating Instruments          |      | 89        | 51    |
| Insulating Oil                  | 555  | 148       | 296   |
| Isolators and Earthing Switches |      | 5253      | 129   |
| Meters                          |      | 37        | 43    |
| Protective Relays               |      | 142       | 255   |
| Colours for Specific Purposes   | 1091 |           |       |

(b) **Service conditions**

|                                 |                         |
|---------------------------------|-------------------------|
| Nominal Voltage                 | 11 kV                   |
| Rupturing Capacity              | 63 kA                   |
| Impulse Level                   | 95 kV                   |
| Highest System Voltage          | 12 kV                   |
| Rated Short Time Current (3 s.) | 25 kA                   |
| Frequency                       | 50 Hz                   |
| Phases                          | 3                       |
| Atmospheric Temperature         | - 5°C min<br>+ 40°C max |
| Altitude                        | 0 m min                 |



|                      |            |
|----------------------|------------|
|                      | 1850 m max |
| Lightning & Dust     | Severe     |
| Average Power Factor | 0,8        |
| Maximum Humidity     | 95 %       |

The system neutrals will be solidly earthed. However, all switchgear and auxiliary equipment shall be designed to withstand the stresses of an unearthed system.

(c) **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.

(d) **Circuit breakers**

(i) General construction

- Circuit breakers may be of the 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. Secondary wiring may be unplugged.
- 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, bushing, covers, busbar insulators, etc. shall be designed to minimize 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.

(ii) Circuit-breaking features

- The 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.

(iii) Busbar and circuit shutters

- Protective shutters, which automatically cover the contacts or the fixed portion of the switchgear when the circuit breaker or voltage transformer is withdrawn to the isolation position, shall be provided.
- The busbar and voltage transformer 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.
  - b) Circuit shutters - The word "CABLE" in black lettering on a yellow background.
  - c) Earthing shutters - The word "EARTH" in black lettering on a green background.

Lettering shall be a minimum of 40 mm high.

(iv) Interlocks

The switchgear shall be mechanically interlocked in accordance with BS 5227 and all interlocks shall be robust and shall not distort or jam in the event of a mal-operation. The minimum safety features provided shall prevent the following actions:

- A closed-circuit breaker from being withdrawn or inserted into the isolating contacts. The circuit breaker shall not trip if an attempt is made to do so.
- 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.
- 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.
- 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.



- 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.
- (v) Earthing
- An earth busbar in accordance with the requirements of par. (f)(iii) shall be provided.
  - All joints shall be tinned or silver-plated and clamping bolts, nuts, washers and lock washers of cadmium-plated high tensile steel shall be fitted.
  - 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 3-s short time current rating equal to the rest of the switchboard.
- (vi) Capacities and fault levels
- The complete primary circuit (OCB's, busbars, etc.) shall be capable of withstanding the rated short time current specified in par. 3 above.
  - The circuit breakers shall have continuous current ratings as specified in the Detail Technical Specification.
  - Circuit-breaker tanks and top plates shall be capable of withstanding, without permanent distortion, a hydraulic pressure of 700 kPa 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 breaker capacities.
- (vii) Closing mechanism
- 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.
  - Motor wound spring charging mechanisms shall be provided with hand cranks for emergency use should the electrical closing circuitry become inoperative.
  - Slow closing facilities shall be provided on all mechanism types for maintenance purposes and these facilities shall only be accessible with the circuit-breaker in the "withdrawn" position.
  - 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 energized 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 Department.

(viii) Tripping mechanism

- A manual tripping mechanism shall be provided on each circuit breaker. It shall be clearly marked "MANUAL/HANDBEDIEN".
- Two 2,5 A trip coils (for overload and short circuit protection) and one 1,0 A trip coil (for earth fault protection) shall be provided where current transformer operated direct acting series tripping is specified. The trip coils shall be suitably rated to withstand the secondary saturation current of the current transformers specified.
- Where shunt tripping is specified DC shunt trip coils shall be provided. The rated control voltage shall be 32 V DC unless specified to the contrary 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.

(ix) Racking mechanism

The racking mechanisms for inserting or withdrawing the circuit breaker shall be designed and constructed to provide a positive action throughout the operations.

(x) 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.

(xi) Auxiliary contacts

- Circuit breakers shall be provided with sufficient auxiliary contacts to suit the circuits served.



- Auxiliary contacts shall be coupled in such a manner as to follow positively the operation of the switching device concerned.
- At least two spares normally open and two spare normally closed contacts shall be provided and shall be completely wired to an accessible terminal block.

(e) **Automatic switches and fused switches**

(i) General

Switches shall be of the fault-making, load-breaking type with earthing and testing facilities.

Switches shall be manufactured and tested in accordance with BS 5463.

(ii) Construction

- The switches shall be totally enclosed, metal-clad, of the vacuum 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 freestanding 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.

(iii) Busbars and circuit shutters

Busbar and circuit shutters shall be provided on all withdrawable type switches as specified for circuit breakers.

(iv) 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:
  - a) The switch from being withdrawn from or inserted into the isolating contacts.
  - b) The closing of the switch except when it is correctly located or fully withdrawn.
  - c) The opening of the tank unless the switch is fully withdrawn and the racking-in of the switch unless the tank is securely fitted.

(v) 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 operating is initiated it becomes completely independent on 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.

(vi) Earthing

- Refer to par. (d)(v).
- 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.

(vii) Cable test facilities

- Cable test facilities are required and must be easily accessible.
- Refer to par. (e)(iv) regarding interlocking of test facilities.
- In the event of a separate test unit being provided, it shall be easily fitted.

(viii) 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 an oil switch shall not be less than 400 A and that of a fused oil switch not less than 90 A.
- Each unit shall be clearly marked to show the current and voltage ratings and fault making capacity.

(ix) 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.
- Neon indicator lights shall be provided on the incoming panel of a switchboard to indicate the status of all three phases of the incoming cable.

(x) Fuses

- Fuses shall comply with BS 2692.
- 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 64,5 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.

(f) **Busbars**

(i) Design and rating



- Busbars shall be manufactured of solid drawn high conductivity copper with rectangular cross-section in accordance with BS 159, SABS 1195 and BS 1433, where applicable.
- The busbars shall be rated for the continuous current carrying capacity. 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 4 and 5 may be used as a guide to determine the current rating of the busbars.
- In addition to the current rating busbars shall comply with the following fault level rating:  
$$A = 8,2 \times I \times (t)^{1/2}$$

A = minimum cross section (mm<sup>2</sup>)

I = prospective fault current (kA)

t = maximum time in seconds required for protection equipment to clear the fault.

(Minimum allowable value for t = 3 s)
- 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.

(ii) 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:



#### **DERATING FACTORS FOR LAMINATED BUSBARS**

| Area of Cross<br>Section<br>(mm <sup>2</sup> ) | No of parallel busbars per phase |      |      |
|------------------------------------------------|----------------------------------|------|------|
|                                                | 2                                | 3    | 4    |
| 500                                            | 1,78                             | 2,45 | 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 1: Derating Factors for Laminated Busbars**

#### **CURRENT RATING OF SINGLE COPPER BUSBARS (A)**

| Width<br>(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 |

**Table 2: Current Rating of Single Copper Busbars (A)**

|                 |   |         |
|-----------------|---|---------|
| Red             | } |         |
| Yellow or White | } | Phases  |
| Blue            | } |         |
| 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 BS 5311 and the insulation level of all busbars and connections shall be in accordance with the values specified in 4(f).
- 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 distance and insulator lengths shall be in accordance with BS 5227 with correction for altitude as required.

(iii) 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:

$$S = \frac{I}{X} \times \left( \frac{t}{dt} \right)^{\frac{1}{2}}$$

where S = cross-section (mm<sup>2</sup>)

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.

**(g) Cable end boxes**

- (i) Cable end boxes to accept the cables specified for each panel shall be provided.
- (ii) The boxes shall be of the metal clad type suitable for indoor use. They 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.
- (iii) The cable end boxes shall comply with the standard specification for "CABLE END BOXES AND COMPOUND."
- (iv) The cable boxes shall be fitted with insulating pieces to allow for the possible future installation of frame leakage busbar zone protection when specified.
- (v) The lowest point of any cable gland position shall be at least 300 mm above finished floor level.
- (vi) Cable boxes shall be so designed that cable terminal connections can be made below compound level.

**(h) Secondary circuitry**

- (i) 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.
  - Where external DC supplies are connected to the switchboard, semiconductor diodes of a suitable power and voltage rating shall be installed in all DC circuits, in both the positive and negative conductors, to prevent reverse polarity connections.
- (ii) 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. Conductors connected to terminals complying with the Department's standard specification for "WIRING TERMINALS", Section C9 need not be soldered or ferruled.
- Secondary wiring shall generally consist of insulated stranded copper conductors with a minimum cross-sectional area of 2,5mm<sup>2</sup>. Solid core conductors are not acceptable. Flexible cords not smaller than 1,0mm<sup>2</sup> 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 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 isolator or N/O operation contacts are connected to the positive pole of the battery.

(iii) 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 drawing.
- 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 O B.A.
- Approximately 10% with a minimum of 2 spare terminals shall be provided on each terminal strip.
- Terminal and test blocks or the "CHAMBERLAIN AND HOOKHAM" or equivalent manufacture shall be provided in each panel for the secondary wiring of the current transformers.



(i) **Cubicle construction**

(i) General

- All cubicles shall be of the totally enclosed, floor mounted type and shall be vermin proof and where possible dustproof.
- Cubicles shall be designed so that it is possible to add additional panels to existing switchboards without undue difficulty.

(ii) Segregation of circuits

- Each circuit in a switchboard shall be provided with an individual cubicle so arranged that accidental contact with live metal 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.

(iii) Doors

- Where doors are provided on circuit breaker or switch cubicles, the doors shall be fitted with handles consisting of a push-button-and-handle combination with 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 mechanism as described in par. 10.3.1 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.

(iv) 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.

(k) **Current transformers**

(i) General

- Current transformers shall comply with the standard specification for "CURRENT TRANSFORMERS".
- The short time current rating of current transformers shall not be less than that of the associated circuit breaker.
- Current transformers shall be easily replaceable.



- The secondary windings of the current transformers shall be brought out to terminal and test blocks.
- Windings shall be earthed at one point only.
- Current transformers shall be installed and labelled so that the ratio is clearly visible.

(I) **Voltage transformers**

(i) General

- Voltage transformers shall comply with BS 3941 and IEC 186A and IEC 358 where applicable.
- The transformers shall be double wound. The neutral (star point) connection shall be brought out via a neutral link. The secondary voltage shall be 110 V unless specified to the contrary.
- Voltage transformers shall be metal-clad, of the oil-immersed or epoxy resin-encapsulated type. Oil filled types may not be used with air or vacuum circuit breakers.
- The transformer shall be withdrawable and shall be so arranged that the primary fuses are not accessible unless the transformer is in the fully isolated or withdrawn position. The voltage transformer shall be padlockable in both the withdrawn and inserted positions.
- Automatic shutters shall be provided to cover the isolating contact when the transformer is withdrawn. The shutters shall be padlockable.

(ii) Voltage transformer protection

- The primary side of all voltage transformers shall be connected to the circuit through high voltage HRC fuses.
- Secondary HRC fuses shall be provided on the voltage transformer, preferably under a removable cover secured by captive knurled nuts. The fuses shall be located as close as possible to the transformer output terminals.

(iii) Voltage transformer rating 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.

(I) **Protection relays**

- (i) Protection relays shall be contained in dustproof cases, which shall not allow accumulated dust to fall into the relay when opened.
- (ii) All cases shall be of the flush mounted withdrawable type.
- (iii) Relay contacts shall be capable of repeatedly making and, where the circuit renders it necessary, repeatedly breaking the maximum current possible in the circuits they control.



- (iv) Where more than one set of contacts are provided, all contacts shall operate simultaneously.
- (v) Tripping contacts shall not close due to vibration engendered by the normal or the fault condition operation of the associated or adjacent circuit breakers.
- (vi) Hand resetting shall be accomplished without opening the case and these relays shall be accessible to a person standing on the floor.
- (vii) All relays shall be provided with test blocks to permit tests to be carried out without disconnecting any wiring. These test blocks may be either included in the relay cases or separately mounted. If separately mounted, they shall be of the "CHAMBERLAIN AND HOOKHAM" type or equivalent.
- (viii) The ratio of the associated current transformer shall be clearly marked on the relay faceplate.
- (ix) All relays shall be adjusted during manufacture to conform to the limits stipulated in BS 142.

(m) **Instruments**

- (i) Instruments, i.e. ammeters, voltmeters, combined maximum demand and indicating ammeters, kilowatt-hour meters, frequency meters and running-hour meters shall generally comply with the standard specification for 'DIRECT ACTING INDICATING INSTRUMENTS'.
- (ii) Voltmeters and ammeter scales shall have a full scale reading at least 5 % higher than the system voltage or associated current transformer rating with the latter values clearly marked.
- (iii) The instruments shall be suitably rated for the supply voltage, current and frequency.
- (iv) Each voltmeter shall be protected with easily accessible HRC fuses.
- (v) Each circuit breaker shall be equipped with a trip counter with cyclometer dial.

(n) **Auxiliary equipment**

- (i) 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 contact shall be silver-plated or gold laminated and shall be suitably rated for the switching function intended.
  - Control switches shall be lockable in the "NEUTRAL" or "OFF" position.
- (ii) 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.

(iii) Indicator lamps

- Indicator lamps shall comply with the standard specification for "INDICATOR LIGHTS".
- The following indications shall be provided:

| <u>FUNCTION</u>           | <u>COLOUR</u>            |
|---------------------------|--------------------------|
| Circuit breaker closed    | Red                      |
| Circuit breaker open      | Green                    |
| Incoming supply available | White                    |
|                           | (on incoming panel only) |
| 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 an indication with the circuit breaker in both the "OPEN" and "CLOSED" positions.
- The condition indicated shall be designated below each light.

(iv) Pushbutton and pushbutton assemblies

Pushbuttons and pushbutton assemblies shall comply with the standard specification for these items.

(o) **DC Auxiliary supplies**

A battery derived DC supply shall be provided with the switchboard. The nominal voltage shall be 32 V DC unless specified to the contrary.

(i) Batteries

- The batteries shall be of the nickel-cadmium type and the cells shall be in high impact polystyrene containers with a large reserve of electrolyte.



- The number of cells and capacity shall be determined from the voltage requirements of the circuit-breaker closing and tripping circuitry and the discharge duties required by the switchboard.
- The battery capacity shall be sufficient to perform either of the following functions:
  - (a) Five successive tripping and reclosing operations of all the circuit-breakers on the switchboard

**Or**

- (b) A single tripping and reclosing operation of all the circuit breakers on the switchboard plus supplying all the standing loads on the battery for at least 10 hours.

- Note : The alternative requiring the larger battery shall be used.

(ii) Battery charge unit

- A constant voltage type charger with current limiting facilities shall be provided. The output voltage shall be kept within 1 % of the float charge voltage designed for maximum charge conservation and a maximum battery life for variations of  $\pm 10$  % of the input voltage.
- The float charge voltage shall be less than the gassing voltage.
- The ripple content in the output of the charger shall be less than 2 %.
- The charger capacity shall be adequate to supply any standing load on the battery plus a charging current, which will recharge a fully discharged battery within 8 hours.
- A switch operated boost charge control shall be provided.
- An auxiliary winding shall be added to the charger transformer providing a secondary AC output suitable for all the indicating lights on the switchboard. The lights shall be supplied from this winding and not from the batteries.
- The charger shall be suitable for operation on a nominal 230 V, 50 Hz mains supply or from a supply obtained from a voltage transformer.
- The charger shall be complete with all the required controls including the following standard equipment:
  - a) Power supply isolator.
  - b) Ammeter indicating rectifier output.
  - c) Battery voltmeter.
- The following HRC fuses shall be provided:
  - a) Input fuses.
  - b) Rectifier output fuses.
  - c) Voltmeter fuses.
  - d) Fuses in charger transformer auxiliary output.
  - e) A pair of fuses for each DC circuit plus fuses for 3 spare circuits.
- If more than one battery output circuit is specified, each circuit shall be fitted with a pair of fuses.



(iii) Cubicle

- The batteries and charger shall be housed separately from the switchboard in a self-contained cubicle with the same finish and colour as the switchboard.
- The cubicle shall be dustproof and vermin proof.
- An undrilled removable cable gland plate shall be provided for bottom cable entry.

(iii) Finish

- All welds shall be ground smooth and joints wiped with plumber's metal in order to provide a smooth finish.
- All the metalwork shall be painted in accordance with the "STANDARD PAINTING SPECIFICATION".
- The final colour shall be confirmed by the Engineer.

(iv) Labels

- Care shall be taken to ensure that all equipment is fully labelled and that accurate descriptions appear in both official languages.
- 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 glueing of labels will not be acceptable. Sufficient fixing screws shall be provided to prevent labels from warping.

(r) **Tests**

(i) Manufacturer's tests

- All component parts of the equipment shall be subject to type tests and routine tests in accordance with the relevant SABS, BSI or IEC standard specifications.
- Oil circuit-breakers shall be subjected to the following tests in accordance with BS 5311, Part 4, adjusted for atmospheric correction:
  - Type Tests :
    - a) Mechanical endurance.
    - b) Temperature rise.
    - c) Dielectric strength and impulse voltage
    - d) Making and breaking capacity and short time current
  - Routine Tests :
    - a) Power frequency voltage
    - b) Resistance of the main circuit
    - c) Mechanical operation

(ii) 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 BS 5227 or IEC 298.
  - b) Insulating oil tests in accordance with SABS 555.
  - c) Insulation resistance tests.
  - d) Primary injection tests.
  - e) Earth continuity and earth resistance tests.
  - f) Operating tests.
  - g) Any other tests which may be required to ascertain the correct functioning of the equipment.
- (iii) 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.
- (iv) 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.
- (t) **Oil and compound**
- (i) The first filling of insulating oil for all the circuit breakers, oil switches, voltage transformers, etc. shall be provided by the switchgear supplier.
  - (ii) An adequate quantity of bituminous or cold filling compound shall be provided by the switchgear supplier for all the cable end boxes.
  - (iii) All other oils or compounds which may be required shall be provided by the switchgear supplier.
- (u) **Tools and auxiliary equipment**
- The following equipment shall be provided with each switchboard and the cost shall be included in the tender price:
- (i) One raising and lowering handle for every three circuit breakers.
  - (ii) One complete set of special maintenance tools for all sizes of circuit breakers.
  - (iii) A full set of earthing devices or earthing trucks.
  - (iv) One wall mounted steel box for the storage of the above loose equipment. The door shall be padlockable.
  - (v) At least six spare HRC fuses of each rating for secondary circuits and three voltage transformer, high voltage HRC fuses.
  - (vi) At least three spare high voltage HRC fuses of each rating suitable for the fused oil switches.



- (vii) One cable test unit for each size circuit breaker or oil switch housed in a wall-mounted metal box.

(v) **Technical information**

- (i) Tenderers shall submit descriptive literature of the equipment with their tenders.
- (ii) Two copies of erection, operating and maintenance instruction manuals covering each type of equipment shall be provided with each switchboard.



### 36. NOTICES AND DANGER PLATES

#### SCOPE

This specification deals with the provision of Notices and Danger Plates as required in terms of the Occupational Health and Safety Act No. 85 of 1993, as well as any other notices that may be required by law or by the nature of the finished Works.

The following standard specifications are referred to in this specification: -

SABS 0140; Parts I to IV: Identification colour marking.

SABS 1186: Symbolic safety signs.

Occupational Health and Safety Act No 85 of 1993.

#### MATERIALS AND FINISH

Outdoor signs shall be either of vitreous enameled type or of cast aluminum with raised or embossed letters.

Indoor notices shall be of non-deteriorating plastic, Perspex or fiberglass.

The colors and size of letters and colors of background shall be in accordance with requirements of SABS 0140 and as approved by the Engineer.

Symbolic signs shall conform to the requirements of SABS 1186.

Signs shall be pre-drilled for fixing.

All fixing accessories shall be of non-corrosive material.

#### INSTALLATION AND ERECTION

The Contractor shall supply and fix permanently in position the signs and notices required by law for all the relevant working areas of the Works. Positions of signs shall be as prescribed by the relevant Regulations and as agreed by the Engineer.

### 37. ROTATING BRIDGE BRUSH GEAR

The brush gear to be installed on the kingpost on the bridge at the center of the tank to facilitate connections between the incoming supply cable and the cable from the kingpost to the motor starter via the rotating arm, shall consist of the following:

- (a) A set of **four** 20 mm wide and **three** 8 mm wide **brass** slip rings on an ebonite or equivalent insulating sleeve (i.e. three slip rings or phase connections, one for the earth connection, three slip rings for the control circuit, namely, start, common and stop connections). Connections to these slip rings shall be achieved via an approved heavy duty terminal block with stud brass terminals onto which the lugs on the cable tails shall be bolted. This terminal arrangement shall be completely independent of fixing screws for the slip rings.
- (b) A set of four main circuits and three control circuit "Morganite" carbon brushes, or equivalent. Each of these brushes shall be spring-loaded to ensure high contact pressure and the springs shall be rust-proofed.

The abovementioned brush gear shall be installed in a weatherproof IP55 grade 304 stainless steel housing with a weatherproof access door, on the kingpost of the bridge. This brush gear-housing shall be suitably sized to accommodate the relevant equipment without cramping, and shall be insect proofed.



The brush gear housing shall be designed and constructed to prevent the accumulation of gas and the condensation of moisture inside the housing and the pressure of the brushes on the slip rings shall be high enough to obtain a self-cleaning effect during operation.

The driving motor must be provided with a weatherproof emergency stop push button station mounted on the bridge in close proximity to the bridge access ladder. The supply and installation of cables between the motor, emergency push button station, brush gear and kingpost, shall form part of this Contract. The cable shall be installed in a grade 304 stainless steel conduit mounted on the underside of the bridge.

All pumps and motors shall be fitted with no-flow protection.



### **3.5.2    GENERAL TECHNICAL REQUIREMENTS FOR THE EXECUTION OF THE ELECTRICAL WORKS.** **(CONSTRUCTION)**

#### **1. INSTALLATION OF MULTICORE CABLES**

##### *Cable Trenches*

The contractor will be responsible for the excavation, bedding, back-filling, consolidating and making good of all cable trenches along the routes indicated on the drawings, with the exception of those sections of the cable routes where it is specifically on the accompanying drawings that open cable ducts will be provided by others. Where indicated on drawings ducts inside new buildings will be provided by others. The Contractor however will be responsible for the bedding and filling soil in cable ducts where necessary. A sealing screed to cover the cable duct shall be provided by others.

NOTE: Tenderers shall acquaint themselves fully with the nature and formation of the ground in which the cables are to be laid, before submitting a Tender. No subsequent claim for extras due to lack of knowledge in this respect will be entertained by the Employer.

Cable trenches for L.T. power and lighting cables shall be deep enough to facilitate the laying of these cables at a depth of 750 mm below final ground level.

Trenches for H.T. power cables shall be deep enough to facilitate the laying of these cables at a depth of 1 m below ground level. The floors of all cable trenches shall be smooth and free from boulders and sharp rock projections.

Plastic danger tape shall be installed in all cable trenches 300 mm above the cables for cable protection during future excavation.

Each cable shall be laid in a bedding of river sand or sifted soil 75 mm over and 75 mm below the cable-clayey soil will not be accepted as bedding.

No cable trench shall be back-filled before the cable(s) in the trench has been inspected and approved by the Engineer.

##### *Underground Cable Pipes*

Cable pipes will be supplied and installed by others unless indicated otherwise on the drawings.

Each cable pipe shall be sealed by the Contractor under this Contract at both ends by means of bitumen impregnated jute bags or similar material, after the cable have been installed.

##### *Crossings with Other Services*

##### *General*

Where a cable is laid above another service it shall not be less than 750 mm below ground level, and if this is not possible, the cable shall be laid underneath the other service and shall be protected by means of concrete slabs in the manner prescribed. The deeper or shallower positions of the cable shall only apply for a distance of 1 m both directions of the crossing.

If not possible to cross underneath the other service the matter shall be referred to the Engineer for a decision.

##### *Clearances*

The following minimum clearances shall be maintained between electrical cables and other services:



|                         | VERTICAL | HORIZONTAL |
|-------------------------|----------|------------|
| Telkom cables           | 0,3 m    | 0,3m       |
| Other water pipes       | 0,3m     | 0,3m       |
| Sewerage pipes          | 0,3m     | 0,8m       |
| Storm water pipes       | 0,3m     | 0,6m       |
| Other Electrical cables | 150mm    | 150mm      |

#### Laying of Cables

Cables must be laid without delay

The cables shall be laid with minimum of delay in order to backfill the trenches as soon as possible.

The Contractor shall, however not backfill the trench until each length of cable has been tested, inspected and approved by the Engineer.

Only one cable shall be laid at a time and the Contractor shall ensure that cables already laid are not damaged.

#### Method

All cables shall be handled with the utmost care and shall be laid in accordance with the best methods observed in good modern practice. All cables shall be run out on rollers in order to prevent abrasion and no cable shall be dragged along the ground. No cables shall be bent to a radius of less than 12 times its overall diameter.

#### Installation of Multi core Cables:-

##### ( a ) In concrete ducts

Cables shall be laid neat parallel with each other on the floor of the duct with the maximum spacing

##### ( b ) On cable ladders

Cable shall be installed neat and parallel with each other with the maximum spacing. On Horizontal sections the cables shall be secured to the cable ladders with intervals of not more than 2 m. On vertical sections or where the cable ladders are installed at an angle the cables shall be secured to the cable ladders with interval with intervals of not less than 500 m.

Sections of the cable ladders shall be electrically connected and provision shall be made for crimping and expansion of the racks.

##### ( c ) In Trenches

Two or more L.T. cables in the same trench shall be laid in parallel and not less than 75 mm apart, except where otherwise approved.

H.T. cables in the same trench shall be laid parallel and not less than 150 mm apart, except where otherwise approved.

All L.T. power cables shall be laid 750 mm below final ground level and H.T. power cables shall be laid 1 m below final ground level.

The contractor shall provide 3 m slack at each run of power cable and its associated earth wire and bury the same in the ground as near to the relevant end as possible. Where the cables and earth wires are to be installed in open ducts outside buildings, the slack shall be coiled in the ducts.

The separation between any signal cable and the nearest parallel power cable shall not be less than 150 mm.

##### ( d ) Against Walls



Cables and earth wires to be installed on walls, where approved by the Engineer, shall be neatly installed on heavy duty hot dipped galvanized steel cable racks. Cables and earth wires on outside walls shall be installed in a similar manner or in suitably sized hot dipped galvanized conduit from 300 mm below up to 2,4 m above final ground level or as required. These conduits shall be secured to the walls by means of hot dipped galvanized steel bath holders at intervals not exceeding 600 mm. (Hospital Saddles).

Saddles shall be secured by means of round headed hot dipped galvanized screws and plugs of an approved type. (Wood will not be accepted as plugging material.) Plug will not be allowed in joints between bricks.

( e )        On Poles

Cables and earth wires to be installed on poles shall be secured to the poles at intervals not exceeding 600 mm by means of 25 mm x 1,5 mm adjustable Grade 304 Stainless Steel straps. Each cable together with its associated earth wire shall be installed in a suitably sized stainless steel pipe or channel from 300 mm below up to 2,4 m above ground level. This pipe or channel shall be secured to the pole by means of 25 mm x 1,5 mm adjustable stainless steel straps at intervals not exceeding 600 mm. To avoid metallic action between different materials Neoprene rubber strip shall be installed between the pole and the strap.

( f )        Cable Channels on Structures and in Buildings

Where cable channels have been provided on structures and in building these must be backfilled with river sand by the contractor.

*Backfilling of Trenches*

Once the cable has been laid, straightened, inspected, approved and covered with the top layer of bedding soil, the trenches shall be backfilled with soil which does not contain more than 40 % rock or shale and will pass through a sieve with 100 mm diameter holes that has been approved by Engineer.

Back-filling of cable trenches shall be done in layers of 150 mm and shall be compacted and consolidated to 95 % modified AASHTO. Test shall be carried out to ensure the required compaction at the cost of the Contractor.

The closed-up sections of the cable trenches shall be maintained by the Contractor in a proper, safe condition for the duration of the contract. Where the soil in the trenches subsides, it shall be refilled and compacted to the satisfaction of the Engineer.

*Jointing and Terminating of Cables*

No joint will be allowed in any run of power cable.

All multi core PVC SWA PVC cables shall be terminated at each end by means of a suitably sized cable gland with armour clamp and Neoprene shroud. The armoring of the cable shall be bonded to earth at each end.

All 11 kV cables shall be terminated in compound filled end boxes.

The termination shall be made to the manufacturer's instructions and with materials stipulated in such instructions and with materials stipulated in such instructions.

Where panels are provided with end boxes, these boxes shall be employed to terminate the cable end boxes and shall be filled with the prescribed mass of compound type Henley list No 57040.

The making off of cable ends shall be done strictly in accordance with the manufacturer's instructions as well as the filling of the boxes.



### *Testing of Cables*

#### *Low voltage cables*

On each completed section of laid and joined cable, the insulation shall be tested to approval with an approved "Megger"-type instrument of not less than 500 V.

#### *11 kV cables*

On each completed section of laid and jointed high-tension cable a high voltage test shall be carried out. The test shall be performed according to SABS 97 of 1991. Alternating or direct current may be used.

#### *Earth wires*

Earth wires shall be installed with L.T. cables as and where indicated on the drawings or specified here in and shall consist of bare hard-drawn copper wire.

These earth wires shall be installed at the same depth as the relevant cables, with at least 75 mm clearance between any earth wire and the nearest cable, unless specifically approved otherwise.

No joint will be allowed in any run of earth wire.

Each earth wire shall be terminated at each end by means of a suitably sized bolted lug either sweated or crimped onto the wire. The lugs shall be bolted onto the relevant earth bars or earthing terminals

#### *Cable Markers*

Cable markers with lead labels cast into the top of the cable markers shall be supplied and installed along the cable routes under this Contract as follows:

Along straight runs of the route, not further than 25 m apart;

At turns - one on each side of the turning point, 900 mm from such turning points;

At each branch, 3 markers – i.e. one on each side of the branch, 900 mm from the branch. The cable marker shall be installed deep enough to ensure that the top of the marker will protrude 50 mm above final ground level.

#### *Route Plans to be Submitted by the Contractor*

On completion of the works, but before the certificate of completion will be issued, the contractor shall submit to the Engineer, route plans (polyester prints) indicating in a satisfactory manner:

The exact cable routes with reference to fixed points (e.g. buildings);

The exact lengths of cable (H.T and LT) installed between terminating points and between joints where relevant; and

The exact position of cable joints with reference to fixed points (e.g. buildings).

Prints of the various plans for the marking up of the information required, will be supplied to the contractor on request.

#### *Cable measuring, procurement & payment*

The cable lengths in the BOQ are indicative only. The successful tenderer shall measure all cable routes and verify all cable lengths before procuring any cable. Payment shall be done only for actual lengths installed. Pricing should include for off-cuts.

## **2. PLUGGING OF BRICK WALLS AND CONCRETE**



Only plugging material of an approved type may be used for fixing to brick walls and concrete, wood will not be acceptable. Plugging in joints of brick walls will not be acceptable. Only round headed brass screws shall be used for fixing.

Steel structures may not be drilled without written approval of the Engineer. Where steel structures may not be drilled the electrical contractor shall use suitable Grade 304 Stainless Steel clamps for securing the equipment.

### **3. INSTALLATION OF DISTRIBUTION BOARDS AND MOTOR CONTROL BOARDS**

Each of the relevant distribution boards and motor control boards shall be securely bolted down on the floor or plinth by means of the requisite number of foundation bolts grouted into the floor in the positions indicated on the drawings.

These positions shall be confirmed with the Engineer on site, prior to installation.

*Testing and Commissioning of Distribution/Motor Control Boards After Installation on site.*

After installation on site but prior to commissioning the following inspections and tests shall be performed on each distribution/motor control board.

Check all components to ensure that they are free from dust and protective packing material;

Check operation of all components liable to damage in transit such as meter and protection measured;

The insulation of all primary circuits between phases mutually and between each phase and earth shall be measured;

All fused links shall be checked for electrical continuity; and

All control supplies shall be checked.

All adjustable protection devices shall then be met and the boards commissioned all in consultation with and to the instruction of the Engineer.

### **4. EARTHING**

The contractor shall do all the bonding and ear thing in accordance with the latest addition of the "Code of Practice for the Wiring of Premises" SABS 0142

The substation and HT switch room earthing shall consist of a 70 mm<sup>2</sup> bare copper earth wire installed in the same trench as the HT supply cables.

### **5. BALANCING OF LOAD**

The contractor shall balance the load as evenly as possible over three phases on the main board, as well as on all the motor control boards.

### **6. NAME PLATES**

Cubicles and pedestals shall be marked with the associated motor number. A list of numbers will be provided by the Engineer. The numbers shall be rear engraved on Perspex or similar material. The number shall be black, 40 mm high, on a yellow background. The height of the plate shall be 50 mm. The number shall be secured, on top of the pedestal, as prescribed for distribution boards.



## PM MECHANICAL SPECIFICATION

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## **PM MECHANICAL SPECIFICATION**

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### **6.1 General**

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This section of the Specification covers the supply, design, manufacture, inspection and testing, packing, delivery to Site, storage, installation, acceptance testing, finishing, painting, commissioning and repairs during the Defects Notification Period of the mechanical plant and equipment included in this Contract.

Prior to, or together with, the submission of Design Documentation for a particular activity or part of the Works the Contractor shall submit to the Engineer for his approval a list of his proposed suppliers and sources of materials, technical specifications, certified dimensional drawings, weights and loadings and power requirements for all principal items of equipment required for the execution of the activity or part of the Works. Samples shall also be submitted for approval at the request of the Engineer.

The materials subsequently supplied shall conform to the material specifications and quality of any samples which have been approved by the Engineer. Names of additional suppliers and sources may be submitted by the Contractor during the execution of the Contract, but no source of supply shall be changed without the Engineer's approval.

The plant is required to be complete in all respects as specified herein and shall include all items of plant, machinery, fittings, equipment, etc. necessary whether such items are specifically referred to in the Contract or not.

Plant and Materials shall comply with the Mechanical Specification, as well as the Process Specification.

Plant and Materials shall be suitable for operation in climate conditions at the site as stated in the General Specification. Plant mounted outside shall be suitable for a temperature range of 5°C below the minimum, to 5°C above the maximum temperatures recorded in the area. Plant shall be designed to operate correctly in periods of high wind speed. The maximum wind speed to be used for design purposes shall be in accordance with maximum wind speeds recorded in the area; the site shall be considered as "Exposed".

The Contractor shall co-ordinate the activities of all his sub-contractors and ensure that all subcontractors for any mechanical works are provided with sufficient drawings, diagrams and schedules to ensure co-ordination before orders are placed by them for their equipment and plant.

The Contractor shall provide enough experienced engineers as mechanical co-ordinating engineers to monitor and co-ordinate all aspects of the mechanical works and equipment.

The Contractor shall allow the Engineer use of all facilities for inspection and testing, during manufacture and installation of mechanical plant and equipment.

The Contractor shall also carry out all obligations and requirements, in relation to the inspection and testing of mechanical plant and equipment at all stages, during manufacture and installation and after completion of the installation of the Works.

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### **6.2 Regulations, Standards, Materials and Workmanship**

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All works carried out, all equipment and all parts to be manufactured and the workmanship executed under this Contract shall comply with the latest editions of BS EN or ISO Standards and shall have ISO 9001 quality certificates unless required otherwise by the Engineer.

All materials shall comply with the appropriate BS EN Standards, International Organisation for Standardisation (ISO), CEE Standards, and the recommendations of the International Electro-technical Commission or other standards specified herein.



If the Contractor should wish to supply material or execute work to an alternative National or International Specification, he shall give full details of his proposals in writing to the Engineer together with English translations of any such proposed specification, which shall be no less onerous than those originally specified. These alternative Specifications shall be detailed in the Contractor's Tender.

For major items of Plant, the Contractor shall provide detailed references from other users of identical or very similar plant to prove that they have been in regular use and operated without any major defects for a period of at least five years.

No payment will be made for any work which fails to meet the above requirements. All materials and workmanship shall be to the satisfaction of the Engineer. Particular attention shall be paid to a neat orderly well-arranged installation carried out in a methodical competent manner.

All trade work shall be carried out by tradesmen fully competent and qualified in their respective trades, and the entire installation shall be performed in a neat workmanlike manner. Tradesmen may be required to demonstrate their proficiency to the satisfaction of the Engineer.

The whole of the equipment supplied shall be of the best modern design, best practice and of high class durable finish and suitable for installation in a modern treatment facility which will be subjected to excessively heavy usage.

The Contractor shall be responsible for ensuring that the components of each system are initially compatible and integrated to form fully efficient systems complying with the drawings and Specification.

The philosophy of the design shall be simplicity and reliability such that the equipment will give long trouble-free service with low maintenance costs. Particular attention shall be paid to easy access to facilitate inspection, cleaning, maintenance, and repair.

All equipment supplied shall be designed to meet the needs for satisfactory operation under all variations of operating loads, pressures and temperatures including variation in the ambient temperature.

All materials shall be new, technologically advanced, modern and of the best quality and shall be selected to withstand the stresses imposed by the working and the ambient conditions without distortion or deterioration affecting the efficiency and reliability of the plant.

Components incorporated in the Plant shall be selected to minimise maintenance costs. As a minimum requirement, items of Plant shall incorporate those features normally associated with the Plant as detailed in manufacturer's specifications and literature, unless specifically excluded.

It shall be the responsibility of the Contractor to ensure that the electrical equipment is completely satisfactory and compatible for use with the mechanical equipment offered.

Each component or assembly shall have been proven in service for a minimum period of five years in a similar application and under conditions no less arduous than those specified herein. The Engineer shall have the right to request the Contractor to justify his selection of equipment. Where it is shown that material or plant are of a standard lower than that necessary to comply with the Specification, the Contractor shall modify or replace the equipment concerned at no extra cost.

The choice of materials and finishes shall consider the atmospheric conditions at the Site.

Outdoor equipment shall be weatherproof and designed to prevent the collection of water at any point. Metal-to-metal joints will not be permitted, and all external bolts or screws shall be provided with blind tapped holes where a through hole would permit the ingress of moisture.

Mechanisms shall be constructed of materials, which will not jam due to rust, corrosion, brine, or dust. Bearings of exposed operating shafts shall be designed to prevent moisture seeping along the shaft into the interior of equipment. Equipment and instruments shall not be in positions where they are vulnerable to falling objects or water drips. Weather shields shall be provided where necessary to protect equipment and instruments.

All materials and components shall be of good quality, new and unused, suitable for the purpose specified, and to the approval of the Engineer. Equipment shall be of the most recent or current design



and specification and shall incorporate all recent improvements in design and materials unless provided for otherwise in the Contract.

No second-hand materials whatsoever will be acceptable. The Contractor may be required to produce certified invoices.

All materials shall be marked with the standards number to which they have been manufactured. If marking is impracticable then the relevant delivery notes shall include the appropriate standards number.

In the case of Standard Specifications and Codes of Practice, the latest edition, which is current at the time of tendering, shall be used.

Due to the high humidity persistent on site all set, fixing and wood screws, studs and the like used through the whole of the mechanical installations shall be brass or sherardized or other material resistant to corrosion.

All component parts of the Works shall, unless otherwise specified, comply with the provisions of this part or be subject to the approval of the Engineer.

The names of the manufacturers of the materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specification. Such parts shall be replaced by the Contractor at no extra cost to the Employer.

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first-class commercial quality, free from imperfections and selected for long life and minimum maintenance. All components of the Works shall be manufactured from materials specifically chosen for their resistance to corrosion.

All submerged moving parts of the plant, or the pins and spindles, etc., of the submerged moving parts or the faces etc., in contact with them shall be of corrosion resistant metals. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without ageing due to the passage of time, exposure to light or any other cause.

Where "stainless steel" is specified or used it shall have resistance to atmospheric corrosion not less than that provided by BS EN 10095 Grade 1.4435. Particular attention shall be paid to the prevention of seizure by fretting where two corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants. Where bronze is specified or used it shall be zinc free.

Particular attention shall be paid to the prevention of corrosion due to the proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, they shall be selected so that the bimetallic corrosion is as low as possible.

The requirements of PD 6484:2005 – 'Commentary on Corrosion at Bimetallic Contacts and its Alleviation' shall be followed.

Equipment shall be installed with high quality workmanship at the required places and levels that are shown on the Drawings made by the Contractor and approved by the Engineer. Any digression from the Drawings shall not be acceptable unless otherwise specified by the Engineer. All plant shall be to the right line, level and location for satisfactory operation and shall allow easy access for making the necessary connections between equipment.

Workmanship and general finish shall be of first-class commercial quality in accordance with best workshop practice.

All similar items of plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerance so that replacements made to manufacturer's drawings may be readily installed.



Unless otherwise described in the Contract the use, installation, application or fixing of materials and components shall be in accordance with all applicable recommendations of the manufacturer. Where appropriate, the Contractor shall make use of any technical advisory services offered by manufacturers.

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### **6.3 Design Life**

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All mechanical Plant shall have a design life of 20 years, unless otherwise stated in the Specification.

All materials and equipment shall be designed for long life with minimal maintenance and the Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel.

Except for consumable items such as gland packing, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation and, where major dismantling is required to replace a part, such life shall be not less than ten years.

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### **6.4 Potentially Explosive Atmospheres**

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The Contractor shall include for and carry out an assessment for the possibility of the existence of potentially explosive atmospheres and determine whether zonal classification should be applied, in accordance with IEC 60079-10-1, for explosive gas atmospheres; and with IEC 60079-10-2 for combustible dust atmospheres.

Electrical Plant in classified areas, and its installation, shall be in accordance with the relevant sections of BS EN 60079.

All non-electrical Plant installed in Hazardous Areas shall be designed to be non-sparking and anti-static.

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### **6.5 Erection and Installation**

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The Contractor shall provide the services of a skilled and competent full time mechanical engineer (or engineers) who is fully conversant in the installation of the various specialist types of equipment and control systems, and supervisor (or supervisors) to take charge and supervise the erection, installation, testing and commissioning of the plant and equipment included in the contract. He (or they) shall also stand by after the commencement of working until the reliability run has been satisfactorily completed. The Engineer shall approve the appointment of all supervising engineers and shall have the authority to withdraw his approval at any time.

The Contractor shall ensure that no installation or erection work shall commence until full and unconditionally approved working drawings, signed, and stamped by the Engineer and Employer, are available at the Site.

The Contractor shall also instruct and supervise maintenance staff in the operation and routine maintenance of the equipment installed under this Contract, in accordance with the requirements set out in the various clauses of this Specification.

The Contractor shall co-ordinate erection programmes with associated civil and electrical engineering and building work.



The Contractor shall ensure that any items of plant which are required to be built into the civil works shall be delivered to site as required prior to the delivery of the main plant.

The Contractor shall provide all tools, equipment, transportation, fuel, and power required during installation.

Any special erecting tackle required shall be provided by the Contractor and be left on site after completion of the Contract.

The Contractor shall provide adequate protection for the plant from the time it is delivered to site until Temporary Acceptance. The Contractor shall provide and fix adequate sheeting, etc. to prevent the ingress of dust and dirt both during erection and whilst the building finishes are carried out after erection.

The Contractor shall repair, make good or replace as new any damaged item to the satisfaction of the Engineer.

The Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations and elevations shown on the Contractor's drawings and other engineering documents submitted by the Contractor in accordance with this Specification. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid drawings and no departures therefrom will be permitted.

All power and instrument cables and all service pipework between items of plant and walls of structures or services ducts or trenches shall be mounted on and neatly and securely fastened to cable trays or similar types of support which are independently mounted off the floor or adjacent structure.

All plant shall be correctly aligned, levelled, and adjusted for satisfactory operation and shall be installed so that the proper and necessary connections can be made readily between the various units and pipework and equipment installed under the Contract.

Before commencing any erection work, the Engineer shall check the dimensions of structures where the various items of the plant are to be installed, and shall bring any deviations from the required positions, lines or dimensions to the notice of the Contractor and the Contractor shall make the necessary corrections. The cost of such corrections shall be borne by the Contractor.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the items concerned. The Contractor shall ensure that all equipment is securely held and remains in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of plant or its supporting base resting on foundations and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundation, without shrinkage or cracking.

The approval by the Engineer of the Contractor's proposals for rigging and hoisting any items of the Plant into final position shall not relieve the Contractor from his responsibility for damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair, or replace any damaged or injured items, whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

No Plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses and deflection, the beams and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subjected to the prior approval of the Engineer.

Where the Contract is to be carried out on an existing site which is to remain operational during the Contract, the Contractor shall co-operate fully with the Operational Staff and may be required to modify his working methods and programme if so justified by Operational requirements arising at the time. The Contractor shall provide method statements to detail how each task of work will be undertaken and the affect it will have on the operation of the Works.



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## **6.6 Design and Standardisation**

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The works in the Contract shall be designed to facilitate inspection, cleaning, and repairs for use where continuity of operation is the first consideration. All equipment supplied shall be designed to ensure satisfactory operation under working conditions.

All plant containing rotating parts shall be capable of operating at speeds up to the maximum duty specified without vibration or excessive noise.

All nuts, bolts and studs shall be threaded in accordance with the relevant Standards for Isometric series threads and fitted with 3 mm thick washers beneath both bolts and nuts.

Corresponding parts throughout the Works shall be made to gauge and shall be interchangeable wherever possible. The Contractor may be required by the Engineer to prove interchangeability by actual interchanging of the various parts.

All work shall be constructed using metric dimensions. Drawings, components, dimensions, and calibrations shall be in metric and the units adopted shall be generally in accordance with the International System of Units.

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## **6.7 Packing, Marking and Delivery to Site**

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Upon the successful completion of the prescribed tests at the manufacturer's premises, and prior to despatch from the place of manufacture, all plant shall be thoroughly protected against corrosion and incidental damage, including the effects of vermin, strong sun light, rain, frost, high temperatures, humidity, salty atmosphere and sea spray.

All items of Plant intended to be painted shall receive the necessary treatment and all unpainted parts liable to corrosion (with the exception of electrical equipment) shall be thoroughly coated with a high melting-point grease or other approved protective substance, which is easily removable during or after erection.

In addition, all electrical equipment shall be suitably protected against corrosion and incidental damage to the satisfaction of the Engineer. Temporary leads shall be fitted to electrical equipment to enable anti-condensation heaters to be energised when the Plant is in store, and such heat shall be applied when climatic conditions so require.

All Plant shall be packed to withstand land and sea transportation, rough handling in transit, and packages shall be suitable for exposure to the atmosphere and storage in the open including possible delays on exposed quaysides. The Contractor shall be held responsible for the Plant being packed so that it reaches its destination intact and undamaged. Packages containing dangerous or breakable goods shall be packed and marked in accordance with any statutory rules and orders applicable locally, abroad and at sea.

Each item of Plant shall be fitted with a temporary label identifying its function and identity, e.g. Pump No. 1, ammeter, etc. Temporary labels shall use the English language. Permanent labels, pre-drilled for fixing but without engraving, shall be supplied loose. These labels shall be engraved and fitted during installation, using translations provided by the Engineer.

Items of Plant or components of Plant, which may require replacement or servicing, shall be clearly and permanently marked with the original manufacturer's name, serial number, and basic information as to rating, etc.

The Contractor shall prepare a delivery programme showing the periods of manufacturing, inspection, testing and transport of all equipment and materials and shall submit this for the approval of the Engineer in accordance with the work programme.



The Contractor shall keep the Engineer and the Employer fully informed of the state of deliveries of the Plant and shall submit copies of all shipping documents to the Employer by the fastest possible means. All shipping documents shall be accompanied by copies of test certificates.

The Contractor shall be responsible for the delivery of the equipment and materials to the Site including its offloading, handling, and safekeeping.

The Contractor shall examine the equipment and materials to the extent possible at the port, highway, or railway terminal, and more thoroughly whilst taking delivery at the Site.

On inspection, **directly after the delivery to site**, should the Contractor discover that any item of equipment and materials has been damaged, or impaired in transit, he shall forthwith direct the attention of the Engineer thereto, who will inspect and give instructions for its replacement. Any equipment and materials condemned by the Engineer shall be immediately removed and replaced by the Contractor who shall also be obliged to negotiate all claims and litigations with the insurers of the plant under the General Provisions of the Conditions of Contract.

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## 6.8 Storage of Materials and Equipment

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All items shall always be adequately protected from damage and deterioration, including the period of storage and erection at the Site. During and following erection of the equipment at the site the Contractor shall be wholly responsible for its care and maintenance as well as for its operation until the acceptance tests and commissioning have been satisfactorily carried out and the equipment has been formally taken over.

During storage and erection at the Site the equipment shall be kept clean and free from dirt and debris and water shall not be allowed to remain in any pockets of the equipment. All items of mechanical and electrical equipment which are unloaded in the storage areas shall be stored clear of the ground on suitable timbers to the approval of the Engineer.

All machinery, particularly the electrical equipment, shall at all times be protected in closed storage areas, as required, approved by the Engineer so that it is not subject to damage by rainwater, moisture, dust, etc., from any source. Storage areas shall be provided by the Contractor.

In the case of transferring the equipment in containers, storage of the equipment on smooth concrete platforms at the Site shall be permitted after approval of the quality of the containers by the Engineer.

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## 6.9 Drawings

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The Contractor shall retain in his site office a complete set of Contractor's drawings which shall be kept fully up to date showing all modifications and amendments which have been carried out during the installation of the mechanical works.

These drawings shall always be available for inspection by the Employer and the Engineer. These drawings shall form the basis of the record drawings.

In addition, a framed diagrammatic layout of the plant, with points requiring routine maintenance indicated in a precise and legible form, shall be provided in all plant rooms to the Engineer's approval.

All specifications, drawings, operation and maintenance manuals and spare parts lists shall be in English.



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## **6.10 Laying Out of Work**

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The Contractor will be responsible for laying out his work and shall obtain all necessary information as may be required to carry out the work, and such information shall be obtained sufficiently in advance to avoid any possibility of delay to the Works as a whole.

The Contractor shall inform himself fully of the details of all work being carried out by the various trades on Site, particularly where such trades may interfere with one another, or where co-ordination is necessary.

No claims for extra costs will be met arising from omissions, oversights, or neglect in this regard.

The Contractor shall check with each supplier that all plant is suitable for the application and will meet the specified design conditions. Where items of associated electrical equipment are provided from different suppliers, (i.e. electrical motors, motor starters, cabling etc), it is the Contractor's responsibility to ensure that these are all compatible.

Failure to enumerate, in detail, individual items of equipment which are implied, throughout this Specification will not absolve the Contractor from his liability to supply and install such items, and the cost of supplying or installing such items will be deemed to be included in the Contractor's price.

The Contractor shall ensure that when plant is being manoeuvred into position, the weight shall be spread so that the load at any point does not exceed the load capacity of the floor or foundation. All plant shall be secured or restrained from moving in the event of an earthquake.

The Contractor shall arrange to supply, in advance of the delivery of the equipment, all necessary foundation bolts, templates, nuts, plates, sleeves, anchorages, etc. as required, and as may be directed by the Engineer.

Additionally, he shall ensure that all equipment can be installed through the opening provided, or that suitable openings are left, as may be required, or directed.

The Contractor shall include for all builder's work required in connection with the various installations. It is the Contractor's responsibility to ensure that all holes and chases, etc. are in the required position, and that any additional duct, holes and chases necessary for the execution of the installation in in-situ concrete walls, floors, slabs, etc. are included in the early stages of construction as appropriate.

Where it is required to fix equipment or accessories to a concrete or masonry structure approved fixings such as expansion bolts of the "Wedge-Anchor bolt" type must be used. Wooden plugs inserted into the concrete or masonry will not be acceptable as a base for fixings. Toggle bolts may be used as fixings on hollow masonry units. Studs driven into the structure by percussion means may be acceptable provided the approval of the Engineer is obtained prior to fixing.

Fixings to steelwork structures involving welding, in general will not be acceptable.

The Contractor shall submit to the Engineer for approval his proposals for fixings prior to the installation.

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## **6.11 Plant Access and Maintainability**

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The Plant shall be designed and installed for ease of maintenance and to allow access or removal without disturbing adjacent Plant, pipework, etc. The Contractor shall ensure that all working areas have adequate access, lifting arrangements, lighting, heating and ventilation. All Plant, materials housings, etc., that may be manually handled during the course of normal operations or maintenance shall be provided with lifting arrangements according to the following:

Above 25 kg - Provision of two man lifting arrangement

Above 35 kg - Provision of suitably rated lifting arrangement



Above 500 kg - Provision of lifting beam with manual chain block  
Above 1 tonne - Provision of overhead crane with electrically operated chain block

All lifting equipment (beams, gantries, davits, blocks, etc) shall be rated for each location for the maximum load to be lifted plus 25% rounded up to the next standard commercially available rated lifting block. This assessed load shall be designated the Safe Working Load (SWL) which shall be indelibly stamped on all equipment relative to the particular location. Blocks with rated SWL greater than the rated SWL for the davit, beam etc cannot be used at such locations. Test loads shall be 125% of the rated SWL.

Lifting arrangements and Plant shall be load tested on site after installation and if necessary, further tests shall be carried out so that the effective date of the latest certified test at any location is not more than 3 months prior to the date of issue of the taking over Certificate. Load test certificates shall be supplied for all lifting Plant.

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## **6.12 Painting and Protective Coatings**

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All items of structural steel work, mechanical or electrical plant, valves, and pipework, supplied in this Contract shall be supplied having a metal protection system corresponding to one of the specifications tabulated at the end of this Clause.

### **6.12.1 Paint**

All paints shall be obtained only from suppliers approved by the Engineer. Unless otherwise agreed by the Engineer, all paints forming part of anyone painting system shall be obtained from the same source. Paints shall be supplied in sealed containers of not more than 5 litres capacity and shall be used in strict rotation.

All pigment and fillers used in manufacture of paints shall comply with the appropriate European Standards. Painting specifications for specific items are covered in the special specification clauses.

### **6.12.2 Painting General**

Preparation, application, and conditions of work shall be in accordance with appropriate painting techniques and relevant standards and specifications.

### **6.12.3 Preparation of Surfaces to Receive Paint**

Before paint is applied to any surface, the appropriate surface preparation, as described in the Contract, shall be carried out in accordance with the following and shall comply with the relevant standards and specifications.

#### **(i) Bare Metal Surfaces**

##### **(a) Blast Cleaning**

Blast cleaning shall be carried out in accordance with the correct techniques and relevant standards unless stated elsewhere, using fine chilled iron grit, or shot as necessary.

The abrasive used for blasting shall be free from contamination and any recovered materials shall be cleaned to the satisfaction of the Engineer. The maximum amplitude, (peak to trough), of the blast cleaned surface shall not exceed the requirements specified for the individual coating systems.

Surfaces shall be protected within four hours of having been blast cleaned.

##### **(b) Pickling**

Steel shall be pickled by a suitable method in accordance with relevant standards and specifications. The first priming coat of paint shall be applied as soon as the steel has dried and is still warm.



(c) Flame Cleaning

The flame clean surface shall be cleaned of all loosened material. The first priming coat shall be applied while the steel is still warm. The sequence of operation for flame cleaning steel work shall be planned and controlled to avoid the risk of distortion and buckling.

(d) Mechanical Cleaning

Mechanical cleaning shall be carried out by power driven tools such as abrasive grinding discs, chipping hammers or needle guns, followed by steel wire brushing and dusting to remove all loosened material. Excessive burnishing of the metal through prolonged application of rotary wire brushes shall be avoided.

Surfaces shall be protected within four hours of having been mechanically cleaned.

Note: Methods of surface protection utilising (b), (c) or (d) will only be permitted with the written permission of the Engineer.

(ii) Welds and Weld Affected Areas

Unless otherwise described in the Specification, welds and surfaces which have been affected by welding shall be prepared for painting by the same process as described in section 4.12.7.

(iii) Painted Surfaces

Painted surfaces shall be cleaned of all dust immediately prior to the application of further paint. Any loose paint and rust shall be removed. Areas contaminated by oil and grease shall be cleaned with oil and grease solvents. Where required by the Engineer, the whole surface shall then be cleaned by washing down with a solution of an approved liquid detergent, followed by rinsing with clean fresh water and allowed to dry thoroughly before paint is applied. Old painted surfaces shall be abraded to provide a key for subsequent coats.

#### 6.12.4 Galvanising and Metal Coatings

Surface preparation for the application of metal coatings shall be in accordance with the following Standards:

- (i) BS EN ISO 1461:2009, Hot Dipped Galvanised Coatings
- (ii) BS 4921:1988, Sherardized Coatings
- (iii) BS EN ISO 2063:2005, Thermal spraying Metallic and other inorganic coatings.

Sprayed metal coatings which are subsequently to be painted shall have a nominal thickness of 100 microns.

All materials and fabricated parts to be galvanised shall be of the full dimensions shown or specified with all welding, punching, cutting, screw tapping, removal of burrs, etc. completed before the galvanising process commences.

All galvanising shall be done by the hot-dip process with spelter of which not less than 98% shall be pure zinc. The zinc coating shall be uniform, clean, smooth, and as free from spangle as possible. The zinc coating shall weigh not less than 400 g/m<sup>2</sup> of area covered and be not less than 0.6 mm in thickness.

No parts likely to come in subsequent contact with oil shall be galvanised. Bolts shall be completely galvanised, but the threads of all nuts shall be left uncoated.

All galvanised parts shall be protected from damage to the zinc during the periods of transit, storage, and erection. Damaged areas of the coating shall be cleaned back to bright metal leaving feathered edges of the surrounding galvanised coating and touched up with zinc-dust paint or other flake metallic compound.



Sampling and testing shall be carried out in accordance with BS EN ISO 1461:2009; or BS EN ISO 2063:2005 whichever is appropriate. All metal sprayed steel work shall be protected within four hours of spraying with one coat of approved etching primer. Where a metal coating is required only on part of an assembled section, it shall be applied before the rest of the section receives its first priming coat.

#### 6.12.5 Storage of Paint

The paint shall be stored in sealed containers in a lock-up store where it is not exposed to extreme temperatures. The temperature of the store shall be kept between 4°C and 27°C; any special storage conditions recommended by the manufacturer shall also be observed. Paint which has not been used within the "shelf life" period specified on the containers or within 12 months of the date of manufacture, whichever is the lesser shall be replaced. Paint from painters' kettles shall be returned to the store at the end of each working period where it shall be kept in a sealed container. This is not permissible for any two pack paints such as Epoxy type. Before it is re-issued for use it shall be thoroughly mixed and no fresh paint or thinners shall be added.

#### 6.12.6 Application of Paint

Preparation, application, and conditions of work shall be in accordance with an appropriate painting technique and with relevant standards and specifications.

Fusion Bonded Epoxy (FBE) coatings of at least 300 microns thickness are preferred for carbon steel or cast-iron components.

Where paint is applied by brush or spray methods, it shall comply with the following:

All primers, undercoats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades.

All paint shall be supplied from the store to the painters, ready for application, and addition of thinners or any other material shall be prohibited. Any instructions given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the painters under supervision. Paint shall be applied to the dry surface which has been prepared in accordance with the requirements specified by the paint manufacturer or the requirements stated in this specification.

Paint shall not be supplied under the following conditions: -

- (i) When the ambient temperatures fall below 4 °C or relative humidity rises above 90%
- (ii) During rain, snow, fog, or mist
- (iii) When condensation has occurred or is likely to occur on the steel.

Two-pack paints of epoxy resin type shall not be applied when the temperature falls below 5 °C or as required by the paint manufacturers, nor shall it be applied when the temperature is likely to fall below the specified minimum during the curing period.

Unless otherwise agreed by the Engineer, each coat of paint shall be applied by the method described in the Specification to produce a continuous film of uniform and even thickness.

As soon as the first priming coat has dried, an extra stripe coat of paint shall be applied by brush, to the edges, corners, crevices, bolt heads, rivet heads and welds, using paint of similar composition to the priming coat but of a contrasting shade. Successive coats shall have different shades for identification and each coat shall be thoroughly dry before the application of a further coat.

The dry paint film thickness shall be measured by Elcometer or other instruments approved by the Engineer. To obtain the dry film thickness specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Wet film thickness gauges may be used for checking but shall not be used after the expiration of the "pot life" stipulated by the manufacturer and the paint of limited "pot life" shall not be mixed with fresh paint or have thinners added to them. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm<sup>2</sup>. Painted fabricated steelwork which is to be stored prior to erection shall be kept



clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no pools of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked materials. Where cover is provided, it shall be ventilated.

Where primed painted steel work is to be stored out of doors before being overcoated it shall not be exposed for periods longer than the following:

|                                       | <b>Out of Doors</b> |
|---------------------------------------|---------------------|
| Etch primers                          | Nil                 |
| Etch primers on metal coatings        | Two weeks           |
| Chromate paint                        | Two weeks           |
| Zinc chromate primers                 | Two weeks           |
| Zinc rich primers 25/37 microns thick | Four weeks          |

#### 6.12.7 Repairs to Damaged Surfaces

Areas of paint which have been damaged shall be cleaned to bare metal or metal coatings where this has been applied and the edges of the undamaged paint bevelled with sandpaper. Where a metal coating has been damaged, the affected areas shall be rubbed down to remove excessive rust, cleaned and an additional coat of an approved primer applied. The full specified painting system shall then be re-applied and new paint shall overlap the existing paint by at least 50 mm all round the affected part.

#### 6.12.8 Painting of Existing and Previously Painted Surfaces

In general, all surfaces shall be suitably prepared by cleaning, abrading, and degreasing, etc and may be repainted with the finishing systems as detailed in this Specification. Decorative paints, such as gloss finish or similar type finishes, may be applied to clean, dry and well-prepared surfaces direct without primer, etc.

Exposed surfaces should be primed and brought forward in the normal manner, that is, prime where necessary followed by undercoat and gloss finish as detailed in the Specification, but sound surfaces may in general be recoated with the finishing paints only. Where two pack materials have been used and where adhesion of the new paint may be difficult, the weakness in adhesion may be overcome with the use of an etch primer. Care should be taken to avoid over application of this primer since this can create additional problems.

#### 6.12.9 Paint Specifications

The Contractor shall give full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the equipment against corrosion. In the case of materials he shall submit details of the basic raw materials source, volatile matter content, nature of solvent, number of constituents including the percentage of epoxy resin, type of application, coverage, time interval between coats, recommended number of coats, toxic properties, shelf life and details of 'patch' repairing.

For epoxy-based paints, the total percentage of epoxy resin in the dry film shall not be less than 25 %.

No thinners shall be used unless approved by the paint manufacturer. To prevent loss of adhesion and solvent entrapment the paint manufacturer's instructions shall be rigidly followed particularly with respect to the minimum and maximum periods between coats and the permissible temperature and humidity range for application.

Care shall be taken to maintain the full paint thickness at all corners and edges and special attention shall be given to the application of protective coatings after welding.

Power tool cleaning may only be carried out on metal surfaces which may be difficult to blast because of their location or shape. These surfaces shall be 100 % disc cleaned to a surface finish equivalent to one that has been sand or grit blasted. Where welds occur within these areas or where these areas cannot accommodate a power disc an air hammer shall be used. Power tool cleaning will only be permitted after review by the Engineer.



The Contractor shall submit for review an overall colour scheme for the exposed surfaces of all equipment. All final coats shall be in the colours thus approved.

#### 6.12.10 Protection During Transportation

All equipment shall receive adequate protection in the workshop or factory to ensure that metal is not affected by corrosion during transportation, loading and off-loading, storage, and site erection.

The Contractor shall supply full details of the extent to which blasting, metal spraying and painting will be carried out in his supplier's workshops, on the site of the work prior to erection or in-situ after erection. If it is decided to carry out the bulk of the painting on the site of the work, a properly equipped painting shop shall be set up using a specialist organisation, experienced and skilled in the preparation of surfaces and the application of protective coating under the prevailing conditions.

#### 6.12.11 Parts Built into Concrete

Cast iron or mild steel parts to be built into concrete at a depth greater than 75 mm shall be painted with an approved metal primer to a Dry Film Thickness (DFT) of 50 microns. Immediately before priming, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating.

#### 6.12.12 Inspection and Tests

The plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the Manufacturer's Works and at the site of the work. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Engineer.

#### 6.12.13 Corrosion Resistant Materials

No blast cleaning or painting shall be applied to corrosion resistant materials such as stainless steels, Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fittings etc. All buried pipes within the Wastewater Treatment Works shall be protected by an approved cathodic protection system.

#### 6.12.14 Box and Tubular Sections

Box and tubular sections shall be permanently sealed. All such sections shall be thoroughly dried out using hot dry air before final sealing and painting is carried out. After sealing all sections shall be tested for air tightness.

#### 6.12.15 Machined Surfaces

Machined surfaces such as gears shall be coated with a thick layer of grease.

Other machined surfaces such as shaft ends, deep plates and other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted, machined interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly.

#### 6.12.16 Manufacturer's Standard Finishes

Where it is the usual practice of the manufacturer of items such as pumps, electric motors, switchgear, control panels and similar equipment, to apply a high standard of protective paintwork in the shop before despatch, this will normally be acceptable provided that such standard finishes are at least equal to the surface finish specified.

Full details of such manufacturer's standard finishes shall be given to the Engineer for his approval prior to manufacture. Special care shall be taken to ensure standard finishes are suitable for the conditions applicable to the individual items of plant.



#### 6.12.17 Switchboards

Prior to painting, switchboards made of sheet steel shall be cleaned from dirt and rust by chemical means and shall be pacified against oxidation. They shall then be phosphated by dipping in a ferric phosphate bath and all surfaces shall be electrostatically painted by epoxy-polyurethane powder paint. The exteriors of such panels shall be a colour specified by the Engineer to give a minimum reflection value of 42 %. Instruments shall be finished dull black and control-handles, push buttons and similar fittings shall be chromium plated or otherwise in a form and type to be approved by the Engineer.

#### 6.12.18 Paint Systems

The following paint systems shall be used for the items of plant listed.

The coatings shall be in accordance with BS 5493, "Code of Practice for Protective Coating of Iron and Steel Structures Against Corrosion", and BS EN ISO 12944 Parts 1 – 8 or equivalent standard approved by the Engineer. Systems shall be designed to give a maintenance free period of at least ten years.

##### **System P1**

USES: Buried steelwork.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

(a) Apply two-pack epoxy primer containing anti-corrosive pigment single coat to 50-micron DFT.

(b) Apply two coats of two-pack epoxy finishing coat to a total DFT of 250 microns.

Total DFT = 300 microns.

##### **System P2**

USES: Steel work, inner surfaces of pipes, valves, fittings, etc exposed to potable water.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

(a) Apply two-pack epoxy primer containing anti-corrosive pigment, but not containing Pb and Cr pigments, single coat to 50-micron DFT.

(b) Apply finishing coat having a Drinking Water Health Certificate  
-three coats of two-pack high solid epoxy to a total DFT of 300 microns,  
or

-one coat of two-pack solvent free epoxy to a DFT of 350 - 400 microns.

Total DFT = 350 - 450 microns

##### **System P3**

USES: Wetted (high humidity) and submerged steelwork and inner and outer surfaces of pipes not exposed to drinking water.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

(a) Apply two-pack epoxy primer containing anti-corrosive pigment, two coats to a total of 100-micron DFT.

(b) Apply two or three coats of two-pack epoxy finishing coat to a total DFT of 250 - 300 microns.



Total DFT = 350 - 400 microns.

#### **System P4**

USES: Steelwork and pipes exposed to weather.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

- (a) Apply two-pack epoxy primer containing anti-corrosive pigment, two coats to a total 100-micron DFT.
- (b) Apply two or three finishing coats of two-pack epoxy to a total DFT of 100 - 150 microns.

Alternatively, where a special colour is required, the finishing coat two-pack resin-based epoxy polyurethane (aliphatic based) to a DFT of 250 microns.

Preferably light colours shall be used.

Total DFT = 200 - 350 microns.

#### **System P5**

USES: Steelwork exposed to weather and immersed in water from time to time, such as penstocks.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

- (a) Apply two-pack epoxy primer containing anti-corrosive pigment, two coats to a total 100-micron DFT.
- (b) Apply one coat epoxy undercoat to a 50 - 100 microns DFT.
- (c) Apply two coats of two-pack epoxy finishing coat to a total DFT of 100 microns.

Total DFT = 250 - 300 microns.

#### **System P6**

USES: Internal plant and pipework, cranes and miscellaneous steelwork not exposed to weather.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

- (a) Apply alkyd-based primer (long chain oil) with oxidised drying containing anti-corrosive pigment, single coat to 40 micron DFT.
- (b) Apply two coats of alkyd based (medium chain oil) with oxidised drying finishing coat to a total DFT of 80 microns.

Total DFT = 120 microns.

#### **System P7**

USES: Buried pipes prior to application of wrapping.



PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

- (a) Apply two-pack epoxy primer containing anti-corrosive pigment, single coat to 50-micron DFT.
- (b) Apply primer compound recommended and supplied by manufacturer of wrapping tape, in accordance with the requirements of the manufacturer, immediately prior to the application of the tape. Wrapping shall be in accordance with section 4.12.19.

#### **System P8**

USES: Steelwork exposed to weather, which has been previously galvanised.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

- (a) Apply alkyd-based primer (long chain oil) with oxidised drying containing anti-corrosive pigment, two coats to a total 80 micron DFT.
- (b) Apply two coats of alkyd based (medium chain oil) with oxidised drying finishing coat to a total DFT of 80 microns.

Total DFT = 160 microns.

Note: This system can be used for galvanised works exposed to weather for decorative purposes.

#### **System P9**

USES: Steelwork exposed to weather and subject to heavy wear and requiring frequent maintenance and repairs.

PREPARATION: Near-White Metal Blast Cleaning to BS EN 8501 Sa 2.5.

PAINTING: Painting shall be in accordance with BS 5493 / ISO 12944

- (a) Apply two-pack epoxy primer containing anti-corrosive pigment, two coats to a total 100 microns DFT.
- (b) Apply two coats of two-pack epoxy finishing coat to a total DFT of 100 microns.

Total DFT = 200 microns.

#### **6.12.19 Wrapping of Buried Pipework**

All buried ductile iron and steel pipes and fittings shall be coated and wrapped with cold applied self-adhesive pipe wrap, comprising an extruded, heavy duty, highly conformable thick PVC carrier combined with a layer of rubber rich tropical grade bituminous compound.

Minimum thickness of PVC shall not be less than 0.76 mm with a total thickness of wrap not less than 1.65 mm.

Minimum physical characteristics of wrap to be:

|                                     |                   |
|-------------------------------------|-------------------|
| Tensile strength                    | 13.6N/mm          |
| Elongation                          | 230%              |
| Tear resistance                     | 47 N force        |
| Adhesion to ASTM D 1000 (1800 Peel) | 21.7 N/cm         |
| Dielectric strength                 | 20,000 V mm       |
| Operating temperature               | 20°C – 75°C       |
| Insulation resistance               | 1 000 000 megohms |



All pipes shall be prepared in accordance with system P7.

The dry, primed pipe lengths shall be spirally wrapped with the specified tape wrap using 150 mm wide tape and 25 mm minimum overlap during application. Sufficient tension shall be applied to ensure complete conformity of the tape to the pipe. The spigot end of the pipe shall be left unwrapped for a minimum distance of 150 mm to allow for engagement.

All field joints shall be wrapped after pipe laying and testing. Any exposed metal surfaces and the existing coating shall be cleaned and primed as previously stated. The tape wrap shall then be applied to the prepared joint area overlapping the pipe barrel wrapping a minimum distance of 75 mm, using 100 mm wide tape applied with a 50 mm overlap. Sufficient tension shall be applied during application to ensure complete conformity of the wrap to the joint area.

End laps between adjoining rolls shall be a minimum of 150 mm.

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### **6.13 Tools**

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The Contractor shall provide all special tools or sets of tools necessary for installing and dismantling plant and for the maintenance during the Defects Notification Period of the machinery and equipment. Such special tools shall be defined as any tool which would not be included within a standard mechanical tool kit. These tools shall be of an adequate number and quality for the training of the operating staff. A list of all special tools proposed shall be included in the relevant schedules.

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### **6.14 Spare Parts**

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The Tenderer shall submit with his tender a priced list of spares, which he considers necessary for the maintenance of the plant for three and five years in normal operation. When considering the proposed list, he must bear in mind the difficulty in obtaining equipment in Mauritius. A Provisional Item has been included in the Bill of Quantities for the supply of necessary spare parts as instructed by the Engineer.

The prices of the spare parts given in the schedule of spare parts shall be valid for acceptance throughout the Contract and the Defects Notification Period.

Prior to setting to work the Employer, together with the Engineer and the Contractor will decide which spare parts will be ordered.

The Contractor shall be responsible for providing spare parts needed during the Defects Notification Period.

All spare parts shall be new, unused, and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long term storage under the climatic conditions prevailing at the Site. Each spare part shall be clearly marked or labelled on the outside of its packing. For each case or other container, a general description of the contents shall be shown on the outside and a detailed list enclosed. All cases, containers and other packages shall be marked and numbered in an approved manner for purposes of identification. All labels, descriptions and lists of contents shall be in English.

All cases, containers or other packages are liable to be opened for such examination as the Engineer may require and packings shall be designed to facilitate opening and subsequent repacking.

The Contractor shall provide assurance that all spare parts shown in the schedules will be readily available for a period of at least ten years after the end of the Defects Notification Period.



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### **6.15 Samples**

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If requested, the Contractor shall provide a sample properly labelled of all fittings, valves, insulation, cocks, unions, switchgear, cables, and other like accessories described in this Specification or as specified by the Engineer.

Such samples shall be submitted to the Engineer for his approval at his offices or elsewhere as directed, with all parts left loose so that they may be taken apart for internal inspection by hand without the necessity of using spanners, screw drivers or wrenches.

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### **6.16 Labels**

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Labels approved in design and shape by the Engineer and the Employer, shall be placed by the Contractor at the required points.

Identification labels of "Traffolyte" or similar approved material engraved black on white unless otherwise agreed, with not less than 5 mm "lino" style letters showing the characteristics of the equipment they are associated with. They shall be fixed on or adjacent to all equipment, valves, control switches and distribution gear, by means of at least two brass screws.

The labels shall bear the identification shown on the drawings, such as indication, designation function and, where necessary, phase voltage, current, pressure and temperature. Plastic adhesive strip labels will not be permitted.

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### **6.17 Noise, Vibration and Seismic Forces**

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#### **6.17.1 General**

The Contractor shall provide a quiet installation. All items of plant and equipment shown on the drawings shall be carefully chosen with a view to minimising sound levels.

Noise levels outside plant rooms shall not exceed 65 dBA when measured 3 metres from the external wall. Noise levels within plant rooms and buildings shall not exceed 80 dBA. The Contractor shall take all necessary measures to meet these limits, including where necessary the provision of acoustic panels or enclosures.

Control room noise levels shall not exceed 55dBA

Hazardous warning notices indicating that ear defenders are to be worn shall be installed at entrances to enclosures where the sound pressure level exceeds 80dB(A). The Contractor shall provide 3 sets of ear defenders at any such location.

#### **6.17.2 Anti-Vibration Mountings and Sound Absorption**

The Contractor shall provide and fix all material for the prevention of transmission of noise and vibration through the structure.

Where appropriate all fans, A/C package units' compressors, and other motive plant shall be mounted on resilient mountings in such a manner that the plant foundations are isolated from the floor or structure. In addition, all rotating plant shall be statically and dynamically balanced.

Mechanical vibration shall be eliminated using anti-vibration mountings and flexible connections to ensure an isolation efficiency of 95 % from the building structure.



Machinery vibration shall not exceed the limits defined in the relevant section of BS ISO 10816.

#### 6.17.3 Seismic Forces

The equipment shall be designed to withstand safely an earthquake force of not less than 0.12 g acting in any direction.

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### 6.18 Protection and Care of Electrical Equipment, Conduits, Ductwork and Pipework etc.

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Before despatch from the works, equipment shall be thoroughly cleaned and packed to provide protection against damage, deterioration, corrosion, and ingress of dirt and be suitable for prolonged storage in a humid atmosphere.

All equipment shall be stored in a waterproof housing and be examined and cleaned before installation. All open pipe ends, and duct ends whether installed or in store, shall be fitted with plastic caps or suitable protective covering.

Every precaution must be taken by the Contractor to prevent damage or the entry of foreign matter into the plant by other trades.

No claim can be met for damage to plant, pipework ductwork or any item of electrical equipment due to the Contractor neglecting these precautions, and all damaged items shall be replaced with new items by the Contractor without any additional payment.

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### 6.19 Dust, Insect and Vermin Proofing

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All equipment which is affected by ingress of dust shall be effectively dust proofed.

All equipment shall be vermin proofed where no protection is afforded in its normal manufactured form, to ensure that no mechanical breakdown shall occur due to interference or damage by vermin. All materials used in construction or for connections shall be resistant to attack by insects, micro-biological life or other local fauna and such materials shall be to the approval of the Engineer.

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### 6.20 Welding

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Welded parts consisting of steel to BS EN 10025: 2004 sections 1-6 or similar, shall comply with requirements not less than BS EN ISO 15607: 2003 and BS EN ISO 15609 or equivalent standard.

All pipes shall be circumferential butt welded and shall be undertaken in accordance with EN 288-9: 1999 or equivalent where applicable.

Prior to any work commencing the Contractor shall submit the Welding Procedure Specification that requires approval by the implementation of the Welding Procedure Test according to EN 288-9: 1999.

The Contractor shall also apply the requirements of EN 287-1: 1992 Approval Testing of welders for fusion welding, including all requirements for the safe use of fusion welding, taking into consideration the danger to eyesight and skin of UV and infra red rays and the use of electrical appliances.

The dimensions of the pipe shall be in accordance with EN 10217-1:2002 in all respects, and all joints intended for butt welding shall have the plate edges accurately prepared to the appropriate profile for welding. The parts shall then be assembled (internal or external clamps) and accurately inspected to ensure the parameters are acceptable according to the Welding Procedure Specification, compliance is mandatory. The welding procedure specification shall specify the minimum energy



inputs to produce satisfactory welds and the energy input shall be such that residual stresses are a minimum and distortion avoided.

Pipe supports and other fittings shall be fabricated, and welding shall be fully completed before final machining or coating is carried out.

Electrodes and /or flux gases used shall be in all cases of the low hydrogen type and shall comply with requirements not less than BS EN ISO 14175: 2008 and EN 760: 1996 and / or equivalent standard. When fusion welding stainless steel the type of electrode shall be equivalent or of a better grade than the parent material. Stainless steel shall be welded using TIG or MIG methods with an Argon back purge. Stainless steel to be welded shall be suitably stabilised and post welding shall be passivated.

The welded stainless-steel surfaces and heat affected zones shall be cleaned from any remaining dirt and then pickled and passivated internally and externally using a proprietary system. Wire brushing is not permitted

All welders to be employed on fusion welding of permanent works shall undertake the tests required by the Welding Procedure Specification.

All qualified welders shall always be in possession of their welder certification card.

The Contractors Pipeline Welding Engineer shall be in possession of up to date detailed records for all types of welding undertaken and these shall show the name of each welder against each run in a weld.

Any welder found to be producing unacceptable welds that are not within the Non-Destructive Testing (NDT) acceptance criteria shall not continue welding until they have been retrained and re-qualified. Those welders that fail the retraining and retesting shall be permanently removed from site/factory.

Where valve bodies, sleeves, etc., are of welded construction all longitudinal butt welds in the shell plates shall be 100% Non-Destructively Tested with the use of radiographic means of the appropriate standard and quality.

For pipelines, the criteria for NDT for site or factory-made circumferential butt welds shall be specified prior to any welding work commencing and as a minimum have at least 10 percent of the weld tested by the use of ultrasonic methods undertaken by an operator who has the correct qualifications and experience to undertake the work satisfactorily.

Junctions found between the circumferential weld and a longitudinal joint commonly called a "T point" shall be avoided wherever possible by orientation of the pipe, however if "T" point occurs then these shall be 100% radiographically examined.

Ultrasonic testing shall be carried out in accordance with BS EN 1714: 1998 and the Contractor shall use Section 5 criteria as a minimum requirement for a standard of acceptance. Site welding shall not proceed more than three days in advance of testing and acceptance, with the contractor submitting their repair procedure at the same time as the WPS and WPQR.

All fillet welds shall be tested using ultrasonic means according to BS EN 1714: 1998, using the appropriate acceptance criteria. For small fillet welds magnetic particle testing to ascertain surface cracking may be proposed, subject to the approval of the Engineer. The acceptance criteria and method require approval before commencement of any work.

For all other items of equipment, the Contractor shall allow for the cost of adequate radiograph examination of the welds at the manufacturers works according to BS EN 1435:1997. Where appropriate the criteria for examination and acceptance of defects shall be proposed and accepted before the commencement of any welding including WPQR tests. The locations to be examined will be taken from the appropriate standard and shall be indicated by the Engineer.

The interpretation of radiographs and the criteria used for acceptance-rejection of welds shall be according to BS EN ISO 6520 as a basis for defining the nature and extent of weld defects. The minimum acceptance grade for weld defects shall be according to BS EN 288-9:1999 Table 2 "Limit for Imperfections".

Before fabrication starts, the Contractor shall give the Engineer his detailed drawings of welding preparations of all parts to be welded and subjected to stress.



No welding shall start before the criteria of acceptance and method for welding have been approved according to the appropriate standards.

When the ambient temperature at the welding site is below +5°C, no welding shall be carried out.

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## 6.21 Castings

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All cast iron shall be of standard grey close-grained quality to BS EN 1561:1997: Grade GJL-200. Ductile (Spheroidal Graphite) Iron shall be to BS EN 1563: 1997 Grade GJS 400 or better. The structure of the castings shall be homogenous and free from non-metallic inclusions and other injurious defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Except for spheroidal cast iron, minor defects not exceeding 12.5 % of total metal thickness and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Engineer shall be notified of larger defects and no repair welding of such defects shall be carried out without prior approval.

If the removal of metal for repair will reduce the stress resisting cross-section of the casting by more than 25 %, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 %, then that casting may be rejected.

If it is required by the Engineer, one or more samples of manufactured parts shall be taken for testing. No payment shall be made by the Employer for these samples. All expenses for tests shall be the Contractor's responsibility.

Castings repaired by welding for major defects shall be stress relieved after such welding.

Non-destructive tests will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine that repair welds have been properly made and all expenses shall be borne by the Contractor.

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## 6.22 Forgings

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All major stress-bearing forgings shall be made to a standard specification which shall be submitted to the Engineer for approval before work is commenced. They shall be subject to internal examination and non-destructive tests for the detection of flaws and shall be heat treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for each such forging shall be submitted to the Engineer. The Engineer may arrange for such forgings to be inspected at the place of manufacture with a representative of the Contractor.

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## 6.23 Fixings

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Nuts, screws, washers, and bolts shall comply with the relevant provisions of the appropriate Standard, as set out below:

| Type                                                       | Standard            |
|------------------------------------------------------------|---------------------|
| Metal washers for general purposes                         | BS 4320: 1968       |
| High strength friction grip bolts, nuts, and washers       | BS 4190: 2007       |
| Stainless steel (Grade X5CrNiMo 17-12-2 also Grade 1.4401) | BS EN 10088-2: 2005 |



Bolting for pipes and fittings shall comply with the relevant provisions of BS EN 1515 and BS EN 1092-2:1997, except that spheroidal graphite iron bolts for use with ductile iron pipes and fittings shall be manufactured from metal complying with the provisions of BS EN 1563: 1997 for Grade 500/7.

Bolt length and tightening torque shall be in accordance with manufacturer's recommendations and shall be sufficient to ensure that nuts are full threaded when tightened in their final position with two threads showing.

Where bolting is metallurgically incompatible with the material being fixed, suitable isolating washers and sleeves shall be used.

Washers shall be provided under the head of the bolt and under the nut.

Unless manufactured of stainless steel, all fasteners shall be protected against corrosion in accordance with WIS 4-52-03.

Sherardised finishes are not acceptable for external applications.

Nuts, bolts, and washers which are submerged in liquid or within the 300mm splash zone shall be Grade X5CrNiMo17-12-2 stainless steel (A4 – 316S31)

Where stainless steel nuts, bolts and washers are to be used adjacent to galvanised metallic surfaces, the contact areas are to be isolated either by painting with an approved silicon sealant, and allowed to dry before tightening together, or with suitable isolating washers and sleeves.

Grades of bolts for varying environmental conditions shall comply with following table:

| Description                                                                                                                                                               | Environment |                                                                                                                                                                                                       | Bolt Type(s)                                                                                                                                |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                           | Class       | Examples                                                                                                                                                                                              |                                                                                                                                             |
| Interior:<br>Heated buildings, normally dry, non-corrosive atmosphere.                                                                                                    | C1          | Offices<br>Administrative buildings<br>Control Rooms                                                                                                                                                  | Sherardized to minimum average local coating thickness = 15µm or Zinc plated to minimum average local coating thickness = 8µm.<br>Grade 4.6 |
| Interior:<br>Unheated buildings, occasional condensation.<br>Exterior:<br>Exposed to atmospheric conditions, rural non-polluted inland sites greater than 5km from coast. | C2          | MCC buildings<br>Package plants<br>Support structures for machinery<br>Stanchion holding-down bolts, Access platforms<br>Walkways and handrails<br>Staircases<br>Lifting gantries<br>Flanged Pipework | Hot dipped galvanized mild steel. Minimum average local coating thickness = 43µm.<br>Grade 8.8                                              |
| Interior:<br>High humidity, substantial condensation.<br>Exterior:<br>Light industrial and urban inland or mild coastal.                                                  | C3          | As above including Treatment processes within buildings                                                                                                                                               | Hot dipped galvanized mild steel. Minimum average local coating thickness = 43µm.<br>Grade 8.8                                              |
| Exterior:<br>Polluted inland sites. Sites, either polluted or nonpolluted, within 5km of the coast.                                                                       | C3A         | As above                                                                                                                                                                                              | Grade X5CrNiMo17-12-2 (316S31) stainless steel (A4) e.g. 1.4401; 1.4571 or AISI 316<br>Grade 8.8                                            |



| Environment                                                                                                      |       |                                                                                                                       | Bolt Type(s)                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------|-------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Description                                                                                                      | Class | Examples                                                                                                              |                                                                                                                                             |
| Interior/Exterior:<br>Submerged/immersed in, or<br>spray from sewage or<br>sludge. Potable water<br>applications | C4    | Interior surfaces of<br>tanks Submersible<br>support frames<br>Scraper<br>mechanisms<br>Access ladders &<br>supports. | Grade X5CrNiMo17-<br>12-2 (316S31) stainless<br>steel (A4) e.g. 1.4401;<br>1.4571 or AISI 316<br>Grade 8.8                                  |
| Buried in soil                                                                                                   | C4A   | Bolted precast<br>segmental shaft<br>units                                                                            | Grade X5CrNiMo17-<br>12-2 (316S31) stainless<br>steel (A4) e.g. 1.4401;<br>1.4571 or AISI 316<br>Grade 8.8                                  |
| Buried in soil (non-<br>aggressive).<br><br>Buried in soil (aggressive).                                         | C4B   | Flanged pipework<br><br>Flanged pipework<br>(to be avoided<br>where possible)                                         | Black bolts Grade 4.6<br>to BS 4190: 2007<br>coated to WIS 4-52-03<br>Black bolts Grade 4.6<br>to BS 4190: 2007<br>(Denso-tape<br>wrapped). |
| Exterior:<br>Marine Environment with<br>high salinity.                                                           | C5    | Sea outfall<br>structures                                                                                             | Grade<br>X1NiCrMoCuN25-20-7<br>(316) stainless steel<br>e.g. 1.4529; AISI<br>904hMo (Chloride<br>resistant) Grade 8.8.                      |

Note: The Environmental Classification is adapted from Table 1 of BS EN ISO 14713: 2010 & BS EN ISO 12944- 5: 2007.

\*\* To be avoided where possible by raising on a support plinth.

AISI = American Iron & Steel Institute

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at Site.

Washers, locking devices and anti-vibration arrangements shall be provided where necessary and shall be subject to the approval of the Contract Administrator.

Where bolts pass through structural members taper washers shall be fitted where necessary to ensure that no bending stress is caused in the bolt.

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 the yield stress of the material under all conditions.

Screw threads for this plant shall comply with BS 3643 - Metric Screw Threads.

The Contractor shall provide all necessary foundation stud bolts for securing the items of plant. Foundation bolts shall be manufactured from corrosion resistant materials and be fitted with suitable washers.

## 6.24 Fixing of Machinery

Except in special cases, e.g. where Plant is mounted on anti-vibration mounts or where special arrangements need to be made to ensure water tightness, items of Plant shall be securely fixed and aligned on a common baseplate or frame. This baseplate or frame shall be levelled, aligned, and secured before grouting in using a non-shrinking grout. All shims shall be metallic.



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## 6.25 Guarding

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Machinery shall be effectively guarded to prevent injury to persons, comply with RD 5304, BS EN ISO 12100: 2003 and meet current European safety regulations.

Guarding shall be provided to prevent access to live electrical apparatus or moving parts of machinery.

Adequate guards shall be supplied and installed throughout the installation to cover drive mechanisms. All rotating and reciprocating parts, drive belts, etc. shall be securely shrouded to the satisfaction of the Engineer to ensure the complete safety for both maintenance and operating personnel. However, whilst all such guards shall be of adequate and substantial construction, they shall also be readily removable for gaining access to the plant without the need for first removing or displacing any major item of plant. Large guards shall be equipped with small removable panels for the inspection and checking of enclosed components.

Guards to parts of machinery which require regular inspection or maintenance shall be constructed of galvanised steel mesh or other corrosion resistant material which enables the parts to be examined and shall be attached in such a way as to permit easy removal and replacement. Guards shall be attached by means of set bolts or studs in tapped holes. Self tapping screws shall not be used.

Where hinged access covers or doors are provided in covers or guards, they shall be interlocked with the electricity supply to prevent the operation of the machinery except when covers are in position and fixed.

Warning notices labelled 'Danger - This plant may start automatically', shall be fitted to Plant where appropriate.

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## 6.26 Bearings

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### 6.26.1 General

The Contractor shall select the most appropriate type of bearing for the plant being supplied.

Equipment with vertical shafts shall have thrust and guide bearings. All bearings shall be designed to exclude the ingress of water except where the bearings are water lubricated.

Sealed for life units are acceptable subject to a minimum design life of 100 000 hours operation at maximum loading. Plant which may be subject to vibration whilst stationery shall be provided with bearings designed to withstand damage from such a cause.

Bearings below water shall be of the journal type, of ferro-bestos gunmetal or equal sleeve and stainless steel journals.

Guide bearings above water level shall have phosphor bronze or synthetic lubrication impregnated bushes and carbon or stainless-steel journals respectively. Synthetic bearings shall only be used when bearing condition can readily be inspected.

Plain type bearings shall be self-lubricating by either grease, forced oil or impregnation.

### 6.26.2 Ball and Roller Bearings

Ball and roller bearings shall be rated for a minimum plant life of 10 years, with due consideration being given to the number of starts and periods of operating under conditions of maximum dynamic axial and radial loading. The size of bearing shall be not less than that calculated for a minimum L10 basic rating life in accordance with BS ISO 281: 2007 considering all considerations of reliability, materials of manufacture and operating conditions.



All bearings shall be generously rated and sized to ensure satisfactory and stable running without vibration under all conditions of operation for a minimum life of 100,000 hours running. They shall be efficiently lubricated and adequately protected from ingress of moisture, dust and sand and the climatic conditions prevalent at the site. All bearing shall be to ISO standard SI unit dimensions where practicable.

All ball or roller bearings, including those supplied as "sealed for life" shall be arranged for grease gun lubrication and a suitable high-pressure grease gun shall be supplied. Grease relief valves shall be provided on all bearing housings to prevent over greasing.

Adequate "Stauffer" screw top pressure grease lubricators or "Tat" grease nipples shall be provided for all moving parts. The position of all greasing and oiling points shall be arranged to be readily accessible for routine servicing. Where necessary to achieve this suitable access platforms shall be provided.

The type of lubricant and intervals of lubrication, which shall be kept to a minimum (not less than nine days), for each individual item of plant shall be entered on a working schedule, which shall form part of the Operation and Maintenance instructions.

A list of recommended lubricants and their equivalents shall be entered in the Operation and Maintenance instructions.

#### 6.26.3 Flexible Shaft Couplings

Flexible shaft couplings where supplied, shall be generously rated to cover the full range of duty.

Couplings liable to impregnation by oil shall be of all metal flexible type.

General service couplings shall be of the flexible multi-pin and bush type, having not less than six bushes and each bush shall have an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with the pin). All pins shall have shoulders to allow positive location and securing to the bosses.

Busses shall be a tight fit on the shafts and secured with hand fitted keys.

Couplings shall be supplied in matching balanced sets and shall be machined, balanced, and marked before leaving manufacturers works.

All couplings shall be fully checked for alignment and all necessary equipment for checking alignment shall be supplied by the Contractor.

Particular attention shall be paid to achieving accurate alignment of solidly bolted couplings and the Contractor's proposed alignment procedure shall be to the approval of the Engineer. In particular, alignment procedures which involve rotating only one-half coupling will not be accepted. The coupling alignment procedure shall include a final check in the "bolted-up" condition for "cranking".

Where flexible couplings are used, the Contractor shall fully describe the arrangements proposed for ensuring that the desired freedom of relative movement between the shafts is obtained, when transmitting a torque corresponding to the continuous maximum rating.

Final alignment shall be checked by the Contractor in the presence of the Engineer.

#### 6.26.4 Gearboxes

Gearboxes shall have a life of 100 000 hours, be selected in accordance with AGMA recommendations for horsepower calculation and service factor application and employ a standard reduction ratio.

Gearboxes which must be angle mounted, shall have a rating; choice of bearings, seals and lubrication system which is suitable for such mounting.

Dependence on splash lubrication alone is not acceptable but it may be used in conjunction with a forced feed method to reach all bearings and gears.

Calibration of the oil dipstick and its position together with that of the sump drain plug will require special consideration.



#### 6.26.5 Allowance for Wastage

The Contractor shall supply as specified and to the satisfaction of the Engineer reasonable excess quantities to cover wastage of those materials which will normally be subject to waste during erection, commissioning and setting to work.

#### 6.26.6 Lubrication

A complete schedule of recommended oils and other lubricants shall be furnished by the Contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Engineer for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearings for electric motors a lithium base grease is preferred.

Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once weekly and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility, grease nipples shall be placed at the end of the extension piping and, when a number of such points can be grouped conveniently, the nipples shall be brought to a battery plate mounted in a convenient position. Button head type nipples shall be used for normal grease and all grease nipples shall be of the same size and type for every part of the Plant. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labelled.

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum, and minimum levels at 30°C shall be clearly visible in the sight glass as viewed from the normal floor level.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or any other potential source of fire.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the plant for two years after the Final Acceptance Certificate has been issued.

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### 6.27 Documentation

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#### 6.27.1 Drawings

All drawings shall conform to BS ISO 14617: 2004 with dimensions in metric units. Each drawing shall contain a title block defining uniquely the project, site, process, and plant shown. Where Plant continues a number of drawings, continuation references, which shall consist of the drawing number and any component reference number, shall be included at all points where the continuation occurs.

Symbols used in wiring diagrams and schematics shall comply with BS ISO 14617: 2004. All electrical drawings shall include a key legend of symbols and references used. Schematic diagrams for individual motor starter cubicles shall be contained on one drawing.

Copies of all related design calculations shall be provided with the drawings.

#### 6.27.2 Operation and Maintenance Manuals

The Contractor shall provide the Engineer with six copies of the approved instructions for operation, maintenance, and overhaul of the Plant, including drawings of the internal details referenced to enable



any spare parts to be readily ordered. All instructions shall be bound together in durable, hard backed, plastic covered binders or folders.

The instructions shall comply with BS 4884 and be produced by a specialist sub-contractor, approved by the Engineer, with experience in producing documents in accordance with BS 4884. Details of the sub-contractor shall be provided with the tender.

The instructions shall be written in English. Plant not supplied under the Contract shall not be referred to in the instructions.

The instructions shall include the following as a minimum:

- (a) Recommendation for consumable supplies e.g. packing, lubricants for the Plant
- (b) Brief outline of the operation of the Plant including the sequence of events required for the operation of each item of Plant. The information shall be in sufficient detail to allow uninstructed personnel to be instructed in the operation of the Works
- (c) Instructions on how to stop and start the Plant, noting any safety and operating sequence requirements
- (d) Details of required preventive maintenance with recommended frequencies of action including the testing, adjustment, and calibration of Plant following maintenance and during normal operation
- (e) Details of each item of Plant including the name and address of the manufacturer and the local agent, type and model, serial number, duty and rating, clearances, and tolerances where applicable
- (f) Detailed assembly drawings and instructions for undertaking dismantling, component replacement and reassembly
- (g) Fault finding charts and procedures.
- (h) Spare parts lists containing all necessary information for ordering parts
- (i) Lists of packing seals and gasket materials
- (j) List of special tools required for maintenance.

A maintenance record system shall be provided comprising a three-card set for each piece of Plant requiring maintenance. A filing cabinet for card storage shall be provided.

The three card sets shall be Plant data, master maintenance and preventive maintenance sections.

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## 6.28 Training

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During the commissioning period, the Contractor shall, using the approved instructions for operation, maintenance, and overhaul, train the Employer's Staff in the safe, efficient operation of the Works. The Works shall not be deemed to have been taken over without satisfactory training being completed.

Instruction of the operations staff shall be divided into four categories: operators, electrical/control staff, mechanical staff, and operations management staff. The syllabus of the instruction for each category of staff shall be suited to their needs and agreed in advance with the Engineer.

The programme of instruction shall be agreed with the Engineer at least two weeks before the commencement of the instruction.

Training shall be carried out by suitably qualified personnel approved in advance by the Engineer. The Contractors training instructors shall provide the following periods of training: -

- (a) Training of operators
- (b) Training of electrical/control staff
- (c) Training of mechanical staff
- (d) Training of operations management staff

Instruction of the different categories of staff may proceed concurrently, providing that separate instruction is provided for each category.



Allowance shall be made for varying instruction times from day to day to consider shift working by the operations staff.

The purpose of the instruction will be to familiarise the operations staff with all aspects of the Works and provide detailed instruction of the operation and maintenance of the particular mechanical and electrical works supplied under the contract, as relevant to the category of personnel. The operations staff can be assumed to be experienced in their respective trades in general, but not necessarily on any Plant provided under the Contract.

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## **6.29 Pipework**

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### **6.29.1 General Requirements**

The Contractor shall include for the supply, delivery and erection of all pipework and fittings within the buildings, sumps and valve chambers and between all sections of the plant as defined and detailed in this Specification and where indicated in the Employer's Requirements, to form a complete and fully functional installation.

In arranging pipework systems, provision must be made for the convenient removal of Plant from the pipework using flange adapters, unions or conveniently placed bends. Flange adapters shall not be used simply to accommodate misalignment in the fixing or building-in of pipework systems. Flange adapters shall be anchored or tied to withstand maximum possible system pressure.

Where there is a possibility of damage due to freezing, pipework and valves shall be protected using suitable weatherproof lagging. This lagging shall be in the form of easily removable jackets which are bolted in position.

Where pipework systems are installed in exposed areas and will remain full of water for extended periods, trace heating shall be installed in accordance with IEC 62395, under the weatherproof lagging detailed above.

Where more than one item of Plant is served by a common pipework system, the pipework shall be arranged so that when a single item of Plant has been removed the remaining items can be operated safely without the need to provide any special fixings and supports for the pipework system.

Pipework shall be adequately supported and fastened so that strain is not placed on any pump casing or other associated Plant due to the weight of fixing of the pipework.

Rodding and flushing points shall be provided on pipelines containing sludge or slurry to enable the complete line to be cleaned.

The Contractor shall ensure that the design, fabrication, and installation of the pipework shall allow for the misalignment of fixed terminal points by 25mm in any direction.

Adequate provision shall be included to cater for settlement of rigid structures/pipework systems.

Joint pipes, puddle pipes, tees, elbows, flanges, reducers, crosses, etc to be used in the plant of different diameters, classes and structures shall be supplied, manufactured, and erected in accordance with the erection plans, technical specifications and directives of the Engineer.

Puddle pipes to be used in water retaining structures shall be placed in the formwork of the walls and cast in with the first stage concrete. Puddle pipes placed in box-outs and cast in with second stage concrete shall not be allowed.

The collar size of puddle pipes, where they pass through water retaining structures or chamber walls shall be the same diameter as the pipe flange and the collars shall be continuously welded to the pipes on both sides of the collar.

Pipes, puddle pipes, elbows, big tee pieces, etc. used in the Works at different diameters, pressures and structures shall be coated with epoxy against corrosion, and buried parts and parts in channels shall be



painted with epoxy in accordance with Paint System P3. Internal linings of pipes shall be as specified in accordance with Paint System P2. Coating damage due to welding or during delivery or handling shall be made good, both inside and outside, by using the same coating materials to the satisfaction of the Engineer. Coating repairs shall follow the procedure as per this Specification.

All pipework, valves and fittings shall be rated more than the maximum pressure they will attain in service including any surge pressure.

The pipework installation shall be arranged to offer ease of dismantling and removal of pumps or other major items of equipment. Flange adapters shall be supplied and fitted in pipework runs, wherever necessary, to permit the easy removal of valves and other equipment without the need to disturb any adjacent valves or equipment which are fixed in place. A flange adapter shall be included in the suction and delivery pipework of all pumps and adjacent to every valve for easy dismantling unless alternative provisions (such as an adjacent flanged bend) are available. Provision shall be made for a flexible joint arrangement adjacent to all structures.

The ends of pipes for use with flange adapters and couplings shall be faced, squared, and sized to the tolerances required by the manufacturer of the coupling.

All loose flanges shall be secured to fixed flanges by suitable tie-bolts.

All pipework shall be adequately supported with purpose made fixings. When passing through walls, pipework shall incorporate a puddle flange or other suitable sealing device.

The final outlet connection of the pipework shall match the connecting point of any external rising main.

Flanged joints shall be made with 3 mm thick full face, fabric reinforced rubber gaskets, pierced to take the bolts, and the face of all flanges shall be machined to give a true angle of 90° to the centre line of the pipe or fittings.

The whole of the jointing work and materials necessary to fix and connect the pipes, including adequate and efficient pipe supports, shall be included in the Contract.

The hydraulic test pressure applied at the manufacturer's works shall be 2.0 times the design working head, or 1.5 times the maximum working head or pipe rated pressure, whichever is the greater.

All pipework shall be adequately sized to limit the velocity to acceptable levels. Pump suction and delivery pipe velocities shall not exceed 2.0 m/s and 3.0 m/s, respectively.

The Contractor shall be responsible for ensuring that the internal surface of all pipework is thoroughly clean before and during erection and before commissioning.

Cleaning shall include removal of all dirt, rust, scale, and welding slag due to site welding. Before despatch from the Contractor's works the ends of the pipes, branch pipes, etc. shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be removed until immediately prior to connecting adjacent pipes or valves.

After completion of any fabrication, all pipes will be hydraulically tested.

If any alterations involving additional fabrication are made after despatch, a further hydraulic test will be required on the pipe or piping assembly concerned.

The Contractor shall have the full responsibility for supplying all types of testing equipment for the tests and for supplying the water for hydraulic and pressure testing the pipelines.

All small-bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment.

The Contractor shall note the necessity for providing flexibility in the pipework at joints in the main structures to allow for differential settlement and thermal stresses which shall not be transferred to the anchor blocks. Flexible joints, collars and cut pipes shall be allowed on all pipework where necessary to allow for some margin of error in the building work. The pipework system shall be so designed to ensure that anchorages at blank ends, bends, tees, and valves may be kept to a minimum. The



Contractor shall indicate on his detailed drawings any thrust blocks that are required to anchor pipework supplied by him.

During installation, all pipes shall be hung on their respective supports and lined up so that their joint faces are parallel before flanges are bolted together. In making joints, no springing of pipes into position shall be allowed.

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joints or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipework to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipework through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Identification markings consisting of single or multiple coloured rings painted around the pipe or proprietary self-adhesive coloured pipe marking tapes shall conform with the recommendations of BS 1710: 1984 where appropriate. Wherever possible, racks or trays shall be fixed to duct walls or walls of tanks and buildings and the pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes, and racks or trays proposed, shall be supplied at the time of tendering.

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipework and its associated equipment in an approved manner. Valves, meters, strainers, and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

After the collars and boxes or other fittings have been fixed in position, the floors, walls, and roof structure will be made good.

#### 6.29.2 Ductile Iron Pipe

Ductile iron pipes, fittings and joints shall comply with BS EN 545: 2010 for potable water pipelines, BS EN 598: 2007 for sewerage applications and BS EN 969: 2009 for gases.

Cast iron pipes, fittings and joints for rainwater and soil drainage shall comply with BS EN 1092 and BS EN 877: 1999.

Flanges for pipes and pipeline fittings shall, unless otherwise required by the Contract, comply with BS EN 1092-1: 2007 and BS EN 1515-1: 2000 for steel, and BS EN 1092-2: 1997 for ductile and cast iron.

Factory-applied coatings shall be in accordance with BS ISO 8179-1: 2004. Where external zinc spray and a bituminous finishing layer are applied, this shall be in accordance with BS EN 545: 2010.

Factory-applied and Site-applied (tubular) polyethylene sleeving shall be in accordance with BS 6076: 1996.

Cement mortar linings for potable water pipelines shall comply with the requirements of BS EN 545: 2010. Where a seal coat is required, it shall comply with the requirements of BS ISO 16132: 2004 and the complete system shall be approved under the Water Supply (Water Quality) Regulations 2000. In addition, the Instructions for Use issued by the Drinking Water Inspectorate as part of the approval shall be followed.

Tubular polyethylene film for use as a loose protective sleeving for buried iron pipes and fittings shall comply with the relevant provisions of BS 6076: 1996, except that the nominal lay flat width shall be 280 mm for use with 80 mm and 100 mm nominal internal diameter pipelines incorporating push-in flexible joints, and 400 mm for 150 mm nominal internal diameter pipelines. Sleeving for pipes for below ground



use for potable water shall be coloured blue and all other sleeving black. Joints in sleeving shall be taped to form a continuous barrier and any damage to the sleeving shall be repaired prior to backfilling.

Bituminous coatings shall comply with BS 3416: 2008.

Ductile iron pipes, in the size range DN80 to DN800, for potable water laid in normal or aggressive soils (natural soils with a resistivity above 1500 ohm.cm with water table) shall be externally coated with an 85/15% w/w zinc-aluminium alloy applied at a minimum 400g/m<sup>2</sup>, and with a final coat of epoxy applied at a mean thickness of 100 microns. Other coatings shall require the pipes and fittings to be polyethylene sleeved, factory applied.

For highly aggressive soils (resistivity <1500 ohm.cm) further protection measures will be necessary as described in the Contract.

All ductile iron pipes for potable water shall be lined with cement mortar, and those in the size range DN80 to DN800 shall have a factory-applied seal coat to the cement mortar lining.

Ductile iron pipes for sewerage, laid in normal soils (natural soils with a resistivity above 2500 ohm.cm with water table), shall be externally coated with a zinc coating applied at a minimum 200g/m<sup>2</sup>, and with a final coat of epoxy applied at a mean thickness of 150 microns. Other coatings shall require the pipes and fittings to be polyethylene sleeved, factory applied.

For aggressive soils (natural soils with a resistivity below 2500 and above 1500 ohm.cm with water table) shall require the pipes and fittings to be polyethylene sleeved, factory applied. For highly aggressive soils (resistivity <1500 ohm.cm) further protection measures will be necessary as described in the Contract.

All ductile iron pipes for sewerage shall be lined with high alumina cement mortar.

Fittings shall be internally and externally coated with epoxy to 200 microns average thickness and 100 microns absolute minimum thickness, applied internally holiday free, Class A, and externally at < 20 holidays/m<sup>2</sup>, Class B.

All flanges shall be PN16 unless otherwise stated in the contract.

All gaskets shall comply with BS EN 681-1: 1996, WA for potable water, or WC/WG for sewerage.

All ductile iron pipes and fittings shall be clearly marked in accordance with BS EN 545: 2010 or 598: 2007, as appropriate.

All pipes, fittings, accessories, and joints shall be fully performance tested in accordance with BS EN 545: 2010 or 598: 2007, as appropriate.

All pipes and fittings shall have BSI Kitemark accreditation.

#### 6.29.3 Steel Pipework and Specials

Steel pipework used for fluids containing sand or micro sand shall be lined with a rubber compound proven to give 20 years service life with the media in question.

General purpose steel pipework with screwed fittings shall be of galvanised mild steel to BS EN 10255: 2004 heavy grade with fittings of galvanised malleable iron to BS 143 & 1256:2007, having tapered internal and external threads to BS EN 10226-1:2004.

Steel pipe and fittings over 80 mm diameter, shall be carbon steel in accordance with BS 534:1990, BS EN 10216-1:2002 with pipe sizes to BS EN 10220:2002. Joints shall be flanged. Pipes shall be fabricated in accordance with BS EN 10224:2002 with welding in accordance with BS 2633: 1987 or BS 2971: 1991 and BS 4515.

After fabrication and machining of flanges all pipework and fittings shall be tested to a test pressure equal to 1½ times the maximum working pressure (pump closed valve head).

Where pipes are to be joined with sleeves or couplings, a sufficient length of pipe shall be left bare of coating to accommodate the sleeve or coupling.



Plain ended pipes shall be supplied rounded at both ends. An adequate number of pipes shall be supplied rounded throughout their length so that they may be cut, and such pipes shall be clearly marked.

Couplings for use with steel pipes shall comply with BS 534: 1990 except where other types of couplings are specified in other sections of this Specification.

Components of flexible joints from different manufacturers shall not be used together.

Tests on pipes shall be made in accordance with the relevant British Standard in the manufacturer's works when required by the Contract Administrator and in the presence of the Contract Administrator. Two copies of the results of all such tests shall be submitted to the Contract Administrator.

Flanges on steel pipes shall be welded in accordance with BS 2633:1987 or BS 2971:1991 and shall have raised or flat faces.

Flanges shall be in accordance with BS EN 1092-1: 2007 PN16 unless otherwise stated in the contract.

Gaskets for use in flanged joints shall consist of rubber complying with BS 7874:1998 & BS EN 682:2002 for type 1 rings or rubber reinforced with fabric and complying with BS 5292:1980 or as instructed by the Contract Administrator. On flat face flanges the gaskets shall extend over the full flange area and on raised face flanges they shall cover the raised face only. No asbestos shall be used on any flange of pipework or fitting carrying potable water.

Steel pipes which are to be welded shall have the ends prepared by the manufacturer to suit the type of welded joint. The pipes shall be free of external and internal coating for 75 mm from each weld line.

After fabrication all welding scale and beads as well as hardened fluxes shall be removed, and joints shall be free of pores and as smooth as possible. Where specified all pipes and specials shall then be degreased and grit blasted prior to coating.

The coating shall be tested to ensure the correct thickness and the absence of pores using spark testing equipment.

Bends, branches, and other fittings for use with steel pipe shall comply with the British Standard or other approved standard. Calculations for the design of all special fittings shall be submitted to the Contract Administrator before manufacture commences.

Pipes shall be stacked on a firm base using two timber packers only under the barrel of pipes.

Fittings and specials of any type shall be stored in a single layer only. Pipes and fittings shall always be adequately protected from damage during transport, storage and handling.

Pipes shall be fitted in the factory with end caps and reinforcement adequate to prevent distortion during transport, storage, and handling. Rubber rings and other pipe jointing material shall be stored under cover away from direct sunshine.

Welding of steel pipelines shall be as follows:

(i) General

Welding of circumferential joints in the pipeline shall comply with the requirements of this Specification and as additionally specified here.

Line-up clamps shall be designed to prevent tears, scars, or indentations of the pipe walls and keep misalignment of pipes at a minimum.

All welding shall be carried out in accordance with specific procedures prepared by the Contractor and approved by the Engineer.

Adequate precautions shall be taken to protect welding operations from wind, rain, blowing sand, etc.



(ii) Welder Qualifications:

All welders employed on the Works shall be fully qualified and shall have successfully passed all tests required by relevant codes for type of work each individual welder does.

Welder qualification tests shall be carried out in the presence of the Engineer or his authorised representative in accordance with this Specification.

The Contractor shall provide necessary labour, pipe welding materials, and equipment for performing welder qualification tests on site.

The Contractor shall maintain a list of approved welders agreed upon with Engineer and no other employees shall perform welding operations on the permanent Works.

(iii) Procedure:

Swab pipe ends with a leather or canvas belt disc to remove dirt, loose mill scale, rust, oil, grease, and other matter which may be injurious to the weld.

Cleaning of pipe ends shall be done by power wire brushing and/or grinding. Pipe ends damaged such that they no longer meet joint specifications shall be re-bevelled by a suitable machine.

Align pipe ends with line-up clamps such that the longitudinal weld seams of the adjacent pipe are staggered at least 20 degrees.

Stringer bead on pipeline shall be applied by at least two welders welding in opposite quadrants.

The number of filler and finish beads shall be in accordance with approved and qualified procedures.

Completed weld shall have a substantially uniform cross-section around the entire circumference of the pipe. At no point shall the crown surface be below the outside surface of the pipe nor be raised above the parent metal by more than 1.5 mm.

No welding shall be done when the shade temperature is below 5°C and falling unless approved by the Engineer who may require preheating of the pipe.

All joints on which welding has started shall be completed before the end of each day's work. At night or when work is not in progress, pipe ends of the pipeline shall be securely capped with a suitable cover to prevent the entrance of dirt, small animals, water, and foreign matter into the pipeline.

Tie-ins shall be carefully aligned to limit residual and/or reaction stresses after completion of the weld. Tie-ins shall be made within the temperature range of 10 to 30°C.

(iv) Quality Control:

All production welds shall be subject to visual inspection by the Engineer. Visual inspections may be carried out at any stage of the welding of a joint.

Each weld shall be clearly marked adjacent to the weld indicating the identification of the welder. Steel die stamping will not be permitted.

Non-destructive testing will be carried out during the work as required by the Engineer. Field welds shall be examined ultrasonically or by dye penetrant testing in accordance with procedures mentioned in this Specification. The Contractor shall pay for the testing and he should include these costs and expenses during pricing of the Contract.

The Engineer retains the right to have cut out and removed one weld only from each welder at no cost to the Employer.



Welds rejected by the Engineer shall be cut out and replaced by Contractor. If the cut-out weld is found on test not to meet Specifications, the cost of the cutting out and rejoining shall be borne by the Contractor. If the weld is found satisfactory, the cost shall be borne by the Employer.

Welds rejected by the Engineer may, at his discretion, be repaired subject to the following:

- Repairs to the filler weld which would penetrate the stringer bead will not be permitted
- Arc burns shall not be repaired by welding but shall be removed by grinding provided that no reduction in wall thickness is made in excess of 12.5% of the nominal wall thickness.

The Contractor shall maintain records of all repairs of whatever nature to pipe and pipeline describing and locating such repairs.

The welding together of pipes that have been cut shall be carried out with a single weld if it is practical to pull the pipes into position, otherwise two welds shall be made by setting in a piece of pipe at least 2.0 m in length.

All steel pipework with a nominal diameter of 600 mm diameter or less shall be fully factory fabricated coated and tested and supplied to site with flanged ends or plain ends where flange adaptors are proposed. Site welding of pipework smaller than 600mm will not be accepted due to the difficulty in making good internal coatings after welding is complete.

#### 6.29.4 Stainless Steel Pipework

Stainless steel pipework shall be manufactured from grade 316L stainless steel and shall have a wall thickness no less than schedule 10s.

The pipe shall be indelibly marked at the point of manufacture with the manufacturing standard, material, and wall thickness. Any pipework delivered to site without such identification shall be rejected and replaced with material of the correct standard.

Stainless steel pipework shall be fabricated in a facility dedicated solely to the fabrication of stainless steel so that there is no carbon contamination.

Welding shall be undertaken using the TIG or MIG process with an argon back purge.

Electrodes shall be chosen such that the weld material exhibits strength and corrosion resistant properties at least equal to those of the parent metal.

After welding, all welds and heat affected areas both internal and external shall be pickled and passivated using a proprietary system. The use of wire brushing or other mechanical means to remove weld discolouration is not permitted.

Stainless steel pipework used for water quality sampling shall be cleaned and de-greased in a caustic soda solution at 96 degrees centigrade, rinsed and shrink wrapped prior to delivery to site.

#### 6.29.5 uPVC Pipework

Unplasticized PVC (uPVC) pipes and fittings shall comply with ISO 3127: 1994 and BS EN ISO 1452: 2010.

Joints shall be either made with rubber sealing (O-ring) rings or shall be solvent welded as specified. Solvent cements for joining pipes shall comply with BS EN ISO 1452: 2010. Solvent weld joints are not permitted for buried pipelines.

Ferrules, straps, and other metal fittings shall be gunmetal.

#### 6.29.6 Acrylonitrile-Butadiene-Styrene (ABS) Pipes and Fittings

ABS pressure pipes and fittings shall comply with the relevant provisions of ASTM D 1527 and ASTM D 2235



#### 6.29.7 Polyethylene Pipework (MDPE and HDPE)

Polyethylene (PE) pipework shall be of the medium or high-density type and shall comply with the requirements of BS EN 12201: 2003.

All joints in the PE pipework shall be either flanged using stub flanges with galvanised steel backing rings or fusion welded. Where fusion welded joints are proposed the Contractor shall provide a proprietary PE pipe fusion welding rig capable of preparing the pipe ends, heating the pipe ends prior to bringing them together under pressure and removing the welding bead prior to installation. The fusion welding rig shall be designed for the sizes of pipes to be joined and shall be complete with suitable clamps for each size of pipe to be joined.

The Contractor shall ensure that fusion jointing of PE pipes is only carried out by fully trained and experienced operatives, and evidence of their training and experience shall be provided prior to any pipe jointing being undertaken.

The Contractor shall demonstrate that the fusion welded joint is as strong as the parent pipe.

#### 6.29.8 Small Bore Pipework

Small bore pipework up to 15 mm OD shall be manufactured from stainless steel tubing with suitable compression type fittings. All small-bore pipework and capillary tubes shall be adequately and securely clipped or clamped. Compression fitting bends shall be kept to a minimum as pulled bends of generous radii are preferred.

Any gauges, transducers or switches etc. fed via small bore pipework shall have an individual isolating cock adjacent to each component with adequate space being allowed for component removal for servicing. Small-bore stainless-steel pipework used for water quality sampling shall be cleaned as stated in section 4.24.4.

#### 6.29.9 Pipe Jointing

##### (a) Flexible Joints

Flexible joints in steel pipelines shall be Viking Johnson or similar. Flange adapters shall be used where necessary for ease of installation and to allow for future dismantling. All flange adapters shall be tied to prevent relative movement due to hydraulic thrust heads. For the connections of pipes to concrete structures (inlet and exit), Viking-Johnson type flexible coupling pieces (connecting pieces) shall be used.

##### (b) Flanged Joints

Flanged joints shall be in accordance with BS EN 1092 as appropriate to the flange material. Bolt threads shall be coated in graphite grease before use unless otherwise instructed.

##### (c) Screwed Joints

Screwed joints in steel pipes shall be threaded in accordance with BS EN 10226-1: 2004.

#### 6.29.10 Dismantling Pieces

Dismantling pieces shall be installed adjacent to any valve to allow for easy removal of the valve unless some other means is possible.

Dismantling pieces shall generally be Viking Johnson flange adaptors or similar approved manufactured from either steel or spheroidal cast iron.

Sealing of the interconnected parts shall be by means of sectional rubber-rings. The seal ring shall be capable of withstanding the maximum working pressure without leaking yet provide flexibility and ease of dismantling for maintenance purposes.

The seal ring shall be of the renewable type and formed of nitrile rubber 70/75 IRHD securely clamped to the pipe by means of a steel clamping ring which shall hold the ring securely in place.



The flange adaptor and associated clamping ring shall be coated with fusion bonded epoxy or Rilsan nylon coatings.

Each dismantling piece shall be complete with nuts, bolts and connections formed of galvanised steel.

#### 6.29.11 Surge Pressures in Pipelines

The Contractor shall demonstrate that all pipelines (being supplied under the Contract or existing ones modified under the Contract or existing ones where the operating regime is changed) liable to surge pressures consequent on the prevailing operational conditions have been designed to minimise unacceptable surge pressures. Where pipelines other than concrete, ductile iron or steel are used and are liable to surge pressures, the rating of the pipe shall be selected such that the amplitude of the minimum/maximum pressure envelope at any point in the pipeline from any source does not exceed 50% of the rated pressure (or negative pressure rating) of the pipe. The Contractor shall undertake surge analyses of pipelines using approved specialist computer methods and shall submit to the Engineer for approval a report in three copies showing the max/min envelope of non-suppressed and, where necessary, suppressed pressures, along the whole pipeline. The effect of any fittings such as air valves if fitted shall be demonstrated.

#### 6.29.12 Flanges

All flanged connections of pumps, pipework, valves, and other relevant equipment shall have flanges in accordance with BS EN 1092 as appropriate for the flange material, with a rating appropriate to the design working pressure.

All flanges shall be machined over their face and edge. Where necessary the backs of flanges shall either be machined, or spot faced as required.

#### 6.29.13 Pipe Testing

##### (a) General Requirements

The testing of pressure pipelines shall be carried out in lengths to be proposed by the Contractor and agreed by the Employer but not exceeding 1000 metres as soon as possible after completion of the length concerned.

Before testing commences the Employer shall ensure that all anchor and thrust blocks are complete or that temporary supports have been installed. Thrust from temporary pipe ends or branch pipes shall be adequately strutted and the section under test closed off with stop ends, blank flanges or other closure fittings.

The Contractor shall supply all equipment and materials necessary for carrying out the requirements of this Clause.

Pressure gauges used for testing pipelines shall have 300 mm dials calibrated in metres head or equivalent. Each gauge shall have been calibrated by a testing station and the Contractor shall produce a calibration chart and dated test certificate for the Employer inspection.

All pipelines shall be cleaned before testing by flushing or by passing through them a swab or pig as appropriate and as agreed by the Employer.

All tests shall be carried out in the presence of the Employer and for this purpose the Contractor shall give the Employer 24 hours' notice in writing of any pressure tests which he intends to carry out. Tests shall be conducted in accordance with the appropriate Sub-Clauses below.

Within 24 hours of the completion of any test the Contractor shall submit two copies of a full record of the test to the Employer. The record shall be in a form acceptable to the Employer.

##### (b) Normal Water Test

The length of pipeline to be tested shall be filled with clean water, making sure that all air is expelled, and then kept under nominal working pressure for 24 hours. At the end of this period the pressure shall be raised to the specified test pressure using a hand operated force pump



which is fed from a calibrated tank. The test pressure will depend upon the circumstances and will be specified by the Employer but for general guidance only will be about 1.5 times the maximum sustained operating pressure.

The test pressure shall be held for the period instructed by the Employer, pumping in water as required from the calibrated tank, and the amount of water used per hour shall be noted.

If the loss exceeds the equivalent of 0.003 litres per millimetre of nominal bore of pipe per kilometre for every metre head of test pressure measured at the highest point of the pipe run in a period of 24 hours, the pipe shall be deemed unsatisfactory and the Employer shall search for and repair the leaks and then repeat the test.

(c) Testing Steel Pipelines with Butt Welded Joints

Where instructed by the Employer welded pipelines shall be subjected to a preliminary air pressure test in short sections. An air pressure of between 0.6 and 0.7 N/mm<sup>2</sup> shall be applied to the section under test and a solution of detergent in water applied by brush to the joints. The location of any leaks shall be clearly marked and the joint in these places shall be gouged out and re-welded.

On completion of a section of pipeline not exceeding 1000 metres the line shall be filled with water and tested as stated in the Normal Water test above, except that the pressure shall be held for 24 hours and there shall be no loss of water. The test pressure will be instructed by the Employer.

6.29.14 Commissioning Pipelines

Pipelines for the conveyance of potable water shall be flushed with clean water and then disinfected in accordance with the recommendations contained in BS EN 14161:2003 as specified.

Commissioning shall not be commenced until the Engineer has approved the whole of the installation in writing.

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**6.30 Valves**

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6.30.1 Valves General

Valves shall be designed to meet the operational and environmental conditions as specified in the specification.

Those for use in sewage, water, gas, air, or oil systems shall be as specifically detailed for the application. Unless otherwise specified, valves shall be provided to suit the maximum working pressures including all surge pressures.

Unless otherwise specified all valves shall be double flanged.

All valve bodies shall give the following information:

- i. Manufacturer's name
- ii. Hydraulic operating pressure
- iii. Size of valve
- iv. Direction of flow 'Arrow'

All valves, spindles and handwheels shall be positioned to give good access for operational personnel. It shall be possible either to remove and replace or to recondition seats, gates or gland packing which shall be accessible without removal of the valve from the pipework or, in the case of power operated valves, without removal of the actuator from the valve.

Extension spindles shall be supplied wherever necessary to achieve the specified operating requirements. Where extension spindles without hand wheels are fitted, such as below operating platforms, the extension spindle shall terminate 75 mm below the operating platform access level with



a securely fixed female tapered square section suitable for T-key operation. The Contractor shall supply a set of T-keys, at least two for each discrete operational area. The T-keys shall be fabricated from mild steel, be free of all weld splatter or sharp edges, have a solid male socket, be 1 m long, and with the cross handle 600 mm total length.

Valves buried or installed in underground chambers where access to a handwheel would be impractical shall be operated by means of extension spindles and/or keys. The operating gear of all valves and penstocks shall be such that they can be opened and closed by one man against an unbalanced head 15 % in excess of the maximum specified service value and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 40 kg. Where the effort required to operate a valve exceeds this figure then a reduction gearbox shall be provided.

All handwheels shall be arranged to turn in a clockwise direction to close the valve or penstock, the direction of rotation for opening and closing being indicated on the handwheels. Handwheel diameters shall not exceed 450mm.

The handwheels shall be coated with black plastic and incorporate facilities for padlocking in either the open or closed position.

Lever operated quarter turn valves shall have the lever parallel with the axis of the pipe when the valve is open.

Power operated valves shall include equipment for manual operation by means of a handwheel or other suitable device which shall be interlocked with, and fixed to, the power unit.

Headstocks and valves shall be fitted with mechanical position indicators to show the amount which the valve is open or closed in relation to its full travel, i.e. closed 0.25, 0.50, 0.75 and fully open.

Valves shall be operated safely in accordance with the properties of the whole system. Valve bodies shall be made from spheroidal cast iron to BS EN 1563: 1997.

Actuator mechanisms for butterfly valves operated manually or by motors shall be of the gear box type.

Gear box mechanisms shall be protected against excessive torque with on-off limit switches and other related accessories.

For power operated valves, gear boxes shall be operated by a mechanical pawl and the valve shall be capable of being manually operated independently of the motor. Valves shall be supplied with their adjoining flanges for incorporation in the pipework system.

Facing rings, seating rings, wedge nuts and all other trim used for valves shall be of corrosion resistant grade bronze or stainless steel.

The valve stem, thrust washers, screws, nuts and other components exposed to the water shall be of a corrosion resistant grade of bronze or stainless steel.

Valve bodies and other components of plastic or other non-metallic materials shall be compatible with the fluid being handled and be of robust industrial design.

All valves of the same size and pressure rating shall have the same face-to-face dimensions and the same flanges and be fully interchangeable. Operating mechanisms of valves of the same size and type shall be interchangeable.

#### 6.30.2 Wedge Gate Valves

All wedge gate valves, unless otherwise specified shall be of the non-rising spindle type and be flanged and be in accordance with the relevant clauses of BS EN 1171: 2002.

Valves shall have good quality ductile iron bodies, high tensile brass spindles, gun-metal nuts, wedge gates with gun-metal faces and seats, bronze gland bushes and bonnets fitted with soft packing glands. Valves greater than 400 mm diameter shall have detachable bolted covers for inspection, cleaning, and flushing purposes.



Valves shall be provided with renewable seats and it shall be possible to replace these without removing the valve body from the pipework.

Unless otherwise detailed on the Drawings, gate valves in chambers, and other similar locations shall be provided with handwheels. Valves which are to be buried in the ground shall be provided with extension spindles, protection tubes, spindle caps, spindle supports and surface boxes.

Valves of 400 mm and above shall be provided with a geared headstock for manual operation. All valves greater than 200 mm diameter shall be suitable for subsequent conversion to power operation.

Where specified, resilient seat type valves shall be provided.

Each valve shall be tested in accordance with the requirements of BS EN 1171: 2002 and BS 5163: 2004 standards or BS ISO 5208: 2009. For gate valves used on drainage lines, gates shall be cast iron and their surfaces shall be coated with resilient nitrile rubber having a 55 - 65 shore hardness. Gate seating faces shall be seatless and gates shall be detachable from above. Gate rings shall be screwed to the gates or alternatively shall be pinned over the full circumference.

#### 6.30.3 Knife Valves

The valve bodies shall be of cast iron, cast steel or stainless steel. Gates and spindles shall be of stainless steel. The gate shall mate and seal against an approved non-biodegradable neoprene/polypropylene/nitrile rubber sealing strip or ring. The valve shall have an unrestricted opening when fully open.

#### 6.30.4 Butterfly Valves

Rubber seated butterfly valves shall be bubble tight when closed. Valves shall be suitable for the application/pressures and for mounting in any position and shall comply with BS EN 593: 2010 and flanges shall comply with the relevant parts of BS EN 1092. All valves shall be double flanged valves, except where otherwise specified. All bolts, nuts and other fixings, which will be in contact with the contents of the pipelines or in the case of buried valves, within the ground, shall be stainless steel.

Butterfly Valves shall not be permitted in any pipeline used for the conveyance of sewage, sludge, sewage liquors or sewage effluent.

Butterfly valves shall be suitable for frequent operation as well as for operation after long periods of idleness in either the open or closed position.

Unless otherwise specified valves shall be motor, and hand operated with handwheels driving through 90° gearboxes.

The valve body shall be spheroidal cast iron, the flanges and hubs for shaft bearing housing being integrally cast with the valve body.

The valve body shall be fitted with a replaceable stainless-steel seat ring secured in place by corrosion resistant stainless-steel fasteners.

The disc shall be spheroidal cast iron having edges machined with rounded corners and polished to a smooth finish. Where required additional strengthening ribs shall be incorporated in the construction of the disc. The valve disc shall rotate through an angle of 90 degrees from the valve opened to the fully closed position where the seating shall be at an angle normal to the axis of the pipe. Adjustable mechanical stops shall be provided to prevent over-travel of the valve disc in both the open and closed positions.

Actuator mechanisms of butterfly valves shall be of the gear box type.

Where required, butterfly valves of 500 mm or greater diameter shall have a by-pass system.

Particular attention shall be given to the pipework both upstream and downstream of all butterfly valves to ensure that the disc cannot foul the adjacent pipe.



Two stub shafts manufactured from stainless steel shall carry the valve disc and be secured to it by high tensile stainless-steel taper pins. The shafts shall be supported by self-lubricating bushes mounted in the body with one shaft extended through the valve body and seal chamber to take the operating unit, and the other acting as a trunnion. The shaft, disc and mechanical stops shall be capable of absorbing the full operating torque with a minimum design safety factor of 5 (five). Shaft seals, when used, shall be rubber O-ring type. Packing shall be self-adjusting chevron type.

The valve seat shall be replaceable and formed of nitrile rubber 70/75 IRHD securely clamped to the edge of the disc by stainless steel seat retention members, or equivalent so as to prevent leakage and to hold the seat securely during operation. The seat retention members shall be securely clamped with stainless steel fasteners. All fastenings shall be set flush to offer the least resistance possible to the flow through the valve.

Valve seats which extend over the face of the flanges to secure the seat in place, or which require surface grinding and/or hand fitting of the disc; or designs which require the adjoining pipe flange to retain the seat in place and resist line pressure, are not acceptable.

#### 6.30.5 Diaphragm Valves

Diaphragm valves shall be of the straight-through design with minimal flow resistance and glandless construction complying with BS EN 13397: 2002.

The valves shall be made up of two durable body parts and the diaphragm. All parts shall be replaceable, and the valves shall be easily maintained.

The diaphragm shall be moulded in a reinforced, flexible material of a grade to suit the specified duty and liquid content of the system. In the open state the diaphragm shall lift clear and not obstruct the flow of liquid. The internal surfaces of the valve body shall also be lined with material compatible with diaphragm duty.

Diaphragms shall be completely leak tight and suitable for pressures up to 10 bars.

The valves shall be operated by handwheel unless otherwise specified on the Drawings. Handwheels shall have adequate leverage to give the closure effort required and a facility to lock in any position.

Where indicated on the Drawings diaphragm valves shall be supplied with extended spindles or extensions for pedestals.

#### 6.30.6 Ball Valves

Ball valves shall conform to BS EN 1983: 2006 for carbon steel valves and be suitable for the working pressure.

The valve, ball and stem shall be stainless steel. Operation of the valve shall be by bar handle directly on stem unless otherwise specified on the Drawings.

The valve body shall be fitted with stainless steel bolts complete with gasket to ensure leak tightness of body joint.

#### 6.30.7 Plug Valves

Plug valves shall have carbon steel body and cover with stainless steel bolts, tapered plug, and stem of the non-lubricated or soft seated type complying with the requirements BS 5158: 1989.

The tapered plug shall be self-adjusting on separate seats providing positive seals at two- or three-way port body styles and suitable for pressures up to 10 bar. The seat material shall be as recommended by the manufacturer for the specified pipe duty.

The valve stem shall be fitted with a long-life seal capable of continuous adjustment under conditions of wear.

The valve shall incorporate, when specified on the Drawings, elements of design to prevent the build up of static electricity.



Entry to the plug valve shall be convenient for replacement of worn seats and maintenance of other parts. The valve shall provide external indication of seat wear.  
Operation of the valves shall be by lever unless otherwise specified on the Drawings.

#### 6.30.8 Air Valves

Air valves shall normally be installed at high points in pipework. The valves shall be capable of exhausting air from pipework automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate.

Valves shall comply with the requirements of BS EN 1074.

Similarly, the valves shall be capable of ventilating pipework automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines.

The valves shall also automatically release air accumulating in pipework during normal working conditions.

Air valves shall be adequate to release trapped air without restricting flow. The material of the body and cover shall be cast iron or spheroidal cast iron.

Air valves shall be of the double orifice type with a large orifice for ventilation or exhaust of the pipeline and a smaller orifice for automatic release of air under normal working pressure. The valves shall be suitable for the maximum working pressures in the systems and tested for pressure tightness in steps of 200 kN/m<sup>2</sup> up to the maximum working pressures and then for mechanical strength at 1.5 times maximum working pressures. All air valves shall be provided with isolating valves and flanged end connections.

Air valves used on pipes conveying sewage, sludge, sewage liquors or sewage effluent shall be of a type specifically approved for these applications.

Air valves shall be designed to prevent premature closure prior to all air having been discharged from the line.

The orifice shall be positively sealed in the closed position, but the float (ball) shall only be raised by the liquid and not by a mixture of air and liquid spray.

The seating shall be designed to prevent the floats sticking after long periods in the closed position.

For main pipeline valves, where the pipeline diameter is greater than 1200 mm, Anti-Shock type double orifice air release and vacuum break valves shall be used.

These valves shall have the following characteristics:

- Uninterrupted high-volume air discharge through a large orifice during pipeline filling
- Uninterrupted high-volume air intake through a large orifice during pipeline draining or column separation because of down surges.
- Discharge of strained pressurised air through the small orifice up to the full working pressure during normal operation of a full pipeline

The Anti-Shock air valves shall incorporate an integral surge alleviation mechanism which, during filling or when a separated water column proceeds to rejoin, shall automatically limit transient pressures induced by the large orifice closure to less than 1.5 times the valve rated working pressure. The limitation of pressure rise shall be achieved by deceleration of approaching water column prior to valve closure. Relief mechanisms that act after valve closure are not acceptable.

The large orifice of the valve shall be equal in diameter to the nominal size of the valve.

No preceding or subsequent restrictions of the large orifice is acceptable and all flow passages through the valve shall be at least equal to the area of the large orifice.

When the valve is full of water the valve seat shall be hydraulically leak tight between 5m (0.5bar) and twice the maximum operating head of the valve.



Air valves shall be protected against malfunction due to the ingress of foreign matter through the large orifice by the provision of robust, securely fastened covers and suitable perforation size mesh or restriction slots securely fitted into the peripheral annular space between the cover and the top of the valve.

Each air valve supplied shall have a 6mm port situated at its base. A 6mm lever operated ball cock manufactured from stainless steel and rated for a working pressure of 40bar shall be supplied and fitted to the 6mm port to facilitate testing, draining, or fitting of a pressure gauge. The ball cock outlet shall be screwed with a 6mm ISO R7 female thread.

DN 25 and DN 50 valves shall have either flanged or screwed connections as required by the specification. DN80 valves and above shall have flanged connections in accordance with BS EN 1092.

Each air valve shall be supplied with a gate valve or full-bore ball valve, which shall be used to facilitate isolation of the air valve for maintenance. Isolating valves which are integral with the air valve are not acceptable.

The valve body and end caps and other parts exposed to water shall be manufactured from stainless steel grade AISI 304 or better. Covers not in contact with water shall be manufactured from cast aluminium or steel, coated with fusion bonded epoxy. Mesh screens and all nuts bolts and other fixings shall be manufactured from stainless steel grade AISI 304 or better.

Floats shall be preferably cylindrical and manufactured from solid HDPE or other suitable material which shall not stick to the large orifice seals even after periods of prolonged contact. Spherical hollow floats should be able to withstand a pressure of 80 bar without deforming, imploding, or cracking along their welded seams.

The valve design shall incorporate an over pressure safety feature that will fail without an explosive effect, such as is normally the case when highly compressed air is suddenly released. This feature shall consist of easily replaceable components such as gaskets, seals, and the like.

The small orifice shall be manufactured from grade 316 stainless steel to prevent electrolytic corrosion. The nozzle seating edge surrounding the small orifice shall be accurately machined to form a flat landing which will not abrade or cut the resilient seal against which it seats. Damage to the small orifice resilient seal shall be prevented by a suitable feature which limits the penetration of the orifice into the seal. Rubber small orifice nozzles are not acceptable.

Large orifice seats shall be manufactured from elastomeric materials and shall be designed of a material with a hardness selected for watertight shut off and long-term service at a minimum pressure of 0.5 bar. Large orifice seat design shall permit easy removal and replacement in the field.

#### 6.30.9 Non-Return Valves

Non-return valves of the swing check type shall be installed as required, including on all pump discharge branches, and shall be suitable for the operating condition and where applicable conform to BS EN 1074. Long pattern valves shall generally be used.

For pump delivery check valves fast acting non-slam type non-return valves shall be installed. Offset disc type valves are not acceptable. Any valves which slam shut when a pump or pumps stop shall be rejected and replaced with a non slam type.

Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.

All non-return valves larger than 500 mm shall be fitted with a bypass with integral gate valve.

Flaps shall be fitted with renewable bronze or gun-metal sealing faces, which shall mate accurately with renewable bronze or gun-metal seating rings in the valve body. All seating/seals shall be positively located.

Covers shall be provided to allow ample access for inspection, cleaning, and servicing.

Valves greater than 500 mm diameter shall be provided with lifting eyes, feet and jacking screws.



Hinge pins/shafts and internal fixing devices shall be stainless steel. Hinge pins/shafts shall preferably be square in section to ensure positive location of flaps and provide for secure fixings.

For valves with external levers and adjustable balance weight the hinge pin/shafts shall extend through a renewable sealing gland on the side of the body.

Valves handling liquid with entrained solid particles shall be of the single door swing type and fitted with heavy duty external lever suitable for back flushing.

Valve body design shall be such that there is adequate clearance around and at the back of the flap to minimise jamming by rags, solid matters, etc.

Check valves for potable water shall be free acting type single flap with hand operated control valve, as necessary. Flaps shall be of design and weight to suit the prevailing hydraulic conditions and shafts shall turn in close fitted low friction bearings.

Non return valves shall be of an appropriate diameter and pressure class for its intended use.

Check valves shall be complete with all flanges, nuts, and bolts.

#### 6.30.10 Pressure and Flow Control Valves

Pressure and flow control valves up to 300mm diameter shall be installed as shown on the Drawings and suitable for operating conditions specified and shall be from manufacturers approved by the Engineer.

Valves used to control water flow to or from treatment works in major pipelines and from dams or reservoirs shall be of the Larner Johnson or ring needle valve type and shall be sized to provide accurate control of pressure and flow over the whole range of design flows. Minimum flows shall be achieved with the valve at no more than ninety percent closed to avoid excessive movement and wear on the valve seat. The valves shall be controlled via an electric actuator with a minimum submerged rating of IP69.

The valve outlet configuration, pipework and discharge chamber shall be carefully designed to avoid turbulence, vibration, and cavitation.

Other basic valves shall be either of the pressure compensating globe valve design with externally arranged spring and diaphragm assembly or of the streamline two chamber concentric plunger and pilot valve regulating assembly enclosed within the valve body as required for the applications.

Valve bodies shall be of meehanite cast iron for operating pressures up to PN10 and ductile iron for operating pressures up to PN25.

Valves shall be sized such that the fully open capacity is more than adequate to accept the specified maximum flow at the minimum differential pressure.

The body design of pressure regulating valves shall have the main seat in the stream flow and an upper cylinder for the valve element control piston and shall have the required number of bosses drilled and tapped to receive the strainer unit, relay valves and pressure gauges, etc. The cover plate shall include an air vent and lifting eyes. The main seat shall have a renewable element and the upper portion shall be in the form of a piston and the lower portion shall have a face ring and ported guide.

Valves shall be fitted with an external control relay system which shall be capable of controlling the required parameter of flow or pressure within + or - 5% of the set value. The relay system shall include connecting piping couplings and isolating valves to permit maintenance or replacement without interrupting supply.

The rate of response of opening and closing of the main valve shall be adjusted and means of external indication of the main valve element position shall be fitted.

The control system for the different duties shall be as specified below:

(a) Altitude Valves:



The main valve shall be controlled by a slave ball cock mounted in the controlled tank at top water level and connected to the valve operating mechanism by small-bore pipework. The level of the ball shall be adjustable in service so that the main valve is fully drop-tight closed when the water level in the tank reaches top water level.

(b) Flow Control Valves:

Flow control valves shall be designed to prevent the flow downstream rising above that specified in the particular requirement or shown on the Drawings for the particular application, regardless of the operating pressures in the system upstream or downstream of the valve. The relay system valve shall be operated by the pressure difference measured across the main flow orifice which shall be fitted at the upstream end of flow control valve.

(c) Pressure Reducing Valves:

Pressure reducing valves shall be designed to reduce a constant or variable inlet pressure to a predetermined constant outlet pressure, at flows varying from the maximum capacity of the valve to zero flow. Adjustment of the outlet pressure shall be made by a screw on the relay valve or by changing weights as appropriate. A pressure gauge indication downstream pressure shall be incorporated.

(d) Pressure Sustaining Valves:

Pressure sustaining valves shall be designed to maintain the pressure in the pipeline immediately upstream of the valve at or above a preset value, irrespective of the flow and pressure conditions downstream of the valve. Adjustment of the upstream pressure shall be made by a screw on the relay valve or by changing weights as appropriate. A pressure gauge indicating upstream pressure shall be incorporated.

(e) Pressure Relief Valve

Pressure relief valves shall be designed to prevent the pressure in the pipeline immediately upstream of the valve rising above a preset value. The valve shall remain closed at lower pressures.

Adjustment of the pressure at which the valve opens to relieve pressure shall be made by a screw on the relay valve or by changing weights as appropriate. A pressure gauge indicating upstream pressure shall be incorporated.

#### 6.30.11 Ball Float Valves

Ball float valves shall be designed for installation on the inlet pipe to a storage tank and shall automatically shut off when the water reaches a predetermined level. They shall be of the single float type and balancing piston and direct float and lever operation.

Valves shall be designed for a working pressure of 10 bar. Valves shall be drop-tight when they are held shut by the floating ball. Valve seats shall be tested for leakage at 10 bar when they shall be drop-tight, and shall be tested for body and valve element strength with the valve closed and a test pressure of 15 bar applied to the inlet end.

Valves shall be constructed of meehanite cast iron with gun-metal trim. The valves shall incorporate rubber faces.

#### 6.30.12 Isolating Cocks

For isolation of small-bore pipework tapping's for instrumentation equipment etc. and for individual component isolation, the cocks shall be stainless steel, quarter turn ball or plug valves with the operating handle arranged to indicate the open and closed positions. Where specified, means shall be provided for securing the valve body to a front panel or rear surface.



Where corporation cocks are specified, these shall be similar to the above isolating cocks but shall have a detachable key handle for fitting onto a squared operating shaft, the shaft end being marked to indicate the open and closed valve positions.

#### 6.30.13 Globe Valves

Globe valves shall be cast iron body and bonnet with brass stem and cast bronze seating rings and suitable for pressure up to 10 bar.

The valve gland packing shall be graphited material and the gasket compressed material for steel bolted flange joints.

Valve operation shall be by handwheel unless otherwise specified.

#### 6.30.14 Valve Testing

All valves shall be tested in accordance with the requirements of BS EN 12266.

Valves shall be tested for both body leakage and leakage across the seat.

During testing there shall be no visible evidence of structural damage to any of the valve components.

Body hydrostatic tests shall be undertaken at 1.5 times the nominal rated pressure at 20 °C for a period of not less than 15 minutes.

Isolating valve disc seals shall be tested at 1.5 times their nominal rated pressure from both sides of the disc. Each test shall be for a period of not less than 10 minutes, and during this time there shall be no visually detectable leakage.

For other types of valves, the test shall only be applied to the pressure side of the valve. Valves shall not be painted or coated before pressure testing is carried out. Internal linings that form a design feature of the valve are permitted.

Motorised valves shall be tested with their actuators, with a differential head equivalent to their maximum working pressure, to prove that the valve actuator is capable of opening and closing the valve under maximum unbalanced head condition within the specified opening or closing period.

#### 6.30.15 Penstocks General

Penstocks shall be of the following types:

- (i) Cast iron with scraped non-ferrous sealing faces
- (ii) Cast iron with rubber sealing faces
- (iii) Plastic
- (v) Aluminium alloy
- (vi) Stainless Steel

The frames, doors, sealing faces and spindles of each type of penstock shall be as specified in the appropriate clauses herein.

Unless otherwise stated, each penstock shall be provided with a suitable handwheel of adequate diameter for the duty required and gearing shall be supplied where necessary to ensure that the required operating force applied by hand to the rim of the wheel does not exceed 40 kg. The height of the handwheel shall be approximately 1.0 m above operating level, unless otherwise stated.

Handwheels shall have cast on them, the direction of closing which shall be clockwise. Vandal and weatherproof clear polycarbonate tube covers shall be securely fitted to protect the threads of rising spindles. Each tube shall be clearly and permanently engraved to indicate the position of the penstock (closed, 0.25, 0.50, 0.75, fully open).

Spindles shall have machine cut robust trapezoidal or square form threads. They shall be of stainless or manganese steel or manganese bronze. Extension spindle couplings shall be of the "muff" type and



they shall be drilled and provided with a nut and bolt for securing the spindle to the penstock spindle head, which shall likewise be drilled to receive the bolt.

Where extended spindles installations required to be operated at elevated floor level, spindle guides or guide brackets shall be provided close to the floor level.

Where penstocks are required to be operated by tee keys, spindle caps shall be fitted. The caps shall be drilled, and each provided with nut and bolt for securing to the spindle which shall also be drilled. Where caps are fitted, they shall each be supplied complete with operating tee key.

All handwheels, headstocks, foot brackets and guide brackets shall be of cast iron. Fixing nuts and bolts supplied by the manufacturer shall be as specified in Clause 1.24.

All penstocks shall be of the rising spindle type, unless otherwise stated and provided with headstocks (except where the handwheels can be mounted on the penstock frames). For penstocks of 300 mm (square or circular) and above and for all motorised and actuator operated penstocks, unless otherwise stated, thrust tubes shall be provided between the penstock frame and the headstock, in order to absorb the operating thrust in both directions. Thrust tubes shall incorporate all necessary fixing brackets and spindle guide plates.

Headstocks and foot brackets shall be provided for non-rising spindle penstocks where the latter are specifically called for. Guide brackets shall be provided where necessary. Non-rising spindles shall be fitted with thrust collars and arranged so as to transmit the thrust arising from operation of the penstock directly to the penstock frame. Where headstocks are required on non-rising spindle installations they shall incorporate a penstock position indicator.

Penstocks shall be water-tight under the conditions of head and direction of flow as stated in this Specification, in accordance with BS 7775: 2005 and/or according to the Contractor's design under all possible operating conditions.

Penstocks shall be tested for watertightness after installation against the full design head, whether on or off seating. The test shall be deemed satisfactory if there is no discernable leakage over a period of one hour.

#### 6.30.16 Cast Iron Penstocks

The frames and doors of cast iron penstocks shall be made from close grained grey iron or spheroidal cast iron. The penstocks shall be designed to ensure tight closure while maintaining freedom of door movement during operation and minimising sliding wear of the sealing faces. They shall incorporate adjustable wedges or swivelling cams and actuating pegs manufactured from a corrosion resistant material. Penstocks shall be suitable for both "on" and "off" seating pressures.

Penstocks in channels shall have flush inverts with resilient seals.

Non-ferrous metal sealing faces shall be formed from accurately machined gunmetal or bronze strips bedded and fixed to machined recesses by corrosion resistant countersunk screws. The faces of the strips shall then be brought together in the operating position and hand scraped to a watertight finish. Rubber sealing faces shall be formed from high quality synthetic rubber suitably shaped to interlock into grooves in the frame or door and shall be securely bonded thereto.

The nut in the door of non-rising spindle penstocks and in the handwheel of rising spindle penstocks shall be gunmetal.

Cast iron penstocks shall be prepared and painted in accordance with Paint System P3.

#### 6.30.17 Plastic Penstocks

Plastic penstocks shall be of the flush invert type and the underside sealing face shall consist of highly resilient material securely bonded into a channel or similar section forming the invert of the frame into which the bottom of the door shall affect a watertight seal.

The frames of plastic penstocks shall be made from continuously welded mild steel, protected against corrosion by preparation and treatment in accordance with Paint System P3. Frames shall be reinforced



and gusseted to ensure rigidity without dependence upon the bridge, which shall be bolted for ease of removal.

The doors of plastic penstocks shall be made from sheets of an approved rigid cellular polymer, sandwiched between sheets of an approved rigid compressed composite plastic. The linear coefficient of thermal expansion of the material shall not be greater than  $1.6 \times 10^{-5}$  per °C and no PVC or GRP materials shall be used. The doors thus formed shall have sufficient strength to withstand the required working pressures without deflection or distortion that would affect the operation or watertightness of the penstock. If necessary, totally enclosed steel matrices shall be incorporated in the door construction to ensure adequate rigidity.

The sealing faces and side guides shall consist of plastic strips which have a high resistance to sliding wear and a coefficient of friction of less than 0.10 and shall be to the approval of the Engineer. The sealing strips shall be securely fixed to the inner faces of the frames. Adjusting devices or other means of ensuring freedom of movement without loss of seal shall be provided. The adjusting devices shall be of stainless steel or other corrosion resistant material and easily replaceable.

Spindle operating nuts shall be of gunmetal or an approved ultra high molecular weight polyethylene material. The operating nuts for non-rising spindles, or the spindle retaining blocks for rising spindles shall be fixed in a visible position inside a separate gate lifting bracket, bolted on to the top of the door with stainless steel fasteners. The operating nut or spindle retaining block shall not be contained within the door.

All nuts and bolts used in manufacture and construction of the penstocks shall be of stainless steel.

All plastic materials shall be non-toxic ultraviolet stabilised.

The materials used in the construction of the plastic penstocks for untreated and treated water, intended for potable use, shall have been examined by the Water Research Centre or a similar body and a Certificate of Approval obtained.

#### 6.30.18 Aluminium Alloy Penstocks

Unless otherwise stated aluminium alloy, penstocks shall be of the flush invert type and the underside sealing face shall consist of back-up plate, securely bolted to the lower edge of the door. Aluminium alloy penstocks shall be limited in application to:

- (i) Process liquid of conductivity not greater than 5000  $\mu\text{mhos}$ .
- (ii) Door size not greater than 2 m x 2 m.

The frames and doors of aluminium alloy penstocks shall be of aluminium alloy which is corrosion resistant to the process liquid and to the approval of the Engineer. The design of the doors shall be such that the required working pressures can be withstood without deflection or distortion that would affect the operation of the penstocks. Any strengthening of doors by the provision of ribs and gussets shall be carried out by welding and not by bolting.

The side sealing faces shall consist of simple metal contact between the door and frame or of synthetic rubber seals and plastic guides as necessary to withstand the required working pressure without leakage.

Spindles for aluminium alloy penstocks shall be manufactured in stainless steel.

The nut in the door of non-rising spindle penstocks and in the handwheel of rising spindle penstocks shall be of gunmetal or an approved ultra high molecular weight polyethylene or other material approved by the Engineer, which is dissimilar to the spindle and which will not react electrochemically with the spindle or the housing.

All nuts and bolts used in the manufacture and construction of the penstocks shall be of stainless steel.

Contact between dissimilar materials shall be prevented using suitable washers, bushes, and bedding pads and by the use of fixing nuts and bolts or suitable materials so as to avoid electrochemical reaction.



#### 6.30.19 Stainless Steel Penstocks

Stainless steel penstocks shall be manufactured from grade 316L stainless steel. All welding shall be undertaken in a clean workshop to prevent carbon contamination. TIG or MIG welding shall be used and filler material shall be selected to maintain the integrity of the base metal. After fabrication, all welds and heat affected zones shall be pickled and passivated using a proprietary system.

Penstock seals shall be of a proven design and the seal material shall be resistant to attack or degradation by any of the chemicals used including chlorine.

#### 6.30.20 Hand Stops

Hand stops shall have cast iron frames with galvanised mild steel doors. Alternatively, aluminium alloy frames and doors may be used for process liquid applications providing the conductivity is not greater than 5000  $\mu\text{mhos}$ .

Hand stops shall be suitable for channel or wall mounting according to the installation requirements. Hand stop doors shall be provided with hand-slots to facilitate operation and a peg and chain shall be provided to hold the door in the open position. Pegs and chains shall be of stainless steel or galvanised mild steel with the exception that for aluminium alloy hand stops, pegs and chains shall be of stainless steel only.

On deep channels or where specified, hand stop doors shall be provided with lifting handles. Lifting handles shall be of identical material to the doors and guide/retaining brackets shall be provided.

Fixing nuts and bolts shall be as per this Specification.

All hand stops shall be prepared and painted in accordance with the Specification.

All materials used in the manufacture of hand stops shall conform with the requirements of penstocks specified herein.

#### 6.30.21 Tilting Weirs

This specification covers the requirements for the supply, installation, testing and commissioning of tilting weirs.

This specification shall, inter alia, form part of the contract document.

This specification contains clauses that are generally applicable to mechanical engineering construction. Interpretation of and modifications to this specification are set out in Process Specification.

The tilting weir will establish an up and downward adjustable overflow level for the decanting of the sludge drying supernatant water.

The tilting weir will perform the specific required function as per the treatment process and the process specification.

The tilting weir will be designed to perform under the specific process treatment environment.

The tilting weir will allow sufficient incremental adjustment to efficiently decant the supernatant water from the drying dams.

The tilting weir will efficiently seal to not drain water pre-maturely.

The tilting weir will be guaranteed to deliver the required function and performance.

The tilting weir will suit the specific civil design requirements.

The tilting weir design will ensure a robust and rigid construction.

The tilting weir must perform according to the complete process requirements of the applicable unit



treatment and required function.

The tilting weir must be manufactured with the most optimal material to ensure maximum operational life.

The design of the tilting weir will take into consideration the operational conditions and the optimal application to ensure the best performance and operational lifetime.

The tilting weir shall be accessible for inspection and maintenance work.

The equipment shall comply with the details stated in the Process Specification as approved by the Engineer.

The equipment shall be corrosion protected in accordance with the corrosion protection specification.

The contractor shall provide all plant that is necessary to install, test and commission all the items of equipment covered in this section.

If so instructed by the Engineer, in order to establish the performance of the equipment, the Contractor shall carry out in situ tests that are witnessed by a representative of the Engineer. Full details of tests and the calculated results shall be handed to the Engineer.

In-situ tests shall consist of;  
Measurement of leakage.  
Measurement of decanting rate.

Measurement and payment shall be in accordance with General Specification.

#### 6.30.22 Electric Actuators

Where required, penstocks and valves shall be operated by means of electrically driven actuators with integral reversing starters.

Each actuator shall be fully submersible (IP68) and fitted with an anti-condensation heater, upper and lower limit switches, and torque switches. Where actuators are installed in below ground chambers or other locations which could be flooded then the actuator enclosure shall be rated IP68 and suitable for being submerged under the maximum head of water that may occur at that particular location.

All local controls shall be protected by a lockable cover. The electrical supply available is 415 volts, 3 phases, 4 wire, 50 Hz, and the unit shall incorporate a 415/220 to 110 volts transformer for control circuits.

Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The operating gear of all penstocks shall be capable of opening or closing the valve or gate against an unbalanced head equal to the maximum working pressure. All actuators shall have adequate torque margin to operate the valve under all conditions including seating and unseating loads and sticking after long periods of non-use.

The gearbox shall be oil or grease filled, and capable of installation in any position.

Alternative hand operation shall be possible, and the handwheel together with a suitable reduction gearbox if necessary, shall be of adequate dimensions for easy operation by two men. The motor drive shall be automatically disengaged when under manual operation. Handwheels shall be rotated clockwise to close the valves and shall be clearly marked with the words "OPEN" and "CLOSE" with arrows in the appropriate directions. The rims of handwheels shall have a smooth finish.

All actuators except for rising spindle penstock actuators shall be equipped with indicators showing the position of the valve or penstock. A transparent PVC cover shall be fitted to protect the thread of the rising spindle type penstocks.

All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.



The motors shall be provided with integrally housed starters and shall be sized to provide an adequate margin to prevent overloading. The motor torque rating shall be at least 10 percent greater than the maximum torque requirement of the actuator at the rated voltage.

The starter housing shall be fitted with contacts and terminals for power supply, remote control, and remote positional indication, and shall also be fitted with internal heaters to provide protection against damage due to condensation. Heaters shall be suitable for single phase 110-volt operation. The heaters shall be switched "ON" when the starters are "OFF" and shall be switched "OFF" when the starters are "ON".

Where remote indication of valve position is required, for instance on flow control valves, then the actuator shall provide a 4-20mA signal.

Each starter shall be equipped as follows:

- 2 No. Three Phase (TP) magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
- 1 No. TP Thermal cut-out device.
- 1 No. 380V-110V, Control Circuit Transformer fully protected by fuses on primary and secondary circuits.
- 1 No. Set of "Open", "Close" and "Stop" buttons.
- 1 No. Local-Off-Remote switch with padlocking facilities.
- 1 No. Set of Torque and limit switches for "Open" and "Close" positions.
- 3 No. Sets of Auxiliary limit switches in each direction.
- 1 No. Valve position indicator
- 1 Set Indicating lamps indicating "open", "closed" or "in transit"

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### **6.31 Thermal Insulation**

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#### **6.31.1 General**

All items of thermal insulation work covered by this specification shall be carried out by an approved specialist thermal insulation sub-contractor. The Tenderer shall only employ skilled operatives in this field of work.

Thermal insulation shall not commence until the whole of the installation has been completed and tested as set out in the relevant sections of this specification. All insulation work shall be carried out in accordance with ASTM F 683.

All insulation materials shall be asbestos free.

#### **6.31.2 Pipework**

All pipework carrying hot liquids or gases etc., within plant rooms and any external pipework which could be liable to freezing shall be individually insulated with plain preformed rigid glass fibre or mineral wool sections in accordance with BS 5422: 2009.

All insulated sections shall be adequately secured using 19 SWG galvanised lacing wire or self-adhesive tape bands at 300mm centres.

All insulated pipework shall then be enclosed with fabricated aluminium cladding or polyisobutylene sheeting or approved equal as applicable. All cladding shall be firmly secured and sealed to form a continuous vapour seal. External cladding shall be fully protected against the ingress of water.

Where bends and offsets occur in pipework, the insulation shall be tailored to suit. Mitred joints or lobster back bends shall be provided on all cladding applied to bends and branch pipe connections.

#### **6.31.3 Plant**

Proprietary items, such as boilers, heat exchangers, hot water cylinders and associated ducts etc. shall be insulated in accordance with the manufacturer's recommendations.



Water feed tanks mounted externally shall be insulated using polystyrene or rigid isocyanurete foam slab secured with approved adhesive reinforced with 25mm mesh galvanised wire netting and super coated with two coats of fibre filled bitumen emulsion trowelled smooth and even having scrim cloth or hessian embedded in the final coat.

All valves, flanges, unions, and other items requiring access for operation and maintenance shall be insulated with quick release removable casings.

The Contractor shall provide full details of the lagging system he proposes to use for approval by the Engineer. Details shall be provided of type and thickness of insulation material, method of securing/fixing sections together with type and thickness of cladding material.

Unless otherwise specified for heat retention purposes all parts that under normal working conditions hotter than 60°C or colder than -5°C shall be adequately guarded by lagging or other approved means.

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## **6.32 Pumps**

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### **6.32.1 General**

Each pump shall be designed and constructed to be suitable for the liquid to be pumped.

All pumps shall comply with the requirements of BS EN ISO 9905: 1994, Technical Specification for Centrifugal Pumps - Class I.

Pumps shall be designed to give the specified output against all losses including those relating to the pump.

The Contractor shall match his pump characteristics to the pipe system networks to achieve the highest pump efficiency and reliability.

The pumps shall have a non-overloading characteristic over the complete range of head and quantity delivered and the drive shall be capable of starting centrifugal pumps against maximum run out conditions.

Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

Centrifugal pumps shall have head/quantity characteristics which fall continuously from the maximum pressure at closed valve conditions and which are steep in order that variation in head shall have a minimum effect on the quantity discharged.

The whole pumping unit shall be capable of withstanding without detriment, reverse rotation to a speed that would occur if the pump were to stop when the differential head was at a maximum and the delivery and/or non-return valve failed to close.

Pumps shall be arranged for priming by gravity, via normal suction flow path.

Waterways through pumps shall be smooth and free from recesses and obstructions. Pumps for wastewater and raw water services shall be capable of passing solids:

- i. equal to the size of the suction pipework up to 100mm diameter,
- ii. of 100mm diameter for suction pipework between 100mm and 199mm,
- iii. of 150mm diameter for suction pipework of 200mm diameter or greater.

Pump speeds shall not exceed 1500 rpm nominal except for water supply borehole pumps where 3000 rpm nominal is acceptable.



The head/flow characteristic of any pump shall be stable under all possible operating conditions including parallel operation and with maximum sump surcharge.

The design of the influent path to the sump and the configuration of the sump shall avoid risk of ingesting entrapped air or other condition likely to result in cavitation.

Velocities in the suction and delivery branches shall be sufficiently low to prevent hydraulic turbulence and cavitation within the pump and the pipework and sufficiently high to prevent settlement of any suspended solids.

The pump and its drive motor shall be suitably rated, and the characteristic curve selected as appropriate to allow for any increased head, due to sliming, etc., of the rising main, without unacceptable loss of delivery during the lifetime of the pump.

Pump suction (except for wet well mounted submersible pumps) and discharge pipework for clean water and effluent duties shall be tapped and plugged with 25mm reducing to 12mm and fitted with a tee. The tee shall be fitted with an isolating cock, suitable for use with a pressure gauge having a 12 mm connection and an isolation cock to act as a vent. The tapping shall be located between two and three pipe diameters from the pump, in accordance with BS EN ISO 9906: 2000.

Pump suction and discharge connections for sludge and un-screened effluent shall be provided with 50mm flanged connections fitted with a flanged tee. The tee shall be fitted with two flanged isolation valves, one for connection of diaphragm type pressure gauge and the second to act as a vent. Open ends of valves shall be fitted with blanking flanges or plugs as appropriate.

The following specific pump requirements are not intended to limit the range of pump types that can be offered.

#### 6.32.2 Pumps for Raw, Treated and Backwash Water

Pumps for raw water, treated water and other general-purpose applications shall be installed in a convention dry well configuration and shall be horizontally mounted. They shall be of the horizontal split case or end suction type.

All pumps should have a flooded suction and shall not require vacuum or other priming systems.

In addition to a flooded suction, there shall be sufficient net positive suction head to prevent cavitation at all operating conditions including operation of a single pump in a system nominally designed for parallel pump operation.

Motors shall have a kW rating more than the maximum power demand of one pump operating unthrottled against the prevailing system head.

Pump sets shall be installed on reinforced concrete plinths. Such plinths shall have a mass of concrete of between 3 and 5 times the combined mass of the pump sets. Baseplate foundation bolts shall be the full depth of the plinth and shall be cast in situ.

Baseplates shall include motor adjusting screws to permit final coupling alignment.

Baseplate alignment shall utilise metallic shims only. Baseplates shall be grouted using an epoxy non shrink grout after final alignment has been checked by the Engineer.

#### 6.32.3 Submersible Wastewater Pumps

The pump motor shall include sealed for life grease lubricated rolling element bearings.

The pump motor shall be capable of continuous operation either dry, partially, or fully submerged. The windings shall be protected against burn-out by a thermostat or thermistor.

The pump shall have two mechanical seals. The seals shall work independently of each other, one to seal off the motor, the other to seal off the pumped fluid. An oil chamber shall act as both a buffer between the seals and a coolant for the seals. A moisture probe in the oil chamber shall be provided to detect any deterioration in the lower seal.



The pump set shall be capable of withstanding the effects of short-term reverse rotation following a pump stop.

Pumps installed in wet wells shall be supported and automatically coupled to the outlet pipework by their own weight and positively guided during the lowering operation. The connection shall allow the pump to be raised from the top of the sump without the need to undo any fixing arrangements.

Lifting chains shall be supplied and permanently fitted to the pumps. The free end of the chains shall be provided with a hook fitted to the top of the wet well. Load test certificates shall be supplied.

Where the Contractor is providing the lifting Plant and there is insufficient height to remove the pump in one lift, a parking facility shall be included to permit the pump to be supported while the lifting hook is repositioned. The parking facility shall be rated for the maximum load likely to be applied.

Pump lifting chains shall be suitable for prolonged contact with wastewater.

#### 6.32.4 Sump Drainage Pumps

Sump drainage pumps shall be of the open impeller centrifugal type, vertically mounted and close coupled to their fully submersible electric motors. Pumps weighing more than 50 kg shall be raised and lowered via guide rails and be automatically located onto the discharge pipework by their own weight. Small sump drainage pumps used for evacuating spillage in dry wells shall be 3-phase, minimum discharge 50 mm, and be fitted with integral on/off float switch.

#### 6.32.5 Progressive Cavity Pumps

The pump casing shall be fitted with replaceable rotor and stator components.

The pumping element shall consist of a single helical rotor revolving within a double helical resilient stator.

The rotor's eccentric motion shall be transmitted by either a flexible drive shaft or by fitting a universal joint between the motor and drive unit. The flexible drive shaft shall be a high tensile steel with an impermeable thermoplastic coating to provide resistance to abrasion and corrosion. Shaft seals shall be of the mechanical type, suitable for abrasive conditions.

The pump drive assembly shall be directly coupled and geared for fixed speed reductions or arranged with a guarded flexible-belt for variable speed drive arrangements.

Pumps shall have temperature sensors embedded in the stator and over pressure protection.

#### 6.32.6 Chemical Dosing Pumps

Chemical dosing pumps shall be of the piston, piston diaphragm or mechanical diaphragm type. Pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute.

Stroke adjustment shall be manual, or by an electrical or pneumatic controlled stroke positioner with step less adjustment between zero and maximum stroke length. Where flow-proportional dosing is required, the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

A stroke length indicator and digital stroke counter shall be fitted.

#### 6.32.7 Pump Casings

The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that all components liable to wear can be replaced. Components shall be permanently marked with the manufacturer's number and where dowels are not used, permanently marked for correct assembly.



The casings of pumps shall be Grey or Spheroidal cast iron as specified and have flanges in accordance with BS EN 1092 to match the specified pipework.

The waterways through the pumps shall be smooth in finish and free from recesses and obstructions.

Pumps shall be designed to facilitate maintenance. Manholes or handholes shall be provided to allow the interior of the casings on all pumps handling solids or slurries and to allow bearing seals on all pumps to be examined without dismantling the pump. It shall be possible to remove pump impellers with the minimum disturbance to pipework and by suitable joints to allow the pump to be removed without dismantling the main pipework.

All joints shall be machined and faced, and bolt holes shall be drilled and arbourised. Locating pins shall be provided where necessary, also starting screw holes, the latter being provided with set screws.

Pump casings shall be of substantial construction to give long life under abrasive conditions and suitably stiffened to withstand shock due to solids in suspension. Pump casings shall be fitted with renewable bronze casing wear rings.

The pump cases shall be tested at a pressure of 1.6 times the manometric design pressure or 1.5 times the pump closed valve head, whichever is greater.

Any internal coating shall be of the glass flake epoxy type or equivalent specialised coating designed specifically for the purpose and applied in accordance with the manufacturer's instructions. Ordinary epoxy paint coatings will not be accepted.

#### 6.32.8 Impellers

Impellers and guide vanes (if any) shall be of bronze or stainless steel, accurately machined and smoothly finished to minimise hydraulic losses.

The rotating elements shall be balanced to achieve minimum vibration and shall be statically and dynamically balanced before final assembly. The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipework.

The impeller shall be provided with means of preventing abrasive matter getting to the glands. Clearance at the eye rings and wear plates shall be kept to a minimum and where it is found necessary to cut back the impeller, this is to be done on the vanes only.

Where specified the impeller shall have renewable wear rings.

Clearance at eye rings and wearing plates shall be kept to a minimum and, where it is found necessary to cut back the impeller, this shall be done on the vanes only.

Eye rings and wear rings shall be bronze or other compatible materials and shall be replaceable without machining.

Impellers, as far as practicable, shall be hydraulically balanced to reduce end thrust on the bearings to the minimum possible. Machining of holes in the impeller shall not be used to balance hydraulic forces.

The suction arrangements shall be such as will avoid pre-rotation in the suction pipework and present a good flow pattern at the entrance to the impeller.

#### 6.32.9 Pump Shafts

The pump shaft shall be of high tensile stainless steel adequately sized, with good fatigue, shock load and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs, the shoulder shall be radiused or undercut to the appropriate standards to reduce stress concentrations.

The shaft shall be complete with easily renewable stainless-steel protecting sleeves at glands and bearings.



#### 6.32.10 Bearings

All bearings shall be liberally rated to ensure cool running and meet the load factors specified. For vertically mounted pumps, the top bearing shall be a combined thrust and journal type, designed to prevent any thrust loads being imposed upon the drive motor.

The pump bottom bearing shall be lubricated by an enclosed water lubricated sleeve bearing for potable water applications but by grease or other approved means for sewage use.

Where grease points are necessary, they shall be fitted with removable screwed plugs which shall be accessible without removing guards. All bearings having automatic lubrication shall also have provision for hand lubrication.

#### 6.32.11 Shaft Seals

The Contractor shall select a seal, compatible with his plant and best suited for the worst conditions likely to be met when the Plant is in operation. For all water applications packed glands using PTFE impregnated cotton packing is preferred.

All seal materials shall be compatible with and/or resistant to the fluid being handled. For potable water, seal materials shall be those specifically approved for use in the Water Industry.

Shafts shall be provided with renewable gland sleeves. Glands subject to abrasive liquors or negative pressures shall embody suitably positioned lantern rings and a clean water continuous flushing system, operative whenever the Plant is in motion.

Gland adjustment nuts shall be readily accessible for routine maintenance.

Gland drain pipework, shall be installed, incorporating rodding facilities and adequate inclines, of 25 mm minimum diameter on water reclamation plant and 12.5 mm on water supply plant, discharging to the nearest sump or drainage channel.

Mechanical seals which are on pumps handling abrasive liquor or subject to negative pressures or corrosive elements, shall be provided with a clean water continuous flushing system, operative when the plant is in motion or the corrosive element present. A back-to-back sealing arrangement with a flushing/cooling system shall be accepted as satisfying the requirements of this Clause.

Special care in the selection of materials shall be taken to avoid binding and electrolytic action between the shaft sleeve and the seal components, particularly where long periods of idleness are inherent in the duty cycle.

The gland lubricating water connections of the pumps shall be provided with suitable filters to prevent abrasive matter from entering the gland stuffing box. These filters shall be designed to facilitate easy cleaning.

#### 6.32.12 Miscellaneous

Cooling and lubrication water pipework shall be fitted with flow indicators where specified.

On horizontal pump sets fitted with hydraulic balance devices, the couplings shall permit free axial movements of pump shafts under load.

On vertical pump sets where the shaft couplings are of the screwed type, the couplings shall be positively locked.

Automatic float type air valves with cocks shall be fitted in the highest part of the casing or head bend to assist priming. Automatic air valves shall be fitted with pipes to convey leakage back to drains.

The Contractor shall ensure that adequate Net Positive Suction Head (NPSH) is available to ensure that pumps operate without cavitation under the worst operating conditions.

Indicating pressure gauges each with an isolating cock and snubbers shall be provided on the suction and delivery side of each pump.



#### 6.32.13 Performance

Any guarantees given in respect of output, overall efficiency and NPSH shall be verified with tests in accordance with BS EN ISO 9906: 2000 Class 1 at the manufacturer's works in the presence of the Engineer. No negative tolerance shall be applicable to the guaranteed values for Quantity, Head or Efficiency.

Any tests shall be performed by pumps driven by their own motors.

For the purpose of this Specification, the following definitions of parameters shall apply:

(a) Static Head

The difference in level between the free water surface levels on the suction side of the pump and the discharge side of the pump.

(b) Delivery Main Friction Head

The head required to overcome the friction in the delivery main from the connection with the main external to the pump house to the discharge point.

(c) Station Losses

The head loss through the suction pipework and valve, delivery pipework and valves, up to the connection with the delivery main external to the Pump Station.

(d) Total Head

The sum of (a), (b) and (c).

(e) Overall Efficiency

The work done by the pump (that is, waterpower) in kilowatts divided by the total power input to the motor in kilowatts. The power shall be based on the total head (d).

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### 6.33 Air Blowers

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#### 6.33.1 General

The Contractor shall provide an air blower or blowers manufactured, cabled, tested, and delivered to the works as a packaged unit ready for use requiring only pipe and cable connections.

The air blower and its associated control panel shall be mounted on a fabricated galvanised steel bedplate and sited on a reinforced concrete plinth.

The air blower shall be of the rotary, air cooled, positive displacement type, with a performance complying with BS 1571.

The blower shall be capable of continuously discharging 100% oil free air under all operating conditions.

The air blower shall be driven by an electric motor, either directly through a flexible coupling or indirectly via Vee belts.

The air blower shall be capable of being operated as a fixed or variable speed machine, as specified.

Air supplied to the blower shall be filtered as specified.



The Air Blower Package shall include the following:

- (a) A spring loaded pressure relief valve on the outlet of the blower;
- (b) Inlet and outlet pressure gauges, each gauge fitted with an isolating valve;
- (c) Silencers provided at the inlet and outlet of the blower;
- (d) Flexible bellow joints provided at the inlet and outlet of the blower. The inlet joint shall be manufactured from rubber and the outlet joint shall be manufactured from stainless steel;
- (e) Anti-vibration mountings shall be provided between the base plate and air blower;
- (f) An unloading valve provided at the outlet of the blower. This valve shall assist starting of the blower by automatically opening to atmosphere in the start up sequence to provide a no-load condition to the blower. The discharge from the unloading valve shall be piped to a safe point outside the building.
- (g) A non return valve provided on the outlet of each blower when two or more blowers are connected to a common manifold. The valve shall be of the free acting pattern and be installed after the outlet flange of the silencer.

The blower casing shall be constructed in two halves with the joint line on the horizontal plane. Guide bar locations shall be provided to prevent damage to the rotor during maintenance.

All covers and flanges associated with spigotted joints shall be provided with easing screws.

The timing gears shall be of helical design and the rotor shaft assemblies supported on heavy duty ball and/or roller bearings.

All bearings and helical gears shall be provided with adequate lubrication from oil chambers.

The rotor shafts shall be fitted with piston ring type labyrinth and lip seals, together with oil thrower rings or other approved methods for sealing the rotor chamber from the oil chamber.

Where the Air Blower installation produces a noise level more than 85 dB(A) at 1 metre, an acoustic enclosure shall be provided for each air blower.

The blower casing shall be manufactured from cast iron complying with BS 1452 Grade 310.

For small units the rotors shall be manufactured from carbon steel complying with BS EN 10130 grade C45N, and for large units the rotors shall be manufactured from cast iron complying with BS 1452 Grade 310.

Drive shafts shall be manufactured from carbon steel complying with BS EN 10130 Grade C45N.

The silencers shall be manufactured from galvanised steel.

The Contractor shall comply with this General Mechanical Specification relating to Pipework.

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### **6.34 Air Compressors**

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#### **6.34.1 General**

The Contractor shall provide air compressor(s) as specified in the Particular Specification. The compressors shall be of the air cooled, or water cooled, type capable of continuously discharging oil and dust free air under all operating conditions. The compressors shall be in accordance with BS 1571. The compressors may achieve oil free output with assistance of filtering.

The compressor shall be directly driven through a flexible coupling, or indirectly via Vee belts, by means of an electric motor or diesel engine.

The complete assembly shall be mounted on a cast iron or fabricated steel bedplate. Both driver and driven units shall be doweled to the bedplate.

All covers and flanges associated with spigotted joints shall be provided with easing screws.



Timing gears shall be of helical design.

Each compressor shall include the following items: -

- a) Suction air filter.
- b) Suction air silencer.
- c) Solenoid operated unloader valve.
- d) Pressure relief valve.
- e) Non-return valve.
- f) Isolating valve.
- g) Coolant temperature gauge. (Where water cooled compressors are supplied).
- h) Pressure and temperature switches to suit the specified control.

Where necessary the compressor shall have a cylinder jacket and after cooler facilities for cooling the delivered air. The after-cooling facility shall have a suitable pressure relief valve and automatic drain valve.

Air receivers shall be manufactured in accordance with BS 5169 Class III Grade E or F, to accommodate the specified design pressure and internal volume.

The receiver shall incorporate the following items: -

- One safety relief valve
- One automatic drain valve with pipe strainer/filter
- One pressure gauge
- Inspection access to permit internal examination of the receiver
- Lifting facilities as determined by the receiver weight.

The receivers shall be in low ambient temperature areas to minimise condensation and the inlet and outlet pipe connections shall be arranged to promote air circulation.

The air distribution main shall include a coalescent, cartridge type filter to remove suspended moisture in the air main.

The air supply shall incorporate filters of the disposable element type close to the point of use.

Filtration shall be carried out using two filters in series. The combination of these filters shall be such that all particles down to 5 microns are removed.

A single inlet silencer shall be included for the compressor. It shall be manufactured from galvanised steel and be of the reactive type. A flange shall be provided at each end, and all necessary supports extending to floor level shall be included.

The silencers shall be designed for the minimum pressure drop.

Automatic drain traps shall be provided for air receivers, filters, and separators. Strainers shall be provided for protection of the drain traps. Ball traps shall have cast iron bodies and stainless-steel internal parts.

The compressor shall maintain the air pressure in the system within the required limits by monitoring the pressure in the air receiver using pressure switches, or pressure transducers, in conjunction with unloader valves and timers to prevent prolonged off-load running.

All moving parts accessible to operational personnel shall be protected and suitably guarded in accordance with the Work Equipment Regulations 1992. All covers and guards shall be designed to facilitate easy removal, by a maximum of two persons. The Contractor shall also refer to the Standard Specification relating to the Guarding of Moving Parts.

The compressor shall be fitted with mechanical seals and incorporate a mechanical oil lubricated system, including an oil flow indicator, level indicator, pressure gauge, filling and drain plugs.

The rotor shall be statically and dynamically balanced and run entirely free from vibration. The critical speed of the rotor shall be above the operational running speeds.



Compressors of the reciprocating type shall be mounted on suitable anti-vibration mounts.

Where noise levels generated by the compressor exceed 85 dB(A) at 1 metre, the compressor shall be installed in an acoustic enclosure. The enclosure shall have an outer skin of 14swg mild steel, or 3mm thick GRP and an inner skin of 22swg zinc coated perforated steel having an open area of not less than 23%. The space between the outer and inner skins should be filled with high density mineral wool having a thickness of 50mm.

To prevent the ingress of dirt and grease a strong impervious, acoustically transparent material should be placed between the mineral wool and the perforated steel sheet.

In all cases where an acoustic enclosure is fitted, particular care shall be taken in the sealing of gaps both at floor and ceiling level and around doors and windows.

In the design of an acoustic enclosure consideration shall be given to ventilation. A ventilation system based on free or forced air shall be installed, combined with the use of acoustic louvres.

For condensation drainage, the pipework system shall be run with a horizontal fall of not less than 1 in 50 in the direction of air flow and incorporate drainage points at distances of not less than 30m. Drainage points shall be formed using equal tees with a down-pointing leg, fitted where changes of direction of flow occur.

Any branch take-off shall be from the top of the main and the bottom of any falling pipe shall incorporate a drainage facility.

The Contractor shall also comply with the General Mechanical Specifications relating to Pipework.

Where water cooled air, compressors are supplied they shall be protected by a pressurised water-cooling system. The water shall be mixed with the appropriate quantities of corrosion inhibitor and anti-freeze.

The use of cooling towers and evaporative condensers will not be accepted.

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### **6.35 Pressure Vessels**

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#### **6.35.1 General**

Pressure vessel Design, Manufacture, Testing and Commissioning shall comply with the requirements of BS EN 13445:2009.

Pressure vessels manufactured from carbon steel shall have a corrosion allowance of at least 1.5 mm in excess of the wall thickness proscribed by the above design code.

Pressure vessels used as part of a treatment process (eg part of Dissolved Air Floatation process) shall be coated internally with an approved epoxy coating having a minimum dry film thickness of 300 microns. Alternatively, the vessel may be manufactured from grade 316L stainless steel.

All pressure vessels shall be fitted with pressure relief valves.

All pressure vessels having capacity more than 2 m<sup>3</sup> shall have an access manway of 600 mm or greater to allow internal inspection.

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### **6.36 Overhead Travelling Cranes, Monorails and Lifting Gear**

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#### 6.36.1 General

Overhead travelling cranes shall be either of the double beam or single beam type. Cranes shall be in accordance with appropriate ISO or ASME Standards, with hoist units designed in accordance with FEM Class II ratings.

The cranes shall have a rated capacity of 1.5 times the maximum load, which they will be required to lift. Crane configurations shall be such that they are able to provide a vertical lift to all items of plant, which they are required to cover.

The bridge structure shall be manufactured from single lengths of rolled steel sections or fabricated from steel plate to form continuous box section girders with box section end carriages, gusset plates, cross member and bracing bars (if required) welded to the main cross girders to form a rigid bridge assembly. Steel for crane beams shall be in accordance with ASTM A36 or better.

The hoisting unit shall be mounted in a trolley assembly, which travels on the upper flanges of the girders. For single beam and monorail type cranes, the hoisting unit may be suspended from the bottom flange of the beam.

The crane end carriages shall be fabricated in the form of steel box sections, sufficiently stiffened throughout to withstand the torsional stresses imposed. End carriages shall be designed to enable the track wheels to be withdrawn easily.

The rail wheels shall be of the double flanged type with a flange to rail clearance of not greater than 10 mm on each side of each rail to allow for deviations from the normal track dimensions. Wheels shall be manufactured from high tensile low alloy steel.

The longitudinal travel motors shall be arranged to drive positively at least one wheel on each end carriage. The individual end carriage motors shall be synchronised to start and stop together.

Crane rails shall be of standard section and shall be manufactured wear resistant austenitic manganese steel. Suitable energy absorbing stops shall be provided at each end of both rails to prevent over-run.

Steel wire rope shall be manufactured from flexible 180 kgf/mm<sup>2</sup> cold drawn, galvanised carbon steel and be of round strand 6 x 37 construction fibre core. The hoisting ropes shall have a 6:1 safety factor on the specified safe working load.

Rope drums and pulleys shall be manufactured from carbon steel. The rope drum shall be parallel to the long travel.

The crane hooks shall be single type manufactured malleable steel. The hook shall be provided with a spring-loaded retaining clip to prevent lifting slings from accidentally becoming detached from the hook. The hook shall pivot through 360 degrees by means of a suitably rated ball thrust bearing.

All bearings and gears shall have a design life of 10 000 hours. All gearboxes shall be protected against dust and moisture and all other rotating parts shall be protected by removable guards.

When cranes are required to operate in chlorine drum stores, chemical buildings or other corrosive environments, the crane materials and coatings shall be resistant to corrosive attack resulting from the environment in which the crane is operating.

All cranes and other lifting devices shall be clearly marked with their maximum safe working load in tonnes in figures not less than 150 mm high on both sides of the main beam.

The maximum deflection under full load shall not exceed 1/1500 of the span.

Power to the crane shall be provided by downshop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces.

The crane shall be controlled by means of hold-on push buttons with interlocks to prevent opposing functions operating. The control box shall be of the flexible pendant type with the weight of the pendant control box being supported by independent flexible wire ropes, which shall be earthed. The pendant shall be supported such that the operator may control hoisting from any position across the entire crane span.



The main hoist shall have two speeds. The normal lift shall operate at 1.8 m/minute with a creep control of 0.2 m/minute. Cross travel and long travel shall be 10 m/minute and 15 m/minute respectively.

After erection, all cranes shall be site tested in accordance with the relevant standards. These tests shall include a load test to 125 % of the rated safe working load and demonstration that the crane can operate over its full working range with the test load. The crane beam shall be checked to ensure that the maximum beam deflection when the test load is at the centre of the span shall not exceed that specified in the relevant standards.

On completion of these tests, a certificate shall be issued by a competent person confirming that the crane has passed the required tests and is safe to use. Until the certificate is issued, the crane shall not be used for any purpose.

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### 6.37 Steelwork, Access Platforms and Handrailing

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#### 6.37.1 General Requirements

The Contractor shall provide and fix all the steelwork, including stairways, ladders, handrailing, chequer plate and open mesh flooring, frames and curbing as detailed in the specification as shown on the Employer's drawings or as required to give access to all item of plant for operation or maintenance.

Approved GRP open mesh flooring may be used in areas subject to chemical spillage.

All steelwork aces platforms, and handrailing shall be constructed in mild steel and shall be heavily galvanised after manufacture in accordance with Clause 1.13.4 except where otherwise specified. After installation all handrailing and steelwork shall be painted in accordance with paint system P8.

All platforms, galleries and stairways necessary to permit safe access to the plant for operation and maintenance, shall be provided and installed by the Contractor .

For all prefabricated metalwork, including multiple duct covers, external ladders, open mesh flooring, chequer plating, handrailing, staircases, structural steelwork and the like, the Contractor shall submit fabrication drawings for the approval of the Engineer prior to the manufacture of any of these items.

A fixed stairway shall be provided as primary access to each elevated working surface where either:

- (a) the frequency of use is at least weekly; or
- (b) materials, tools or other equipment normally must be carried for operation or maintenance; or
- (c) there is potential for exposure to injurious chemicals or material at the elevated working surfaces; or
- (d) any work activity requires two or more people to gain access at any one time.

Where a dedicated emergency escape route from an elevated walking / working platform is required, a fixed stairway shall be provided.

A secondary means of egress (which may be a fixed ladder or fixed stairway) shall be provided for each elevated working surface if:

- (a) the location is 3 m or more above ground, floor or deck level and has 20 m<sup>2</sup> or more area; or if
- (b) there is a potential hazard or injurious chemical exposure that could block access to an exit.

The secondary means of egress shall not be more than 25 m horizontally from an area where operating or maintenance personnel may be working, and shall be located such that an alternative route of escape to a place of safety is provided.

Dead ends in elevated work areas shall not be over 7.5 m long.

Minimum headroom above all walkways, platforms, ladders, working / walking surface shall be 2.1 m.



#### 6.37.2 Handrailing

Handrailing shall be of galvanised mild steel of circular hollow section. Handrailing shall include galvanised mild steel toe boards, 100 mm. high by 3 mm thick.

Hand railing shall be double rail 1100 mm high. Standards shall be 38mm diameter solid forged steel with 60 mm diameter solid forged steel balls at handrail locations. Standards shall be fixed at maximum 1800 mm centres to metal work or 1500 mm to concrete. Handrails shall be 33.7 mm tubular steel. All components shall be hot dip galvanised to BS EN ISO 1461: 2009.

Where openings in the hand railing are required to facilitate removal and replacement of pumps or mixers or similar items of Plant, such openings shall be designed to open away only from the area being protected and the moveable section shall be securely fixed in position at all other times.

Handrailing and fixing shall be designed to withstand a horizontal force at handrail level of 85 kg per metre run. The deflection of rails shall not exceed 0.8 % of their span between standards and the deflection of standards shall not exceed 0.8 % of their height.

All mounting flanges drilled for not less than three bolts with two bolts on a line parallel to and on the walkway side of the line of the handrailing and vertical flanges drilled for not less than two bolts the line through the bolts being vertical. Fittings shall be screwed or secured with grub screws. When provided in sections, handrailing shall be jointed together with purpose made fittings secured by screws or grub screws.

All ladders, stairways or other openings shall be guarded on three sides by handrailing conforming to the requirements stated above. Access to the ladders or openings shall be guarded by two removable galvanised hanging chains.

The Contractor shall ensure that unless specified to the contrary all handrailing shall be of uniform appearances and manufacture.

#### 6.37.3 Open Mesh and Chequer Plate Flooring

Open mesh flooring and gratings shall generally comply with relevant standards except where otherwise specified hereinafter. Such flooring and gratings shall be of rectangular mesh and non-slip and shall be mild steel and galvanised as specified herein.

Approved GRP mesh flooring may be used in areas subject to chemical spill. It shall comply with loading criteria stated below.

Flooring shall be provided to span between the supporting members as shown on the Drawings.

Where necessary intermediate support members shall be provided and fixed.

Toe plates shall be provided around all cut-outs except where ordered by the Engineer.

Both the load bearing and transverse bars in rectangular flooring panels shall be positioned symmetrically around the centre lines of the panels in both directions, so that when the panels are fixed in extensive areas or in long runs, the bars of all panels are in line.

Chequer plate flooring shall be of the non-slip type, not less than 10 mm thick measured excluding the raised pattern. The flooring shall be secured to its frame by stainless steel countersunk set screws.

All flooring shall be designed to carry a loading of 400 kg/m<sup>2</sup> or such greater loading as is specified, and the deflection shall not exceed 0.2% of the span and shall be provided with curbing at the edge of walkways.

All flooring shall be removable and set flush in frame of similar material. Where frames are to be fixed over openings the frames shall be provided with lugs for building in.

Floor panels shall be sized to not exceed 25 kg for single person lift and provided with appropriate cutouts to permit its removal without disturbing or dismantling spindles, supporting brackets, cables or pipework. Where there is adequate space for movement around the panel (as detailed in the Manual



handling Operations Regulations 1992), 35 kg for a two person lift. The design shall prevent any possibility of overturning of individual panels. Where openings are required for access to valve or penstock operating spindle caps or other items, the holes in the flooring shall have a binder plate and if the access opening is greater than 50 mm circular or square, it shall be provided with a flush hinged plate or flush removable cover.

Intermediate supporting members to give the required rigidity to the spanning edges of individual flooring sections over the wider openings and trenches shall be provided and bolted to suitable built-in fixings. The members shall also be removable to afford clear access to the openings and trenches.

Lifting keys shall be supplied for each location.

#### 6.37.4 Stairways

Stairways shall be detailed, fabricated and erected to the dimensions shown on the drawings and designed and detailed to carry a load of 350 kg/m<sup>2</sup>. Treads shall be open mesh fixed to the stringers, not directly to concrete. Sloping handrailing shall be as specified for horizontal handrailing but with the top rail 900 mm vertically above the line of pitch and standards vertical and spaced at not more than 1500 mm measured parallel to the line of pitch.

Staircases shall be constructed to the size and position shown on the drawings or as instructed by the Engineer. They shall be steel hot-dip galvanised at works after manufacture and shall comprise stringers supporting the open work stair treads and shall be supplied complete with handrails and stanchions to dimensions similar to above.

Staircases shall generally have risers of 190 mm and goings of 270 mm. Stair's widths shall be a minimum of 1.1 m for general use or 0.8 m for infrequent use. A minimum headroom of 2.1 m shall be provided. The maximum number of risers between landing shall be 16. Landing length shall not be less than 1.1 m.

#### 6.37.5 Ladders

Ladders shall be fabricated of mild steel and galvanised as specified. The stringers shall be flat section not less than 65 mm x 10 mm spaced 380 mm apart and shall be flanged and drilled for wall fixing at both ends. The stringers shall be radiuses over the top where they shall be not less than 600 mm apart. Ladders over 3000 mm long shall have additional intermediate stays at not more than 2500 mm.

Where ladders reach platforms, the stringers shall be extended to a height of 1100 mm above platform level to allow safe access on to the platform.

Rungs shall be 20 mm diameter solid at 250 mm centres shouldered at each end and securely riveted into countersunk holes. Rungs shall be not less than 230 mm from the wall.

All ladders over 2.3 m above ground level shall have safety cages which shall be constructed of three flat vertical strips supported by flat hoops, with a diameter of 750 mm. The hoops shall be at approximately 700 mm centres and the first hoop shall be 2300 mm above ground. Where vertical ladders rise from elevated platforms then protection shall be provided against falling from platform level.

Where the rise exceeds 6000 mm, an intermediate landing shall be provided.

Ladders shall not be permitted as a primary route for escape.

#### 6.37.6 Multiple Duct Covers and Frames

Multiple duct covers and frames shall be of cast iron, waterproof, non-rocking and recessed for filling with concrete or similar material.

They shall be of the type incorporating integral, removable, intermediate beams to give an appropriate clear pit opening.

A heavy grease seal is to be formed between the cover and frame to prevent ingress of grit.



All covers, frames and supporting metalwork shall be designed for loadings to relevant standards. All supporting steelwork shall be galvanised as per this Specification.

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### **6.38 Fire Protection and Safety Equipment**

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#### **6.38.1 Portable Fire Fighting Equipment**

Portable fire extinguishers shall be provided in all control rooms, laboratories, offices, workshops and any other area where fire might break out.

Extinguishers shall be of the Water Type or Dry Powder Type depending on the location and possible hazard.

In general, water type extinguishers shall be used for Class A risk areas and shall be 9 litre capacity.

Dry powder extinguishers shall be suitable for electrical, chemical and oil fires and shall contain not less than 5 kg of extinguisher.

Extinguishers shall be colour coded and clearly marked with their type and the class of fire for which they are suitable and comply with the relevant ISO or ANSI standards.

The numbers and dispositions of extinguishers shall be in accordance with any local requirements and shall be agreed with the Engineer.

#### **6.38.2 Compressed Air Breathing Sets**

Compressed air breathing sets shall be provided wherever dangerous chemicals are stored or where emergency access to confined spaces may be required.

The sets shall comprise harness, back plate, air bottle, pressure reducer assembly, demand valve, contents gauge, face mask and all necessary air hose and fittings. Air bottles shall be sized to give an endurance of not less than 30 minutes.

The sets shall be located in steel or GRP enclosures having a clear glass or PVC front so that any deficiency in the equipment shall be apparent.

The location of the cabinets shall be agreed with the Engineer.

#### **6.38.3 Ductwork**

Ductwork, fittings and all associated hangers, supports, dampers, flexible joints, sealants, insulation, access, testing and builder's work connections shall conform to the recommendations of the HVAC unless otherwise stated. Air duct velocities in main duct shall not exceed 12.5 metres per second and duct aspect ratios shall not exceed 4:1. Ductwork shall be true in section independently supported and free from contact with the building structure.

Internal jointing of ducting shall be avoided wherever possible, but if unavoidable, joints shall be constructed so as to minimise air turbulence at these sections. They shall give a smooth internal surface with no reduction in cross sectional area of duct. Longitudinal standing internally formed joints or stiffening may be allowed however on large section ducts. Any required angle stiffening shall be external and access covers shall be provided at each internal joint.

Ductwork shall be designed to suit the environment in which it is designed to operate. Material of construction shall be polypropylene, PVC-U, GRP or stainless steel.

Ductwork within buildings shall be above ground level.

Ductwork external to building shall be installed below ground level or below tank covers.



The material of construction shall be completely suitable for operation in the prevailing internal and external atmospheric conditions.

Main duct runs and branches shall be installed with damper to allow for flow regulation/balancing and for isolation purposes. Access openings shall be provided adjacent to control/isolation dampers with diameters equal to and greater than 150 mm.

Dampers shall provide airtight seal in the closed position.

Pilot test holes shall be provided in all main duct runs and branches for airflow measurement to allow the complete system to be balanced. Suitable grommet and sealing plates shall be fitted to the test holes.

Appropriate gas sampling points shall be supplied in ducting running from each major leg at a distance of not less than four duct widths from any bend. Ports for manual sampling shall have a minimum diameter of 30 mm. Removable plugs for each of the sampling ports shall be supplied.

Ductwork shall be designed to be laid with falls and be complete with valves situated at low points to enable condensation to be drained. Ductwork should generally fall back to the extraction point to ensure that condensation falls back to the tanks from which air is being extracted. The ductwork shall be designed to ensure that the total number of drain points are minimised.

Drain legs that contain water shall be protected from freezing.

The ductwork installations shall be designed to avoid trappings of fumes or gases in dead ends and prevent the collection of condensation which may be formed internally at any point in the duct work and which cannot be drained through drain valves located at accessible positions.

Air flow meters shall be provided to monitor the total airflow in the systems.

Flexible joints shall be used at connections to items of Plant.

Attention shall be given to adequate and sufficient supporting of ducting, together with accommodation of thermal expansion.

Ductwork supports shall be fabricated from either stainless steel or from galvanised mild steel. Duct supports shall be held off ductwork with neoprene lining to brackets.

Dampers and test points shall be accessible from ground level or from walkways and platforms.

Labels shall be provided as follows:

- i. Identification of test points
- ii. Identification of drain points
- iii. Identification of isolation/control dampers and commissioned setting of dampers

Airflow rates shall be regulated in accordance with the recommendations and tolerances laid down in CIBSE commissioning code A. A full commissioning record shall be kept together with final airflow rates achieved.

Ductwork shall be smoke tested to ensure that joints are gas tight.

Ductwork shall be earthed to ensure that no uncontrolled static discharge can occur.

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### **6.39 Tanks**

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#### **6.39.1 General**

Tanks shall be designed, erected, and tested generally in accordance with AWWA D100: 2005.



Welded steel tanks shall be designed with a corrosion allowance of 1.5 mm.

Steel plate thickness shall not be less than 5 mm.

Internal roof support structures shall be protected from corrosion to maintain the design life of the tank.

Tanks shall be provided with drain points, which shall terminate with a Bauer type coupling.

High level interconnecting pipework with an isolating valve shall be fitted between adjacent storage tanks of similar purpose.

High level overflows shall be fitted to tanks for emergency situations.

Drilling or welding to the tank structure after the plates have been coated shall not be allowed.

Tanks shall be provided with a davit operated access hatch on the side of the tank for cleaning purposes. The access hatch shall be easily opened and closed with the minimum of dismantling time. The hatch seal shall not be compromised upon operating the hatch and shall be re-usable. The seal shall be designed such that it only requires replacement after more than 15 operations. The hatch design shall provide for the safe access of personnel to the tank for all inspection and maintenance functions.

#### 6.39.2 Glass Coated Steel Tanks

Glass coated steel tanks shall consist of a shell fixed to a concrete base. Vertical cylindrical tanks constructed of bolted sectional panels shall be supplied. Stiffening of the vertical surface of the tank shall be fixed to external surfaces.

The tanks shall be classified to suit the operating pressures that can occur when in service.

Superimposed loads on the tank shell, shall be based on: internal vacuum; plus snow load; plus weight of roof, or 1.2 kN/m<sup>2</sup>, whichever is the greater.

Tank flange nozzle connections shall be provided with suitable reinforcing plates for bolting to the tank shell. Tank nozzles and reinforcing plates shall be manufactured from stainless steel.

Tank fittings to be galvanised shall have work carried out on them, i.e welding, drilling, bending, etc., prior to coating. After galvanising the surfaces shall be passivated against the formation of white rust.

The sectional panels making up the tank shall be of glass coated steel (vitreous enamelled), the coating being applied to both sides. The coating shall comply with the applicable requirements of ISO 28722: 2008. Bolted lap-jointed construction shall be employed using an inter-panel sealant to give a structure which is leak tight.

The steel plates used to make up the panels shall be to BS EN 10130: 2006, Grade HR3 or of a higher strength steel, and in every case steel produced suitable for vitreous enamelling.

Machining, i.e., cutting the plates to size and shape, providing bolt holes, providing holes for flanged connections, and rolling to the correct curvature, shall be carried out prior to coating. Drilling or welding to coated panels shall not be allowed.

Drifting to align holes during assembly shall not be allowed.

Prior to coating, the plate surfaces shall be blast cleaned to remove all rust and mill scale then chemically cleaned if necessary, to remove any grease and dirt.

The panel surfaces shall be coated evenly with a three-coat protection system to a minimum glass thickness of 280 microns. The coating shall be tested to 1000-volt zero defect with controlled test voltage + 1% at probe contact.



**Typical physical properties shall meet the following requirements:**

| Parameter             | Value                                                                                                                                                      |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Adherence             | glass to steel, in excess of 34 MN/m <sup>2</sup>                                                                                                          |
| Flexibility           | glass and steel to be the same                                                                                                                             |
| Young's Modulus       | 70 GN/m <sup>2</sup>                                                                                                                                       |
| Percentage Elongation | 0.3%                                                                                                                                                       |
| Poisson Ratio         | 0.2                                                                                                                                                        |
| Hardness              | 3.5 to 6 (Mohr Scale)                                                                                                                                      |
| Abrasion              | 0.0078 gm (Tabular Test)                                                                                                                                   |
| Chemical Resistance   | Alkalis and acids, both organic and at Design Temperature inorganic (not hydrofluoric acid or sodium hydroxide) between pH5 and pH11 - complete resistance |
| Peeling               | None                                                                                                                                                       |
| Chipping              | None                                                                                                                                                       |
| Porosity              | None                                                                                                                                                       |

Tank fixings which will come into contact with the product to be contained in the tank, including the gases released from the product, shall be manufactured from suitable corrosion resistant material.

Tank shell stiffening rings and foundation fixings shall be of carbon steel hot dip galvanised in accordance with BS EN ISO 1461: 2009.

Bolts, nuts, and washers shall be high tensile grade carbon steel hot-dipped and spun-galvanised. Washers shall be provided at all positions under the nuts. Bolts shall be of sufficient length such that at least one clear thread pitch protrudes through the nut on final assembly. Loading on the bolts, imposed by the panels and other tank attachments, must be taken on the shank portion of the bolt and not the threaded section.

Bolt heads occurring within the tank shall be mushroom shaped to spread the load on the glass coated steel surface. The head shall be encapsulated with polypropylene, or of a similar material, to completely seal the bolt head from the liquids and gases within the tank, and to effectively seal the assembly hole in the panel.

The bolt head encapsulating material shall be suitable for being in contact with the waste liquids specified.

A full-width mastic joint sealant shall be applied between the glass coated steel panel sections. The sealant shall exude through the bolt hole to completely fill the gap between the bolt shafts and the panels and along the edges of the panels. Along these edges a neat continuous fillet shall be produced which shall extend by at least 4 mm across the panel face to give protection to the panel corners.

The sealant shall be suitable for being in contact with the product stored.

The sealant shall be non-biodegradable and resistant to both ageing and weathering under the expected service conditions which will exist. A good adhesion to the panel glass coating shall be assured.

Application of the sealant shall be carried out strictly in accordance with the maker's recommendations. The panel surfaces and edges shall be thoroughly cleaned of all oil, grease and other surface contaminants prior to any sealant being applied.

Quality assurance checks and inspections shall be carried out throughout the entire manufacturing process, including packing for transportation and during erection at site. Documented evidence of such checks and inspections, including Certificates of Test, shall be maintained, and made available for review if requested.

The tanks as finish installed at site shall be of high quality and the programme of quality assurance checks and inspections to be carried out shall take this into consideration. Testing shall be carried out in accordance with the relevant sections of BS 1344 'Methods of testing vitreous enamel finishes', BS EN 14483 and BS EN ISO 8289: 2001 'Vitreous and porcelain enamels - low voltage test for detecting and locating defects'.



The Contractor shall provide a portable detector to facilitate witnessed defects checking on site.

Damaged panels shall not be used for construction of the tanks. Panels which sustain damage prior to the take over of the installation shall be dismantled and removed from site.

Only minor superficial damage to the coating and isolated porosity shall be allowed to be repaired on the panel faces. Panels with excessive porosity, cracks, crazing of the coating, deep scores, chipping or peeling evident on the surfaces shall be rejected. There shall also be a uniformity of colour between panels.

Details of the proposed method of repair and materials to be used for repair shall be submitted to the Engineer for approval.

#### 6.39.3 Sectional Epoxy Coated Steel Tanks

Except for the coating specification sectional epoxy coated steel tanks shall comply with the requirements stated for glass coated steel tanks.

#### 6.39.4 Tank Burial

Generally, glass and epoxy coated steel tanks are intended for above ground use. Where the lower section has to be buried, the buried depth shall not exceed the depth of one horizontal plate, the backfill to the steel plate shall be 10mm single size rounded gravel to ensure uniform loading, and the overall design shall resist flotation under any condition whatsoever without resort to temporary pumping or reliance on drainage.

#### 6.39.5 Roofs and Covers

Roof and covers shall be provided with inspection hatches for: viewing of the tank contents; removal of plant and viewing of installed plant and materials including weirs and launders.

Roofs and covers shall be designed to act as occasional man access to roof mounted plant and inspection hatches and for forced air purging/ventilation.

Non-slip surfaces will be required for defined walkway areas. The surfaces shall be non-slip in both wet and dry conditions.

Roofs and covers shall be designed in accordance with the design loadings stated in AWWA D100: 2005. Design pressure classification shall be selected to suit the operating pressures that can be created when in service.

Dead loadings shall apply to the self weight of the roof material.

Superimposed loads shall be based on internal vacuum plus a snow load, or 1.2 kN/ m<sup>2</sup>, whichever is the greater.

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### 6.40 Surge Protection Vessels

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#### 6.40.1 General

Surge vessels shall be of the air pre-charged bladder type. The air shall be contained between the bladder and the vessel shell.

A method statement for the safe charging of the vessel with air shall be included in the Operation and Maintenance Manuals.

Vessels shall be constructed and tested in accordance with PD +A1 5500: 2009 or equivalent International Standard.

Internal weld surfaces shall be dressed for a smooth finish prior to painting.



If vessels are to be installed in locations where they are subject to freezing conditions, they shall be applied with insulation fitted with an outer cladding protection. Trace heating of the vessels shall also be installed.

#### 6.40.2 Bladder

The bladders shall be manufactured from a suitable quality butyl rubber with a minimum life expectancy of 15 years.

The bladders shall be capable of being readily removed without the need to dismantle the vessel from the installation. A method statement for the safe removal of the bladder shall be included in the Operation and Maintenance Manuals.

#### 6.40.3 Fittings

Each vessel shall be fitted with:

'Schrader' type valve for gas pressurisation.

Suitably rated safety valve.

Water drain valve, complete with plug fitted to the open end. For sewage applications, the drain outlet shall be a minimum size of 200 mm.

100mm diameter pressure gauge calibrated in bar and meters head, complete with snubber and isolation valve.

Gas bleed valve, complete with plug fitted to the open end.

Water level indicator suitably marked with the correct operating levels for pump stopped and operating with varying numbers of pumps under steady state conditions.

Flange connection for connecting to the pumping main.

450 mm minimum size inspection opening.

Two 25 mm threaded bosses for future instrument connections, fitted with suitable plugs.

The gas charge connections shall be accessible from floor level. The hose assembly for connecting to pressurising plant shall be provided with each vessel.

The water level indicators shall be suitable for continuous monitoring, i.e. they shall not allow gas to 'escape' under low water mains pressure conditions without the need to close isolation valves.

Isolation valves which if accidentally opened allow gas or water to 'escape' shall be provided with locks.

#### 6.40.4 Pressure and Vacuum Gauges

Gauges shall be provided for all pumps as detailed in the Specification and for all other equipment where necessary.

Pressure and compound gauges of approved manufacture shall be provided and fixed directly to and at the same level as the delivery and suction branches of each dry well pump. The gauges shall be fitted with diaphragm type isolating valves, but siphon pipes will not be required. Gauges shall not be connected to air release or auxiliary suction pipes.

All gauges shall have concentric dials of 150 mm diameter, pressure gauges being graduated in metres head, and compound gauges in centimetres of mercury and metres head. Gauge graduations shall be such that the gauge is never used continuously beyond 60% of the maximum graduation. The face of the dial shall have a warning label marked in red attached thereto reading:

"IMPORTANT TURN OFF WHEN NOT IN USE"



The gauge mechanism shall be of the Bourdon tube type, having stainless steel movements and shall comply with relevant standards. It shall be sealed from the liquid being measured by means of a diaphragm or capsule and be filled with silicone oil.

All gauges shall be fitted with a pressure snubber to dampen pressure pulsations.

Before the gauges are delivered to site, each gauge shall be tested in accordance with relevant standards and a test certificate for each gauge, confirming that they are of the required accuracy, shall be sent to the Engineer. Further copies of the test certificates shall be incorporated in the operating and maintenance manuals.

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#### **6.41 Electric Motors**

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All motors shall be of a make approved by the Engineer and shall be suitable for operating from the specified power supply. Motors shall comply in all respects with the relevant parts of IEC 60034. High efficiency type motors shall generally be supplied.

Motors shall be three phase, squirrel cage or wound rotor, induction type, continuously rated for the heaviest specified duty, totally enclosed and suitable for operation on the electricity supply.

In addition to the requirements of the standards BS 5000, the motors shall be capable of satisfactory operation with a frequency variation of  $\pm 5\%$  above or below the normal frequency of 50 Hz.

The design of the motors shall be adequate in all respects for the number of starts per hour required when the driven equipment is in normal operation at maximum ambient temperature.

All motors shall have Class F insulation as a minimum, but the motor temperature rise shall be limited to that applicable for Class B insulation.

Motor enclosures should be a minimum of IP55 unless specifically stated.

Motors shall be fitted with locating type bearings and/or heavy type thrust bearings at the non-drive end and roller type bearings at the drive end according to the type of motor offered, but all bearings shall be of adequate proportions and design suitable for the particular application. All motor bearings shall be rated for 100 000 hours continuous running.

Grease lubrication shall be applied using hydraulic type nipples and where necessary an automatic feed system.

"Sealed for life" bearings shall not be used.

The motors shall be built of high grade components and materials in accordance with the best practice for the type of plant offered.

Motors 4 kW and above shall be fitted with temperature sensitive thermistors embedded in the motor windings. The thermistors shall be suitable for connection to a monitoring unit in the motor control circuit to provide protection against winding failing due to overheating. The motor starters shall trip in the event of high winding temperature being experienced.

All motors shall be capable of delivering 10% in excess of the maximum power absorbed by the equipment being driven under the most adverse operating conditions.

Continuously rated anti-condensation heaters shall be installed in all motors above 5.5 kW. They shall be sized by the supplier to suit the motor frame size.

Heaters shall be located within the motor so that the heat dissipated does not damage the insulation of any of the windings or associated cables. Heaters shall be interlocked with the motor starters such that they are switched off when the motors are running.



Terminal boxes shall be conveniently located and of adequate size to accommodate the cables. Terminal mountings shall be arranged such that the motor supply wiring can be disconnected without disturbing its internal connections. The connections of the motors shall be brought out to terminals at the side of the frame and properly clamped and terminated within a cable box complete with correct glands to accept the size and type of cable specified. In general the glands shall be downward pointing at an angle to pass the cables clear of the base frame and plinth.

All cables entering terminal boxes shall be provided with compression type glands, which shall firmly locate the cable and provide a weatherproof seal commensurate with the IP rating of the machine.

The end of each winding shall be brought out to a separate terminal, connecting links being provided to facilitate interconnection of individual terminals.

A diagram of connections shall be fixed inside the terminal box cover which shall be provided with watertight, oil resisting gaskets.

Where motor anti-condensation heaters are fitted additional terminals and a separate cable gland entry shall be provided.

Plates shall be fixed on each motor, giving the following information:

| BS No            | No of Phases  |
|------------------|---------------|
| Manufacturer     | kW            |
| Serial No        | Voltage       |
| Insulation Class | Speed         |
| Frequency        | Current at FL |

All motors rated in excess of 150 kW shall be fitted with suitable vibration control devices to automatically shut down the motor in the event of excessive vibration.

Vertical spindle motor units rated in excess of 11 kW shall be fitted with a thermo couple at the upper thrust bearing to shut down the motor in the event of the bearing temperature exceeding a recommended value. Details shall be provided for approval  
Motors that are water cooled shall include suitable protection to safeguards against the lack of water flow.

Air vents and other openings where provided will be screen protected.

Emergency stop/lock-off push buttons shall be provided adjacent to all electric motor drives. Each shall be of the surface mounted weatherproof push to break and mushroom type with latching device to resist the push button return movement so that contacts remain normally open until the latch is released by a counter clockwise direction.

The overall power factor of the plant under any load or operating condition shall not be lower than 0.9 lagging. Power factor correction capacitors rated at 85% of the no-load kVAr of the motor shall be provided for each motor of above 5kW rated output. In addition, capacitors shall be fitted to smaller motors as necessary to maintain the minimum power factor specified above.

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## **6.42 MIXERS**

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### **6.42.1 General**

This Specification covers the requirements for the supply, installation, testing and commissioning of mechanical mixers.

This Specification shall, inter alia, form part of the contract document.

This specification contains clauses that are generally applicable to mechanical engineering construction.



Interpretation of and modification to this specification are set out in the Process Specification.

The mixers shall be designed for the mixing of chemical and flocculation solutions used in the treatment processes.

The volume and liquid depth of the tanks will be as specified in the Process Specification.

The mixers shall be of robust construction from heavy gauge material, and shall be protected from corrosion as specified in the Specification dealing with Corrosion protection and painting.

The gearboxes shall be designed to withstand the loads imposed by the driven equipment and shall be of "Hansen" or equivalent approved manufacture. All bearings shall be designed to have a B.10 life of not less than 100 000 hours.

Gearboxes shall be selected so that the power service factor is not less than 2.0. The mechanical efficiency shall not be less than 95%.

The gears shall be of the helical teeth or spiral bevel gear type. Worm gears shall not be used. The gears shall be cut, hardened and ground to final profile. Gears shall not have been machined in a semi-hardened state.

The bending, radial and axial loads imposed by the mixer on the gearbox shall be within the limits specified by the gearbox manufacturer. The gearbox housing shall be manufactured from high quality cast iron.

The driving motors shall be connected to the gearboxes by means of flexible couplings. The couplings and exposed shafts shall be protected from the weather and from corrosion due to moisture by means of suitable covers or skirts incorporating properly designed ventilation and drainage openings.

Lubrication points shall be easily accessible. Extension tubing or other approved remote lubrication arrangements shall be provided for awkwardly located bearing, etc. All oil baths shall be provided with a dipstick with the maximum and minimum levels permanently marked.

The gearbox shall be positioned sufficiently above the support platform to provide space for a receptacle for drained oil. The oil drain shall be provided with a valve spout projecting beyond any base frame on which the gearbox may be mounted.

The gearbox or the baseplate on which it is mounted shall be provided with jacking bolts which allow for 50mm movement up and down.

Remote lubricating facilities for the output shaft lower bearing shall be provided. The gearbox shall be constructed with a dry well for the output shaft lower bearing to avoid complete drainage of oil in the event of an oil seal failure. The gearbox casing, breather and dipstick breather shall be designed to prevent moisture from entering.

The electric motors shall be rated for a 380 V 50 Hz three phase power supply and shall comply with the Electrical Specification.

The heaters, instruments and controls shall be rated for a 220 V 50 Hz single phase power supply.

The contractor shall provide all plant that is necessary to install, test and commission all items of equipment covered by this Specification.

The equipment shall comply with the details stated in the Process Specification as approved by the Engineer and shall be supplied complete with electric motors and gearboxes.

The mixers shall transfer sufficient energy to the liquid to maintain all the solids in suspension and create adequate scour velocities near the floor of the tank to prevent an accumulation of solids on the floor, but minimize velocities near the surface. The mixers shall not give rise to turbulence leading to the entrainment of atmospheric oxygen into the mixed liquor.

Platforms and access bridges must be provided for the mixers.



Mixer shafts shall be aligned to within 5 mm of vertical. Shafts shall not be more than 1 mm out of straight.

If so instructed by the Engineer, in order to establish the performance of the equipment, the Contractor shall carry out in situ tests as specified below that are witnessed by a representative of the Engineer. Full details of tests and the calculated results shall be handed to the Engineer.

In situ tests shall consist of:

Measurement of power absorbed by each motor during mixing.

Determination of concentration according to Standard Methods on samples taken at levels one third, two thirds and full liquid depth with a 50 mm diameter Perspex tube sampler at a minimum of six locations.

Measurement of dissolved oxygen concentration 900 mm below water level at two locations at the inlet and outlet of the basin. The basin shall receive no influent during the test. The dissolved oxygen concentration will be measured at the start and end of 30 minutes mixing period.

The measurement of power, solids concentration and dissolved oxygen concentration shall be taken during the same test.

The test shall be conducted after the process has had time to build up to the design concentrations.

The equipment will be accepted as commissioned when the power absorbed as measured on Site is within 5% of the value stated by the Contractor in the Detail Sheet.

The mixing shall be accepted as complying with the specification if the solids concentration between the top and bottom sample at any location does not differ by more than 10%.

The dissolved oxygen concentration increase/decrease across the anoxic basin will be accepted as complying with the specification if the average of three determinations is within 5% of the value stated by the Contractor in the Detail Sheet.

Measurement and payment shall be in accordance with General Specification.

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#### **6.43 DAF, LAMELLA PLATE SETTLERS & THICKENING TANKS**

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##### **6.43.1 General**

This specification covers the requirements for the supply, installation, testing and commissioning of mechanical equipment for settling tanks.

This specification shall, inter alia, form part of the contract document.

This specification contains clauses that are generally applicable to mechanical engineering construction. Interpretation of and modifications to this specification are set out in Process Specification.

The quality of sludge to be settled may vary and the settling tank shall be capable of operation at the design inflow and sludge flux loading and withdrawal rates.

The size, side water depth and design flows for the settling tank shall be as specified in the Process Specification.

The equipment shall comply with the details stated in the Process Specification as approved by the Engineer.

The equipment shall be painted in accordance with the corrosion protection specification.

The sludge withdrawal shall be performed by means of hydraulic pressure via openings with pipeline and valves.

Sludge withdrawal shall be continuous and shall be controlled by means of a valve installed on the de sludge line outside the confines of the tank.



The following sludge and screen must be reposed as specified in the Process Specification.

Weir plates shall be 'V' notched and fabricated from stainless steel. Scum baffles and supports shall be fabricated from stainless steel, and shall be 300 mm deep, with at least 200 mm extending under the water level at average flows,

The overflow weirs shall be adjusted against actual hydraulic overflow conditions.

The electric motors shall be rated for a 380 V 50 Hz 3-phase power supply. The heaters, instruments and controls shall be rated for 220 V 50 Hz single phase power supply.

The contractor shall provide all plant that is necessary to install, test and commission all the items of equipment covered in this section.

Weir plates shall be fixed to the channel in such a way as to ensure 50 mm of vertical adjustment.

Scum baffles shall be positioned 300 mm away from the overflow weir and shall be sufficiently rigid in construction and support so as to remain true under operating conditions.

Should the Contractor require weir and scum plate holding down bolts to be cast in to the structure, he shall supply templates to the main civil engineering contractor for this purpose.

The concrete tank shall be constructed to the following tolerances:

|             |                                                      |
|-------------|------------------------------------------------------|
| Tank        | ±15 mm                                               |
| Top of wall | ±5 mm but ± 3 mm in any continuous length of 3.00 m. |

If so instructed by the Engineer, in order to establish the performance of the equipment, the Contractor shall carry out in situ tests that are witnessed by a representative of the Engineer. Full details of tests and the calculated results shall be handed to the Engineer.

In-situ tests shall consist of;  
Measurement of sludge withdrawal  
Measurement of scum withdrawal

Measurement and payment shall be in accordance with General Specification.

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#### **6.44 Chlorination Equipment**

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##### **6.44.1 General**

This specification covers the requirements for the supply, installation, testing and commissioning of chlorination equipment for use in water purification.

This specification shall, inter alia, form part of the contract document.

This specification contains clauses that are generally applicable to mechanical engineering construction. Interpretations of and modifications to this specification are set out in the process specifications.

The chlorinator equipment shall be capable of chlorinating filtrate (clear water) from the gravity filters.

The equipment shall be capable of chlorinating the filtrate at the dosing rates and flows specified in the Process Specification.

The design of the chlorination equipment shall conform to any Government and/or Local Authority regulations governing the storage and handling of chlorine.

The chlorination equipment shall comprise the following elements suitable for the duties and cylinder or



tank sizes specified in the Specification.

- Chlorinator and injector for dosing gaseous chlorine.
- Weighing equipment such that any of the bottles or tanks can be weighed without disconnecting the chlorine supply from the bottle or tank.
- All valves, controls, switches, piping and heaters.
- Booster pumps complete with float switches, pipework and diffuser.
- A set of chlorine gas masks and rubber gloves housed in a weatherproof cabinet mounted at the entrance of the chlorinator house.
- A complete caustic soda (NaOH) scrubbing system to neutralize 1 Ton of chlorine gas in the case of a leakage.
- All electrical equipment required for the proper operation of the chlorination equipment.
- Any special tools required for maintenance and changeover.

The electric pump motor shall be rated for a 380 V 50 Hz 3-phase power supply, and shall comply with the Electrical Specifications.

The contractor shall provide all plant that is necessary to install, test and commission all items of equipment covered by this specification.

The equipment shall comply with the details stated in the Detail Sheets as approved by the Engineer.

The chlorinator shall be capable of dispensing chlorine gas in the dosage range specified in the Process Specification. The chlorine feed shall operate under a vacuum produced by an injector on the feed water supply system, which injector shall dispense the chlorine gas into the water at the dosing point. In the event of failure of the feed water supply to the injector, the chlorinator shall shut-off automatically.

The chlorinator shall have a simple, easily read, linear rate of feed scale graduated in units of mass per unit time. Adjustment of the feed rate shall be by means of an adjustable knob. The chlorinator shall have a minimum downturn ratio of 1:12.

The filtrate to be chlorinated will discharge freely at a fairly constant rate from gravity filters chlorine contact tanks. The tank will provide for sufficient retention. A booster pump shall be provided to draw water from the contact tank, and the chlorine shall be drawn under vacuum into the delivery line of the pump for return of the chlorine solution to the contact tank. The pumps and pipework shall be capable of operating under the conditions specified in the Process Specification.

The pumps shall be provided with float switches which shall switch the pump and hence chlorine delivery, on and off for flow and no flow conditions respectively.

The injector, complete with strainers and all gas and solution piping to connect the various items of equipment, and convey the solution to the point of application, shall be supplied as part of the chlorinator. The chlorinator shall be fitted with gauges indicating the chlorine gas pressure and the injector water pressure. A vent tube shall be provided to conduct chlorine gas to the outside of the building in case the whole of the chlorine gas is not absorbed at the injector. Two gas masks in a suitable case shall be supplied as part of the chlorinator equipment and mounted outside the chlorinator room door.

The size of chlorine cylinders tube used, and the minimum dosage rate shall be as specified in the Process Specification. When the maximum withdrawal rate exceeds 1.5kg/h for 68 kg cylinders or 9 kg/h at 20°C for 1 000 kg tanks, provision shall be made for the gas to be drawn from a bank of cylinders or tanks.

Notwithstanding the requirement for more than one cylinder or tank under peak dosage requirements, it shall be possible to operate the equipment under reduced dose with only a single cylinder or tank online.

Unless otherwise specified in the Process Specification, the terms of Medium pressure pipeline, valves, etc. shall apply, where relevant.

If so, instructed by the Engineer, in order to establish the performance of the equipment, the contractor shall carry out in situ tests that are witnessed by a representative of the Engineer. Full details of tests and the calculated results shall be handed to the Engineer.

In situ tests shall comprise:



- Testing of chlorination rate in kg/h chlorine used.
- Testing of booster pump delivery rate and pressure.  
The equipment will be accepted when the test results are within 5% of the values stated by the Contractor in the Detail Sheets or required in terms of this specification.

Measurement and payment shall be in accordance with the General Specification.

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#### **6.45 LIME DOSING EQUIPMENT**

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##### **6.45.1 General**

The proposed lime dosing facility shall consist of the following elements:

- Lime solution make-up system comprising of lime hopper with vibration agitation, 2 dry feeders (1 duty and 1 standby) and mixing bowl.
- Lime hopper to be sized for holding 1 shift, i.e. 8 hours requirements.
- Lime solution dosing pumps, delivery pipework and fittings, and dosing control equipment.

Lime dosing equipment and ancillary works shall generally conform to the following requirements:

- Design flow velocities in dosing lines shall be between 1.0 m/s and 2.0 m/s. More viscous solutions shall operate at the lower limits. Flow velocities below 0.6 m/s and above 3.0 m/s shall not be acceptable.
- All chemical dosing lines shall be coupled to a clean water supply to facilitate the flushing of dosing lines after shut down.
- Pipework and manifolds shall incorporate adequate isolation control and/or reflux, valves, suitable for the respective chemical, to allow for acceptable operation, maintenance and flexibility. All positive displacement pumps shall be equipped with a pressure relief valve on the delivery line, allowing for discharge back to the source.
- Dosing pumps shall be accurately adjustable and capable of maintaining set rates to  $\pm 2.5\%$  of the required rate at average duty flow. The delivery to each dosing point shall be equipped with a suitable rotameter sized for the respective pump duty.
- Pipework shall be adequately fixed or supported to prevent pipe deflections of more than 5 mm from the true line.
- Dosing of the lime will be automatically controlled by positive displacement metering pumps with a variable speed drive and control unit the control unit will consist of a microprocessor that will receive a 4-20mA signal from a flow meter and PH sensor to regulate the chemical dosing rate.

Slaked lime ( $\text{Ca}(\text{OH})_2$ ) dosing is required for the correction of pH. The lime dosing control loop will be as follows.

Adequate measures shall be taken to prevent lime dust pollution to the environment. The dry feeders shall be fitted with a hopper to accept at least enough lime for one 8-hour shift at average loading conditions. Adequate dust control measures shall be taken at all problem points. Lime hoppers shall be equipped with vibrators to ensure a constant supply to the dry feeder. A standby dry feeder shall be supplied. The dry lime feeder will be dosed by mechanical screw into a vortex mixing bowl driven by hydraulic jet (feed and suspension water) in order to wet lime and prepare a homogeneous lime suspension. This suspension will be dosed by transfer pump (1 duty, 1 standby).

Milk of lime suspensions shall always be pumped at flow velocities between 1.0 m/s to 2.0 m/s. The lime concentration shall be altered to increase or decrease the lime mass flow rate in order to maintain the required flow velocities.

The lime dosing pumps shall be of progressive cavity metering type with the control of the dosing rate using a variable speed drive. The pump heads shall be manufactured from durable material compatible with material to be pumped.



A pressure sustaining valve and pressure relief valve shall be installed downstream of the isolating valve on the discharge pipe from the pump set.

All materials used in the manufacture of equipment and pipework shall be resistant to the corrosive action of the specific chemical to be handled.

Electrical power supply is at 220V single phase, 50 Hz frequency, or 400V three phase where required.

The contractor shall carry out performance tests on the plant and equipment after the completion of installation testing and commissioning that shall be witnessed by the Engineer. The contractor shall provide all calibrated and other equipment and staff necessary to conduct the tests.

Performance testing under operational conditions shall include the following minimum operations:

- Effective operation of the complete system under manual and automatic control.
- Measurement of maximum and minimum withdrawal and dosing rates of Lime.

Sampling and analysis shall be in accordance with the standard Methods. The performance of the equipment will be considered acceptable if the criteria set in the QCP have been achieved.

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#### **6.46 FILTER INSTALLATION**

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##### **6.46.1 General**

This section details the requirements for filters. The tenderer may offer alternative plant and equipment to achieve the process requirements stated in this specification. If an alternative system is offered, the tenderer shall submit detailed technical information and references together with the tender offer.

The mechanical portion of the Works described under this section include for the design, manufacture, supply, transport, offloading, handling, storage, erection, installation, testing, adjustment, commissioning, trial operation, handling over in complete working order, and upholding during the Defects Notification Period of mechanical plant and equipment.

- Dual media filters installation inclusive of filter media, nozzles, backwash system, scouring system, control system, and feed and outlet pipework, valves and fittings.
- Archimedes lifting pump installation for lift clarified effluent to the flocculation chamber ahead of the sand filters.
- Penstocks and Sluice gates.

The filter installation will be fed via a common inlet channel and which will discharge into a common filtered effluent collection manifold.

Backwash requirements will be provided by a central backwash installation comprising a duty and standby pump arrangement, with piping and valve arrangements to control backwash to any of the filter units.

Air scouring will be provided by a central blower installation comprising of a duty and standby compressor, with piping and valve arrangements to control scouring to any of the filter units.

The reactor configuration as depicted on the civil drawings accompanying this tender shall be considered as preliminary. The final design will take into consideration of the Contractor's requirements based on the specific equipment, media and arrangements offered. Where modifications to the Engineer's design is required, these modifications are to be detailed in the tender submission.

The Contractor shall be fully responsible for the design of the entire filtration system, inclusive of selection of the filter media, sizing of filter beds, inlet and outlet system, backwash system and air scouring system.

The rapid gravity filters will operate on a constant rate principle with an adjustable valve on each filter outlet to compensate for low initial headloss through the filter bed, increasing as the filter clogs up. Once the filter outlet valve reaches the fully open position (or if the water level on the filter increases above a preset level), the automated filter backwash cycle will be initiated. Filters will be backwashed in a preselected series. The filter wash cycle will consist of the following steps repeated for each filter in



sequence:

- Isolate inlet gate to filter
- Isolate filter outlet valve
- Start blower and open blower airline to filter
- Start backwash pump in low flow mode and open filter backwash inlet. (low flow can either be by VSD or by regulated bypass pipe) Low backwash flow will be activated for the duration of the air scour period (2 to 5 minutes, adjustable)
- After the air scour period the air inlet will be closed, and the blower stopped.
- At this point the backwash pump flow will be increased to the desired maximum flow to achieve effective backwash and bed expansion. The backwash period will last for 3 to 10 minutes.
- Close filter backwash inlet valve and stop pump
- Open filter inlet/feed valve
- Open filter scour for discharge of initial filter flow (0 to 2 minutes)
- Close filter scour valve and open filter outlet
- Repeat procedure for next filter in sequence

The backwash pumps supplied under this Contract shall be horizontal spindle centrifugal solids handling type.

Two air blowers shall be provided (1 duty, 1 standby), each capable of delivering sufficient air to suite the equipment offered.

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#### **6.47 OVERFLOW WEIRS**

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##### **6.47.1 General**

This specification covers the requirements for the supply, installation, testing and commissioning of mechanical equipment for overflow weirs.

This specification shall, inter alia, form part of the contract document.

This specification contains clauses that are generally applicable to mechanical engineering construction. Interpretation of and modifications to this specification are set out in Process Specification.

The overflow weir will perform the specific required function as per the treatment process and the process specification, being equal overflow or accurate flow measurement.

The overflow weir will suit the specific hydraulic and civil design requirements.

The overflow weir design will ensure a robust and rigid structural construction with accurate levels and linear installations.

The weir design will incorporate adequate vertical as well as horizontal adjustment to ensure correct leveling and alignment.

The overflow weir must perform according to the complete process and hydraulic requirements of the applicable unit treatment and required function.

The overflow weir must be manufactured with the most optimal material to ensure maximum operational life.

The design of the overflow weir valve will take into consideration the operational conditions and the optimal application to ensure the best performance and operational lifetime.

The overflow weir shall be accessible for inspection and maintenance work.

The equipment shall comply with the details stated in the Process Specification as approved by the Engineer.



The equipment shall be corrosion protected in accordance with the corrosion protection specification.

The contractor shall provide all plant that is necessary to install, test and commission all the items of equipment covered in this section.

If so, instructed by the Engineer, to establish the performance of the equipment, the Contractor shall carry out in situ tests that are witnessed by a representative of the Engineer. Full details of tests and the calculated results shall be handed to the Engineer.

In-situ tests shall consist of.

- o Measurement of level and aligned installation.
- o Measurement of flow rate.

Measurement and payment shall be in accordance with General Specification.

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#### **6.48 EXTRACTION FANS**

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This specification covers the requirements for the supply, installation, testing and commissioning of mechanical extraction fans.

This specification shall, inter alia, form part of the contract document.

This specification contains clauses that are generally applicable to mechanical engineering construction. Interpretation of and modifications to this specification are set out in Process Specification.

The fan will perform the specific required function as per the treatment process and the process specification.

The extraction fan will be able to deliver the maximum required process performance at only 80% of the equipment full performance capacity.

The extraction fan will be designed for 24 hour per day operation.

The extraction fan will be designed to perform under the specific process treatment environment.

The extraction fan will be designed and selected to perform within 15% of the best efficiency point.

The extraction fan performance will be guaranteed at the specified duty point.

The complete extraction fan unit will be designed and selected with the appropriate enclosure and protection to operate in the required process environment.

The extraction fan will suit the specific civil design requirements.

The extraction fan design will ensure a robust and rigid construction.

The extraction fan must perform according to the complete process requirements of the applicable unit treatment and required function.

The extraction fan must be manufactured with the most optimal material to ensure maximum operational life.

The design of the extraction fan will take into consideration the operational conditions and the optimal application to ensure the best performance and operational life time.

The extraction fan shall be accessible for inspection and maintenance work.

The equipment shall comply with the details stated in the Process Specification as approved by the Engineer.



The equipment shall be corrosion protected in accordance with the corrosion protection specification.

The contractor shall provide all plant that is necessary to install, test and commission all the items of equipment covered in this section.

If so instructed by the Engineer, in order to establish the performance of the equipment, the Contractor shall carry out in situ tests that are witnessed by a representative of the Engineer. Full details of tests and the calculated results shall be handed to the Engineer.

In-situ tests shall consist of;  
Measurement of air flow rate and pressure.

Measurement and payment shall be in accordance with General Specification.

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#### **6.49 ALUMINIUM SULPHATE DOSING EQUIPMENT**

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##### **6.49.1 General**

The proposed Alum dosing facility shall consist of the following elements:

- Two Alum discharge hoppers, one for each tank. The hopper must suit the discharge from the 1 Ton bag and the discharge into the mixing tank, via the dissolving trays.
- Each tank will have a mixer to completely mix and dissolve the Alum with the make-up water.
- The Alum dosing pumps will be able to receive Alum solution from either mixing tanks, via suction piping and isolation valves. The Alum pump sets, duty/standby for each of the two dosing points, will discharge into dedicated dosing pipelines to the two dosing points.

Alum dosing equipment and ancillary works shall generally conform to the following requirements:

- Design flow velocities in dosing lines shall be between 1.0 m/s and 2.0 m/s. More viscous solutions shall operate at the lower limits. Flow velocities below 0.6 m/s and above 3.0 m/s shall not be acceptable.
- All chemical dosing lines shall be coupled to a clean water supply to facilitate the flushing of dosing lines after shutting down.
- Pipework and manifolds shall incorporate adequate isolation control and/or reflux, valves, suitable for the respective chemical, to allow for acceptable operation, maintenance, and flexibility. All positive displacement pumps shall be equipped with a pressure relief valve on the delivery line, allowing for discharge back to the source.
- Dosing pumps shall be accurately adjustable and capable of maintaining set rates to  $\pm 2.5\%$  of the required rate at average duty flow. The delivery to each dosing point shall be equipped with a suitable rotameter sized for the respective pump duty.
- Pipework shall be adequately fixed or supported to prevent pipe deflections of more than 5 mm from the true line.
- Dosing of the Alum will be automatically controlled by positive displacement metering pumps with a variable speed drive and control unit. The control unit will consist of a microprocessor that will receive a 4-20mA signal from a Streaming Current Monitor instrument to regulate the chemical dosing rate.

Adequate dust control measures shall be taken at all problem points.

The Alum dosing pumps shall be of progressive cavity metering type with the control of the dosing rate using a variable speed drive. The pump heads shall be manufactured from durable material compatible with material to be pumped.

A pressure sustaining valve and pressure relief valve shall be installed downstream of the isolating valve on the discharge pipe from the pump set.

All materials used in the manufacture of equipment and pipework shall be resistant to the corrosive action of the specific chemical to be handled.



Electrical power supply is at 220V single phase, 50 Hz frequency, or 400V three phase where required.

The contractor shall carry out performance tests on the plant and equipment after the completion of installation testing and commissioning that shall be witnessed by the Engineer. The contractor shall provide all calibrated and other equipment and staff necessary to conduct the tests.

Performance testing under operational conditions shall include the following minimum operations:

- Effective operation of the complete system under manual and automatic control.
- Measurement of maximum and minimum withdrawal and dosing rates of Lime.

Sampling and analysis shall be in accordance with the standard Methods. The performance of the equipment will be considered acceptable if the criteria set in the QCP have been achieved.

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## **6.50 POLYELECTROLYTE DOSING EQUIPMENT**

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### **6.50.1 Project Specification**

### **6.50.2 General**

The proposed poly dosing facility shall consist of the following elements:

- Two 5000L day storage tanks. The transfer pump, suitable for poly handling, will transfer poly from the 1000L transport tanks into any of the two 5000L day storage tanks.
- The poly dosing pumps will be able to receive poly solution from either day storage tanks, via suction piping and isolation valves. The poly pump sets, duty/standby for each of the two dosing points, will discharge into dedicated dosing pipelines to the two dosing points.

Alum dosing equipment and ancillary works shall generally conform to the following requirements:

- Design flow velocities in dosing lines shall be between 1.0 m/s and 2.0 m/s. More viscous solutions shall operate at the lower limits. Flow velocities below 0.6 m/s and above 3.0 m/s shall not be acceptable.
- All chemical dosing lines shall be coupled to a clean water supply to facilitate the flushing of dosing lines after shutting down.
- Pipework and manifolds shall incorporate adequate isolation control and/or reflux, valves, suitable for the respective chemical, to allow for acceptable operation, maintenance, and flexibility. All positive displacement pumps shall be equipped with a pressure relief valve on the delivery line, allowing for discharge back to the source.
- Dosing pumps shall be accurately adjustable and capable of maintaining set rates to  $\pm 2.5\%$  of the required rate at average duty flow. The delivery to each dosing point shall be equipped with a suitable rotameter sized for the respective pump duty.
- Pipework shall be adequately fixed or supported to prevent pipe deflections of more than 5 mm from the true line.
- Dosing of the poly will be automatically controlled by positive displacement metering pumps with a variable speed drive and control unit. The control unit will consist of a microprocessor that will receive a 4-20mA signal from a Streaming Current Monitor instrument to regulate the chemical dosing rate.

The poly dosing pumps shall be of progressive cavity metering type with the control of the dosing rate using a variable speed drive. The pump heads shall be manufactured from durable material compatible with material to be pumped.

A pressure sustaining valve and pressure relief valve shall be installed downstream of the isolating valve on the discharge pipe from the pump set.

All materials used in the manufacture of equipment and pipework shall be resistant to the corrosive action of the specific chemical to be handled.



Electrical power supply is at 220V single phase, 50 Hz frequency, or 400V three phase where required.

The contractor shall carry out performance tests on the plant and equipment after the completion of installation testing and commissioning that shall be witnessed by the Engineer. The contractor shall provide all calibrated and other equipment and staff necessary to conduct the tests.

Performance testing under operational conditions shall include the following minimum operations:

- Effective operation of the complete system under manual and automatic control.
- Measurement of maximum and minimum withdrawal and dosing rates of Lime.

Sampling and analysis shall be in accordance with the standard Methods. The performance of the equipment will be considered acceptable if the criteria set in the QCP have been achieved.

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## 6.51 MECHANICAL SLUDGE DEWATERING EQUIPMENT

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### 6.51.1 Definitions

The following general definitions to clarify the terms used as part of the specification.

Feed: Under the pressure of the sludge delivery (pump/gravity), the sludge to be filtered is delivered through the inlet into the filtering chambers.

Filter Cake: De-watered by the filter press, the filter residue is produced in the chamber, discharged from the filter press, and then dropped into the belt conveyor beneath the filter press.

Filtrate: The liquid discharged from filter press after it dewateres the sludge.

Filter Plate Set: A set of adjacent filter plates installed between the keep and thrust plate of the filter press.

Acid Washing: Fouling attached to the filter cloth must be removed through washing with acid solution.

Membrane Squeezing: Squeeze the filter cake with compressed air or pressure water into the membrane plates to further dewater the filter cake, and to discharge the filtrate from the machine.

Filter Cake Washing: Washing of the filter cake with a liquid to remove the solute remaining in the filter cake, or to recycle the liquor retained in the filter cake.

Filtering Medium: Filter cloth and filter paper generally.

### 6.51.2 Description of Plate Press Equipment

The filter press must be an energy-saving, efficient and rapid series chamber membrane filter press type, automatic operation, intermittently operating, for pressure filtration applicable for the solid-liquid separation of a variety of suspension liquid. It must have broad applicability, good separation effect, a simple structure, easy operation, safe and reliable. It must be widely used in water treatment industries.

The equipment must feature an integral design combining mechanical, electrical, and hydraulic principles. The automatic filter press has taken advantage of the long stroke cylinder to pull multiple plates at one time, thus greatly shortening the unloading time.

A variable frequency motor must be used for plate pulling, to shorten unloading time. This equipment must be equipped with membrane plates to vary the filter chamber volume through water or air pressure, and to squeeze the filter cake for lowering water content. The filter plates are made of reinforced PP through mould press, and the membrane plates are made of reinforced Polypropylene (PP), manufactured through mould press and heat seal.



All the electrical and hydraulic components and products must be of reputable brands, selected for best practice applications, with long operation life. The chamber type automatic membrane filter press must be the ideal selection for the implementation.

#### 6.51.3.1 Main Equipment Components

Applying an integral design combining mechanical, electrical, and hydraulic principles, the filter press must be automatic programmable, with variable frequency motor for plate pulling, and is of reliable and robust construction, simple operation, easy maintenance, safe and reliable.

The filter press must feature automatic control of filter plate pressing, filtering, back flushing (membrane cleaning), filter cake washing, plate releasing, unloading and other procedures required to efficiently dewater the sludge.

The equipment must feature membrane plates as well as to vary the filter chamber volume through water or air pressure after filtering and squeeze the filter cake for lowering water content. The chamber filter plates must be made of reinforced PP through mould press. The membrane plates must be made of reinforced PP through mould press and heat seal.

All the electrical and hydraulic components and products must be of reputable brands, selected for best practice applications, with long operation life. The chamber type automatic membrane filter press must be the ideal selection for the implementation.

The filter press must be constructed, but is not limited, to the following five parts: the rack, the filtration, the hydraulic pressure, the unloading and electric control sections.

##### (a) The Rack

The rack is the foundation of the entire equipment, which is used to support the filtering mechanism, and is made up of the thrust plate, the keep plate, the machine base, the cylinder and the main girder

The main girder used for supporting the filtering mechanism must be made of Q345 steel through submerged arc welding. Through the sand blasting of high-speed air flow shot blasting machine, the surface is cleaned off rust and oxide layer, and tiny pitting is made on the surface to improve the paint adhesion effect to prevent peeling. With advantages of corrosion resistance, large tensile strength, and high impact resistance, it must guarantee the safety and stability, and meet the requirements of high-pressure filter plates. It must be of high resistance to lateral bending, large tensile strength, and good mechanical performance and no deformation of the main girder.

The thrust plate, the keep plate and the machine base must be made of quality Q345B. The middle plate through welding, and the oil cylinder of 27SiMn seamless steel tube.

The piston rod must be of 45# steel, which is galvanized with 0.06 hard chrome after the adjustment and processing. The seal must be fabricated with cupric tetrafluoroborate hydrate, for ideal mechanical performance.

During the operation of the equipment, the piston rod on the oil cylinder must push the keep late to press tight the filter plates and filter cloth between the keep plate and the thrust plate, to keep the sludge under press to be filtered in the filtering chamber.

##### (b) Filtration

The filtration section must be made up of the filter plates (chamber, membrane) neatly arranged on the main girder, and the filter cloth between the plates.

When the filtering starts, under the push of the feed pump, the sludge must run through the thrust plate to enter chambers. Solid-liquid separation must be carried out under the pressure produced by the feed pump.



Under the effect of the filtering media (filter cloth), the solid remains in the chamber and becomes the filter cake, and the filtrate must be discharged through the outlet. If the filter cake must be washed, the water can be charged through a washing port on the thrust plate.

If the filter cake requires lower water content, compressed air or high-pressure water, through the filter cake, may be required, to further reduce the water content of the filter cake.

**Filter Plate:** Filter plates constitute the core part of the filter press, whose material, pattern, and quality will directly affect the final product quality. The reinforced PP membrane plates and chamber plates must apply the flexible PTE, offering high mechanical performance and stable chemical performance, presenting pressure resistance, heat resistance, corrosion resistance, non-toxic, light weight, smooth surface, good sealing effect and easy to wash.

**Filter Cloth Selection and Preparation:** The selection of filter cloth is of great importance, which is essential for the filtering process. The performance of the filter cloth will directly affect the filtering effect. In order to achieve an ideal filtering effect and speed, the selection of the filter cloth must be based on the particle size, density, viscosity and chemical components of the material as well as filtering technological conditions.

The filter cloth must consist of polypropylene fibre, polyester, nylon, and cotton. Polypropylene fibre must be of light weight, high strength and flexible, acid resist, alkali resist, wear resistance, durable toxic free.

The polyester cloth must be acid resistant, non-alkali resistance, and thermo-stabile. The nylon cloth must be alkali-resistant, but non-acid resistant. The material must be determined according to the actual filtering requirements.

The cloth must be laser-cut to guarantee that the pitch and diameter of the holes on the cloth are consistent with those of the filter plates, therefore avoiding the blockage of the feed or washing port due to inconsistent pitch or diameter of holes. Where the filter plates have cloth pins, the openings on the cloth are required to be aligned with the cloth pins on the plates.

**Filter Cloth Replacement:** All the filter plates shall be supported by their handles and placed neatly on the main girders on both sides of the filter press. For the filter press with membrane filter press, a membrane filter plate shall be placed behind the anti-corrosion plate of the keep plate, which is followed by a chamber type filter plate. The membrane plates and the chamber type plates shall be arranged in the alternated manner.

For the required filter plate and cloth exchange, it must be performed by two people, who stand on the platform of each side of the filter press and guide the electric hoist operation and make sure that the rope is tightly fixed onto the handles of both sides of the filter plates. After fixing or replacing the cloth, replace the plate onto the filter press with the same method.

(c) Hydraulic Press

**General:** The hydraulic system must consist of the hydraulic unit, hydraulic cylinder, various pressure instruments and valves.

Each procedure of fabrication and assembly for the hydraulic system must furnished with detailed operation specification, safety requirements and an Quality Control Plan before proceeding to the next procedure. The entire assembly process of the hydraulic system must be completed in a dust free and constant temperature workshop, with constant temperature in the workshop, and free of air opening, dust, and cutting area to guarantee fresh and dust free air.

After assembly, the hydraulic unit and the hydraulic cylinders must be stored in a warehouse and looked after by specific personnel. All the oil ports should be plugged with plastic plugs and covered with paper boxes, moreover, the products to be delivered will be wrapped tightly with plastic films to protect them from water and dust during the transportation. Records must be kept for all the products in or out of the warehouse, and each hydraulic unit or hydraulic cylinder will correspond to the work order, which must be recorded in the detail specification of the hydraulic unit, the configuration of the oil pump motor, the valve brand, the specification, and stroke of the hydraulic cylinder.



The hydraulic system must apply a manifold block design to coordinate with the sequence of the electrical control system in completing the basic operations including automatic pressing, automatic pressure maintaining, automatic pressurizing, automatic releasing, moving forward/backward in place and stop, thus improving the safety and reliability of the entire hydraulic system.

Main Hydraulic Elements Selection: The elements and main control valves of the hydraulic unit must be of a reputable and reliable brand, which easy to operate, safe and reliable, and run flexibly, with the service life up to five years (operating without fault or leakage). The elements supplier must guarantee their various performance indexes of the filter press.

The pressure gauge and electro connecting pressure gauges must be of a reliable and reputable brands. The electro connecting pressure gauge possesses the measurement control function, which can randomly set the upper and lower limits of the controlled pressure value, with stable and reliable operations, high precision, great shake proof, long service life must be guaranteed.

The hydraulic oil pump must be the variable displacement piston pump from a reliable and reputable supplier, with high volume efficiency, smooth operation, good flow evenness, low noise, and high working pressure. Large flow at no load can shorten the idle running time of the cylinder, increase the number of cycles, and improve the work efficiency, when raised to high pressure, the flow will decrease automatically to save the motor power, reduce the loss, and save the energy.

A three-phase asynchronous motor must be used in the hydraulic unit for high efficiency, energy saving, high performance, small vibration, low noise, long service life, high reliability, easy maintenance, and large starting torque.

The installation dimensions and power level must fully conform to the IEC standards. The master motor used for the hydraulic unit must be designed to match with the oil pump, saving the use of bell housing and coupler, thus greatly reducing the length of the oil pump motor unit, and making the volume of the motor unit smaller.

Hydraulic Oil - Processing Technology: The oil tank and oil tank cap of the hydraulic unit must be MS8-160X3200 multipurpose steel plate shearer. The oil tank cap is fabricated with BYJIN3015 CNC laser cutting. Laser cutting must be of high precision, high speed, and small HAZ (heat affected zone) which is not easily distorted, to render smooth seams, and requires no consequential processing.

Electrostatic spray, coating is of quality appearance, and great adhesion and mechanical strength. The curing time of the spray is shorter, the coating is of far higher corrosion and abrasion resistance, no primer required, construction is easy and simple. The cost is lower than the paint spraying.

Processing Technology of the Manifold Block: LY-3000MB high-precision CNC milling, J1VMC400B machining centre and WBSM12-42 CNC drilling machining must be applied in the fabrication of the manifold block. The form and location tolerance between the holes must be fully consistent with the drawings.

M7130H surface grinder with horizontal spindle and reciprocating table must be used to carry out the high precision grinding of the manifold block, so as to guarantee the roughness of the mounting surface of the valves, and to prevent the oil leakage from the sealing face.

SC1979 automatic pass-type ultrasonic jetting machine must be used to clean the scrap iron, rust, and debris, after which the electroless plating is carried out.

Testing of the Hydraulic Unit: After the assembly, the hydraulic units of us must undertake 9 functional tests, before being assembled.

#### **Hydraulic Cylinder**

The nominal pressure of common hydraulic cylinder is up to 25Mpa, which will fully satisfy the filter plate sealing requirements of the filter press. The hydraulic cylinder must be designed with fastener hole and boss to facilitate the installation and dismantling. After assembling the hydraulic cylinder, use Q3730 ceiling mounted shot blasting machine to blast the external wall of the hydraulic cylinder, and then transfer the cylinder into DPS-075 telescopic and mobile spraying.



Before the shot blasting and painting, special sheaths to cover the piston rods, screw threads, and other parts that do not need such processing.

#### **The Raw Material and Machining Technology of Hydraulic Cylinder**

The cylinder tube must use 27SiMn seamless steel tube with good machinability, and medium cold deformation plasticity and weldability, for during the heat treatment, the steel tenacity will not reduce too much, but the steel strength and abrasive resistance are very high.

The cylinder tube, flange, cylinder bottom shall be preheated before welding (to 230-250°C). Carry out step brazing after preheating and keep the temperature between the layers at between 250-300°C. After welding, use welding torch to do the post-heat treatment at the temperature of 250-300°C. Keep the temperature for 2 hours after the welding at 250-300°C. Carry out stress annealing at 650-680°C within 4 hours after the welding and keep the temperature for 2 hours. Use JM-58 CO<sub>2</sub> gas protective welder with welding stick at the diameter of 1.2mm, the voltage of 28-32V, the current of 280-300A and the volume of protective gas of Q=15-20l/min.

This welding technology meets the key requirements in two aspects for the cylinder welding:

#### **The hydraulic cylinder flange and the cylinder bottom**

Q345B is a steel material. It is low alloy steel ( $c < 0.2\%$ ) with good combination property, cryogenic property, cold stamping property, welding property and machinability.

The inner wall of the oil cylinder is fabricated with T2250A deep hole boring machine, through heavy boring, fine boring and rolling. The machining precision is up to Grade IT8. The inner wall must harden to improve high abrasion resistance and airtightness.

#### **Guide sleeve and piston**

Use QT400-15 steel. After machining in CW6163C/3000 lathe, the guide sleeve and piston must undertake drilling and thread chaing in Z3050\*16/1 radial drilling machine.

#### **Material Selection and Machining Technology of the Oil Cylinder Seal**

The oil cylinder seal must make use of reliable and reputable brand.

#### **Hydraulic Rubber Tube Assembly**

Raw material: Carbon steel joint and high-pressure steel wire woven rubber tube.

Standard: The carbon steel joint must be made up of the joint and the sleeve, both of which must be sourced from the nationally leading suppliers.

Automatic Pressing: When the pressing starts, the hydraulic unit's oil pump motor and the electro-hydraulic directional control valve gain power. The motor motivates the oil pump to supply oil for the high-pressure chamber of the oil cylinder. Under the effect of the oil pressure, the piston rod starts to advance, pushing the keep plate to compact the filter plates and the membrane plates. When the pressure achieves the upper limit on the electro connecting pressure gauge, the motor and the solenoid directional valve lose power, the motor stops automatically and enters the pressure maintaining state, and the system pressure is now determined by the overflow valve.

Automatic Pressurizing: After compacting the filter plates and membrane plates of the filter press, the pilot operated check valve will lock up the circuit and maintain the pressure, and the electro-hydraulic directional control valve has the valve element at the middle position. When the oil pressure drops to the lower limit on the electro connecting pressure gauge, the electro connecting pressure gauge will send electrical signals. The motor and the solenoid directional valve of the pump unit gain power, and the oil pump will supply oil for the back chamber of the oil cylinder for pressurizing. When the pressure achieves the upper limit on the electro connecting pressure gauge, the motor and the solenoid directional valve lose power, and the motor stops automatically. Automatic pressurizing is realized through such circulation.

Automatic Releasing: After the filtering, the high-pressure unloading valve will unload (for a period of 10-15 sec.). Distance between opened plates the pump unit motor and solenoid directional valve gain power, and the motor drives the oil pump to supply oil for the low-pressure chamber of the oil cylinder. The piston rod drives back the keep plate. When the keep plate and the limit switch contact, the pump station motor and the solenoid directional valve lose power, and then the system pressure is determined by the direct relief valve. After the automatic discharge, a cycle is completed.



(d) Discharge Mechanism

1) The unloading mechanism of the automatic programmable chamber filter press must be mainly composed of a low-energy and mini-watt variable frequency gear motor and puller, drive shaft, chain wheel, chain, frequency converter, PLC, and other main components. When unloading after the filtering, the keep plate will be released in place. The pulling motor gains power and rotates and drives the pullers on two main girders through the chain wheels and chains to move the filter plates synchronically, until all the filter plates are pulled. Then the puller gets the reset signal and returns to the original position. In this way, a complete unloading process is completed.

2) The unloading mechanism of automatic programmable high-efficiency filter press must be a fast repeating pulling system, manufactured with the latest technology. The fast repeating pulling system must divide the filter plates into several groups, and all the groups are linked with iron chains. During the pulling, it must pull one group at one time, and spreads all the filter plates in succession.

The advantage of this pulling system must lie in that it can pull for several times, unload rapidly, pull the plates at high speed and take the plates at low speed, switching the speed automatically. It is mainly composed of a low-energy and mini-watt variable frequency gear motor and puller, drive shaft, chain wheel, chain, frequency converter, PLC and other main components.

It must start unloading after the filtering. The keep plate must release, and the first group of filter plates will be pulled open, successively, the motor on the machine base gains power and rotates, drives the pullers on two main girders through the chain wheels and chains to move towards the filter plates, and pulls open the second group with the plate taking and pulling mechanism on the puller, and then the third group, until all the filter plates are pulled open.

Then the puller gets the reset signal and returns to the original position.

(e) Electrical Control

The electrical control section is the control centre of the entire system, which must be made up of electrical control cabinet, breaker, air switch, intermediate relay, PLC, frequency converter, travel switch, proximity switch, touch screen, etc.

It works in two modes, automatic and manual. Under automatic mode, the entire operation of the filter press will proceed according to the designed program without manual intervention. Its operation process is, 1<sup>st</sup> close the air switch, turn on the power, set the selective switch at the automatic position, press down the program activating button, and the pump station motor starts, at the same time, the pressing solenoid valve is energized, the keep plate proceeds forward, and after the upper limit of the oil cylinder pressure is achieved, the keep plate stops automatically; the two feed valves open, and the feed pump starts the feeding.

After the feeding achieves certain pressure, pressure maintaining and timing start, and the feeding stops after the setting time is over, i.e., the feed valves are closed, and the feed pump stops. The squeeze valve opens, the air release valve is closed, and membrane swelling and squeezing starts, which stops after maintaining for a period, i.e., the squeeze valve is closed, and the air release valve opens. This state maintains for a period and the air is emptied from the membrane plates.

Then blow the air, i.e., the aeration valve and the reflux valve open, to blow away the empty core material with the high-pressure air, which stops after maintaining for a period, i.e., the aeration valve and reflux valve are closed.

The filtering is completed, and the unloading starts. The piston rod drives the push plate back, the high-pressure unloading valve opens for releasing pressure, which is closed after the pressure dropped to a certain degree, and the release valve opens. The piston rod keeps retreating to the release limit, the pump station motor stops, and the release valve is power off. Then the pulling motor drives the puller to pull plates for unloading, and when all the filter plates are pulled open for unloading, the puller returns to the original position under the control of the program. In this way, a cycle is completed, and the next cycle can be run.



The electrical control must include the pneumatic valve, the feed pump, the belt conveyor, and other peripheral equipment under the automatic control together with the filter press.

#### 6.51.3 Sludge Cake Conveyance Equipment

Each plate press shall have a belt conveyor receiving the dewatered sludge discharge from the plate press.

Proper chutes, to prevent spillage and discharge of the sludge cake onto the building floor, must be provided. The chutes must allow for visual monitoring and ease of operation and maintenance of the conveyor, especially cleaning.

Each conveyor will discharge the received sludge cake through the 1<sup>st</sup> floor opening directly into the sludge bins situated directly below the conveyor discharge, on the ground floor.

The conveyance equipment will include proper chutes and discharge equipment to prevent wastage and spillage of the sludge cake between the conveyor discharge and the sludge bin.

#### 6.51.4 Sludge Cake Bin Equipment

Each conveyor discharge will have a nine (9) cubic meter waste bin, situated on the ground floor, directly beneath the conveyor discharge.

There will be a total of two duty sludge bins, and two standby bins.

A bin transportation trailer or truck must be supplied with the four bins. The transportation equipment must conform with the operating authority specifications to allow ease of operation and maintenance.

#### 6.51.5 Sludge Feed Pump Equipment

The sludge dewatering equipment must include the proper sludge feed from the sludge thickeners. The contractor must include sludge feed pumps, duty standby configuration.

The pipe work must suit the civil layout and structure design, from the sludge thickener discharge to the plate press inlet. The pipe work must be 304 stainless steel, with the necessary pipe fittings, control and isolating valves, control devices and instrumentation, to conform to the automatic and manual operation of the plate press.

If the gravitation pressure is sufficient to feed the sludge efficiently from the thickeners, the sludge feed pumps may be omitted, but the necessary pipe fittings, control and isolating valves, control devices and instrumentation, to conform to the automatic and manual operation of the plate press, must be supplied and installed.

#### 6.51.6 Chemical Dosing Equipment

The sludge from the sludge thickener will require a chemical to condition the sludge for optimal dewatering.

Each plate press unit will have its own duty and standby dosing pump set, with all ancillary pipe work, pipe fittings, control and isolation valves, control devices and the necessary instrumentation, to conform to the automatic and manual operation of the plate press, must be supplied and installed.

The chemical sludge conditioning equipment must be designed and supplied according to the sludge characteristics.

The Make-up water pumps must supply the necessary make-up water to the chemical dosing make-up units.

#### 6.51.7 Wash Water & Make-Up Water Supply Equipment

The sludge dewatering equipment must include the required wash water supply to the plate press and the make-up water supply to the chemical dosing equipment.



The wash water supply system and the make-up water supply system must be two separate systems.

Each water supply system must include, but is not limited, to the following infrastructure, a duty and standby pump set, with all ancillary pipe work, pipe fittings, 20kL storage tanks, control and isolation valves, control devices and the necessary instrumentation, to conform to the automatic and manual operation of the plate press and the chemical dosing equipment.

**END OF SECTION**



## Phokwane Local Municipality

### HARTSWATER BULK WATER SUPPLY UPGRADE

#### C3.5 MANAGEMENT

##### **C3.5.1 Management of the Works**

###### **C3.5.1.1 Construction Project**

Refer to Section C3.4.1 (B1204)

###### **C3.5.1.2 Drawings, Operation and Maintenance Manuals**

Refer to Section C3.4.1 (PS6.)

###### **C3.5.1.3 Site Administration**

Acceptance control, record keeping and payment certificates shall be done in accordance with the Employer's Agent's standard system except if the Employer's Agent approves that the Contractor's standard system may be used.

###### **C3.5.1.4 Daily Site Diary**

The daily site diary shall be kept up to date by the Contractor's Site Agent and will be signed on a daily basis by the Employer's Agent's Representative.

###### **C3.5.1.5 Information in Respect of Plant**

Information relating to plant on Site shall be recorded in the daily site diary. In addition, the Contractor shall deliver to the Employer's Agent, on a monthly basis, a detailed summary of construction plant kept on the Site, full particulars given for each day of the month. Distinction shall be made between plant in working order and plant out-of-order. Such inventory shall be submitted by the first day of the month following the month to be reported.

###### **C3.5.1.6 Information in Respect of Employees**

Information relating to labour and management on Site shall be recorded in the daily site diary. In addition, the Contractor shall deliver to the Employer's Agent, on a monthly basis, a detailed summary of supervisory staff, labour employed (own and local labour) by category, and sub-contractors (both local and imported) for each day of the month. Such return shall be submitted by the first day of the month following the month to be reported.

###### **C3.5.1.7 Rainfall Records**

Rainfall records for the period of construction shall be taken on Site and recorded in the daily site diary. The Contractor shall provide and install all the necessary equipment for



accurately measuring the rainfall. The Contractor shall also provide, erect and maintain a security fence plus gate, padlock and keys at each measuring station, all at his own cost. The Employer's Agent or his Representative shall take and record the daily rainfall readings. The Contractor shall be permitted to attend these readings, in the company of the Employer's Agent's Representative. Access to the measuring gauge(s) shall at all times be under the Employer's Agent's control.

#### **C3.5.1.8 Site Instructions**

Site instructions by the Employer's Agent, addressed to the Contractor at his office on the Site, will be numbered consecutively and will be deemed to have been received by the Contractor's Representative unless a break in the sequence of numbers is brought to the notice of the Employer's Agent in writing immediately.

#### **C3.5.1.9 Site Meetings**

The Contractor and his authorised representative shall attend all meetings held on the Site with the Employer and the professional team at dates and times to be determined by the Employer's Agent. Such meetings will be held to evaluate the progress of the Contract, and to discuss matters pertaining to the Contract which any of the parties represented may wish to raise. It is not the intention to discuss day-to-day technical matters at such meetings.

#### **C3.5.1.10 Payment Certificates**

Monthly Progress Payment Certificates shall be submitted to the Employer's Agent's Representative on Site not later than the 15<sup>th</sup> of each month (or on the last working day prior to this date) in order to allow for checking and reconciliation of all quantities, rates, extensions and additions in the certificate. Each progress payment certificate shall include work executed or reasonably expected to be executed up to the 30<sup>th</sup> day of the specific month.

Upon agreement by the Employer's Agent's Representative the certificate shall be submitted by the Contractor in a neat typed form in accordance with the prescribed format, and with the correct spelling, to the Employer's Agent by not later than the 20<sup>th</sup> of each month (or on the first working day thereafter), together with four additional copies, for certification.

Where dayworks have been instructed by the Employer's Agent, the Contractor shall submit the returns to the Employer's Agent for signature and approval within twenty-four (24) hours of the end of the working day on which the work was executed. Daywork returns shall be submitted on forms following a standard format for this purpose. Failure to comply with the terms of this clause will result in non-payment for such dayworks.

The tax invoice will be submitted with each certificate dated appropriately for the period certified. All costs for the preparation and submission of progress certificates shall be borne by the Contractor.



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**C3.5.1.11 Workmanship and Quality Control**

Refer to Section C3.4.1 (PS4)

**C.3.5.1.12 Features requiring Special Attention**

Refer to Section C3.4.1 (PS3.)

**END OF SECTION**



## Phokwane Local Municipality

### HARTSWATER BULK WATER SUPPLY UPGRADE

#### CONSTRUCTION

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## OCCUPATIONAL HEALTH AND SAFETY

### 1 INTERPRETATIONS

Occupational Health and Safety Act, Act 85 of 1993 shall apply to this Contract. The Construction Regulations promulgated on 7 February 2014 and incorporated into the said Act by Government Notice R. 10113, published in Government Gazette 37305 apply to any person involved in construction work. These regulations are hereinafter referred to as "the Construction Regulations" and the said Act as "the Act".

Construction work is defined as:

"Any work in connection with: -

- a) the erection, maintenance, alteration, renovation, repair, demolition or dismantling of or addition to a building or any similar structure;
- b) the installation, erection, dismantling of or maintenance of a fixed plant where such work includes the risk of a person falling;
- c) the construction, maintenance, demolition or dismantling of any bridge, dam, canal, road, railway, runway, sewer or water reticulation system or any similar civil engineering structure; or
- d) the moving of earth, clearing of land, the making of an excavation, piling, or any similar type of work".

### 2 GENERAL

The Contractor shall ensure that all employees and visitors are informed, instructed and trained regarding safety conditions on site.

- 2.1 Proof of induction training to all workers shall be filed in the Health and Safety file on site. All employees shall sign the relevant induction training forms.

The Contractor shall ensure that all professionals entering the site are informed, instructed and trained regarding safety conditions on site. Proof of Professional site safety induction shall be signed by professionals and filed in the Health and Safety file on site.

The Contractor shall ensure that all visitors are informed, instructed and trained regarding safety conditions on site. Visitors have to sign the visitors register before entering the site. Hardhats shall be issued to visitors. No visitor shall enter the site without the appropriate safety shoes.

- 2.2 Should the Contractor at any stage in execution of the Works -
- a) fail to implement or maintain his health and safety plan;



- e) execute construction work which is not in accordance with his health and safety plan; or act in any way which may pose a threat to the health and safety of persons, the Employer will stop the Contractor **AT HIS/HER OWN COSTS** from executing construction work.

- 2.3 The Contractor shall provide proof of this registration and good standing with the Compensation Fund or with a licensed compensation insurer when submitting a tender. Tenders without this will be regarded as non-responsive.
- 2.4 The Contractor shall, in submitting his tender, demonstrate that he has made provision for the cost of compliance with the specified health and safety requirements, the Act and the Construction Regulations.
- 2.5 The Contractor shall consistently demonstrate his competence and adequacy of resources to perform the duties imposed on the Contractor in terms of this Specification, the Act and the Construction Regulations.

### **3 INDEMNITY OF EMPLOYER AND HIS AGENTS**

- a) The annexures to this Contract Document contain a "Mandatory Form of Authority and Agreement in terms of Section 37(2) of the Occupational Health and Safety Act, No. 85 of 1993" which agreement shall be entered into and duly signed by both the Employer and Contractor prior to commencement with work.  
A copy of the signed agreement shall be included in the Contractor's health and safety plan.
- b) Any acceptance, approval, check, certificate, consent, examination, inspection, instruction, notice, observation, proposal, request, test or similar act by either the Employer, any of his agents or the Engineer (including absence of disapproval) shall not relieve the Contractor from any responsibility he has under the Contract, the Act and the Construction Regulations, including responsibility for errors, omissions, discrepancies and non-compliances.
- c) A Section 37(2) agreement shall be entered into and duly signed by both the Principal Contractor and Sub Contractor prior to commencement with work by Sub Contractor.  
A copy of the signed agreement shall be included in the Principal's Contractor's health and safety plan.
- d) Any acceptance, approval, check, certificate, consent, examination, inspection, instruction, notice, observation, proposal, request, test or similar act by either the Employer, any of his agents or the Engineer (including absence of disapproval) shall not relieve the Sub Contractor from any responsibility he has under the Contract, the Act and the Construction Regulations, including responsibility for errors, omissions, discrepancies and non-compliances.



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## **4 SCOPE**

- 4.1 The specification as set out in this Portion is known as the Health and Safety Specification for the Construction work to be carried out by the Principal Contractor as per regulations of the Construction Regulations February 2014.

Information herein addressed might affect the Health and Safety of employee's or persons carrying out the construction work as per this tender document.

The Contractor shall ensure that it is fully conversant with the requirements of this Specification.

This Specification is not intended to supersede the Act nor the Construction Regulations. Those sections of the Act and the Construction Regulations, which apply to the scope of work to be performed by the Contractor in terms of this Contract, continue to be a legal requirement of the Contractor.

The principal Contractor will be appointed in writing to be in overall control of the Construction site.

- 4.2 A Health and Safety Plan must be submitted by the Principal Contractor to the Employer's Health and Safety Agent containing all the relevant documentation as required by this specification and terms of the provisions of this Specification, the Act and the Construction Regulations.

A Health and Safety Plan must also be submitted by the Sub Contractor to the Principal Contractor containing all the relevant documentation as required by this specification and terms of the provisions of this Specification, the Act and the Construction Regulations

The H&S plan shall be submitted before commencement of any work on site

## **5 HEALTH AND SAFETY FILE**

The following documentation shall be in the Health and Safety File of the Principal Contractor and Sub Contractors:

- A1 Copy of the Occupational Health and Safety Act No 85 of 1993 including the Construction Regulations – February 2014
- A2 Proof of registration with Compensation Commissioner (Principal Contractor)
- A3 Copy of Notification of Construction work to the Department of Labour



- 
- A4 Agreement in terms of section 37(2) of the Occupational Health and Safety Act, No. 85 of 1993. To be signed by employer and Principal contractor in presence of witnesses
- A7 Health and safety plan describing all activities as mentioned elsewhere.
- A8 Company Safety Policy – To be signed by the Chief Executive Officer of the Company.
- A9 Organogram indicating site specific organizational structure with reference to requirements of the construction regulations.
- A10 Letters of Appointment

The following appointments are required for the project. Deviations will only be allowed with the approval of the Agent. Appointment of an employee for more than one responsibility will be allowed and shall be approved by the Agent.

#### **Basic Appointments**

- Appointment of Principal Contractor by Employer
- Appointment of Contractors (Sub Contractors) by Principal Contractor (where applicable)
- Appointment of Construction Work Supervisor (full time employee on site)
- Appointment of Assistant Construction Work Supervisor (full time employee on site if required)

#### **Appointments of full-time employees on site**

- Appointment of a SHE Representative (Competent employee to control/monitor all H&S activities)
- Appointment of an Accident and Incident Investigator

A12 Evacuation plan

A13 The contents of all Training Material used on site – eg.  
Accredited and non-accredited training  
Toolbox talks  
And all training records signed by workers

A14 Risk Assessments - All Risk Assessments done before and during the Construction period



- 
- A15 Registers as required
- A16 Safe Work Procedures and material safety data sheets
- A17 Fall protection plan
- A18 Incident recording forms
- A19 Medical records
- A20 Minutes of safety meetings

Emergency telephone numbers to be displayed on the back of the file

## **6 NOTIFICATION OF CONSTRUCTION WORK – REG 3 OF THE CONSTRUCTION REGULATION – FEBRUARY 2014**

The Employer will appoint the Contractor in writing for execution of the Works. The Contractor shall accept its appointment under the terms and Conditions of Contract. The Contractor shall sign and agree to those terms and conditions and shall, before commencing work, notify the Department of Labour of the intended construction work in terms of Regulation 3 of the Construction Regulations. The Contractor shall submit the notification in writing prior to commencement with work. The annexures to this Contract Document contain a "Mandatory notification of construction work in terms of regulation 3 of the construction regulations (2014) of the Occupational Health and Safety Act no 85 of 1993" which shall be filled in by the contractor and forwarded to the Department of Labour. A copy of this notification shall be included in the Contractors Health and Safety file.

The Principal Contractor must notify the Provincial Director of:

- Construction work on a form similar to Annexure B in the Construction Regulation 2014 of the Occupational Health and Safety Act and Regulations.
- A copy of the notification form must be available on site for inspection by an Inspector.

No notification is required from the Sub Contractors.

## **7 CONTRACTOR'S SHE REPRESENTATIVE**

Before commencing work, the Principal Contractor shall designate a competent Safety, Health and Environmental representative (SHE Rep) who shall be acceptable to the Agent, to represent and act for the Contractor and Sub Contractors.



It should be noted that the Principal Contractor is held responsible for the activities of the Sub Contractors.

Failure of Health and Safety measures by the Sub Contractor will revert directly back to the Principal Contractor.

The Contractor shall inform the Agent in writing of the name and address of the Contractor's SHE Rep and of any subsequent changes in the name and address of the SHE Rep, together with the scope and limitations of the SHE Rep's authority to act for the Contractor. The Contractor's SHE Rep shall make available to the Employer an all-hours telephone number at which the SHE Rep can be contacted at any time in the event of an emergency involving any of the Contractor's employees, or other persons at the Works.

## 8 CLOTHING

All employees of the Contractor shall wear suitable protective clothing when working in proximity of machinery, power tools, hazardous materials or chemicals.

Proposed Personal Protective Equipment required on this project:

|     | TYPE                             | WHEN TO WEAR                            |
|-----|----------------------------------|-----------------------------------------|
| 1.  | Hard Hats                        | Always                                  |
| 2.  | 400mm Shoulder Length PVC Gloves | Working with cement                     |
| 3.  | Plastic Trousers                 | Working with cement                     |
| 4.  | Safety Goggles                   | Grinding, Cutting Cement                |
| 5.  | Gumboots                         | Working in water                        |
| 6.  | Welding helmet                   | Welding                                 |
| 7.  | Gas welding safety goggles       | Gas Welding                             |
| 8.  | Safety shoes                     | Offloading and positioning of materials |
| 9.  | Dust Masks                       | Grinding                                |
| 10. | Ear Muff                         | Grinding                                |
| 11. | Leather apron                    | Welding/ gas welding                    |



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**AGREEMENT IN TERMS OF SECTION 37(2) OF THE OCCUPATIONAL HEALTH AND SAFETY ACT, NO. 85 OF 1993**

The Employer and the Contractor hereby agree, in terms of the Provisions of Sections 37(2), 9 and 8(2) of the Occupational Health and Safety, Act No. 85 of 1993, hereinafter referred to as 'the Act', that the Contractor as an employer in its own right and in its capacity as Contractor for the execution of the works, shall have certain obligations and that the following arrangements shall apply between them to ensure compliance by the Contractor with the provisions of the Act, namely:-

- i) The Contractor undertakes to acquaint the appropriate officials and the employees of the Contractor with all relevant provisions of the Act, and the regulations promulgated in terms of the Act, and
- ii) The Contractor undertakes that all relevant duties, obligations and prohibitions imposed in terms of the Act and regulations will be fully complied with, and
- iii) The Contractor hereby accepts sole liability for such due compliance with the relevant duties, obligations and prohibitions imposed by the Act and regulations and expressly absolves the Employer and the Employer's Consulting Engineers from being obliged to comply with any of the aforesaid duties, obligations and prohibitions.
- iv) The Contractor shall be obliged to report forthwith to the Employer any investigation, complaint, or criminal charge which may arise as a consequence of the provisions of the Act and regulations pursuant to work performed on behalf of the Employer, and shall, on written demand, provide full details in writing of such investigation, complaint or criminal charge.

SIGNED at ..... on this ..... day of

..... 20.....

For and on behalf of the **Contractor**:

\_\_\_\_\_

Print Name: \_\_\_\_\_

AS WITNESSES:

1. \_\_\_\_\_

2. \_\_\_\_\_

Print Name: \_\_\_\_\_

Print Name: \_\_\_\_\_



---

For and on behalf of the **Employer**:

\_\_\_\_\_

Print Name:\_\_\_\_\_

AS WITNESSES:

1. \_\_\_\_\_

2. \_\_\_\_\_

Print Name: \_\_\_\_\_

Print Name: \_\_\_\_\_



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**MANDATORY NOTIFICATION OF CONSTRUCTION WORK**  
**IN TERMS OF REGULATION 3 OF THE CONSTRUCTION REGULATIONS (2014)**  
**OF THE OCCUPATIONAL HEALTH AND SAFETY ACT, NO. 85 OF 1993**

This document is to be forwarded by the Contractor to the Office of the Department of Labour **prior to commencement** of the Works. The Contractor shall ensure that all Sub-Contractors accountable to him forward similar documents to the mentioned Authority **prior to commencement with the Works**.

A. Particulars of Contractor

Name: .....

Postal Address : .....

Compensation Fund Registration No. ....

B. Particulars of Contractor's MD/ CEO/Managing Member of cc

Name: .....

ID No. ....

Postal Address: .....

Tel No. .... Cell phone No. ....

C. Particulars of Contractor's designated Construction Safety Officer appointed in terms of Clause 6(1) as the Construction Supervisor, with the duty of supervising health and safety at the Works:

Name: .....

ID No. ....

Postal Address: .....

Tel No. .... Cell phone No. ....

D. Particulars of Contractor's sub-ordinate supervisors at the Works, appointed in terms of Clause 6 (2):



| Name | ID No. | Postal Address | Tel No. | Cell phone no. |
|------|--------|----------------|---------|----------------|
|      |        |                |         |                |
|      |        |                |         |                |
|      |        |                |         |                |
|      |        |                |         |                |
|      |        |                |         |                |
|      |        |                |         |                |

E. Physical address of the Works (Construction Site)

.....

.....

Co-ordinates (if available) Latitude (S) .....

Longitude (E) .....

F. Nature of the construction work:

.....

.....

G. Expected commencement date:

H. Expected completion date:

I. Estimated maximum number of persons on the construction site.



J. Planned number of Sub-Contractors on the construction site accountable to Principal Contractor:

.....

Name(s) of Sub-Contractors.

.....

.....

.....

K. Particulars of Employer (client)

Name:

Postal Address: .....

.....

Name of Employer's designated Representative / Agent.

.....

Tel No. .... Cell phone No. ....

L. Particulars of Design Engineer

Name:

Postal Address: .....

Tel No. .... Cell phone No. ....

Signed at ..... on this ..... day of ..... 20.....



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**INFORMATION TO BE SUPPLIED BY THE TENDERER**

This following form shall be completed by the Tenderer.

A Particulars of WCF

Compensation Fund Registration No. ....

Expiring Date .....

B. Particulars of Contractor's designated Construction Safety Officer appointed in terms of Clause 6(1) as the Construction Supervisor, with the duty of supervising health and safety at the Works:

Name: .....

ID No. ....

Postal Address: .....

Tel No. .... Cell phone No. ....

C Particulars of Contractor's Health and Safety Representatives:

Name:.....Qualifications.....

Name:.....Qualifications.....

Name:.....Qualifications.....

D Particulars of First Aider

Name: .....

ID No. ....

Valid First Aid Certificate: Yes.....

No.....

E Particulars of Fire Fighter

Name: .....



ID No. ....

Valid Fire Training Certificate: Yes.....

No.....

F Training Records of Construction Vehicle Operators

Name:.....Qualifications.....

Name:.....Qualifications.....

Name:.....Qualifications.....

G. Incident Statistics:

| Incidents during last 12 months | Date | Degree of Injury | Production days lost | Costs involved. |
|---------------------------------|------|------------------|----------------------|-----------------|
| 1                               |      |                  |                      |                 |
| 2                               |      |                  |                      |                 |
| 3                               |      |                  |                      |                 |
| 4                               |      |                  |                      |                 |
| 5                               |      |                  |                      |                 |
| 6                               |      |                  |                      |                 |
| 7                               |      |                  |                      |                 |

**END OF SECTION**



## Phokwane Local Municipality

### HARTSWATER BULK WATER SUPPLY UPGRADE

#### SPECIAL REQUIREMENTS

#### INDEX

| Section        | Description                                                                     | Page No |
|----------------|---------------------------------------------------------------------------------|---------|
| Section C3.5.3 | Special Requirements in terms of OHSA and Construction Regulations.....C3.5.3.1 |         |

END OF SECTION



### **C3.5.3 SPECIFIC REQUIREMENTS IN TERMS OF OHSA AND CONSTRUCTION REGULATIONS**

Inter alia the risk assessment to be done by the Contractor, specific requirements and areas that must be addressed is provided hereunder as the risk identification provided by the Employer and summarised hereunder:

Specific requirements and areas that must be addressed with the risk assessments and work procedures are summarised hereunder:

#### **Public safety**

- Pedestrian and vehicle movement along the entire section of works
- Public awareness, especially of the works to be executed under single lane traffic accommodation, safety precautions and specifically advance warning areas. Advance warning areas to be assisted with advance variable message signs and warning signals as per specification.
- Plant in operation and/or under holding conditions immediately next to trafficked lanes (refer to specifications).
- Speeding during construction and control measures (assisted with speed message sign).
- Level differences during rehabilitation stages with adequate signs and safety precautionary measures. (Refer to restrictive conditions and same day work allowances)
- Communication on site.
- Constant traffic monitoring by site safety officers and daily inspection of signage required with auditable records.

#### **Stockpile areas**

- Safety measures to ensure usability of hazardous conditions exist to road users and special measures to ensure night-time visibility.
- Environmental matters, control and spillages, e.g. pre-coating fluid, bituminous products, diesel, etc.

#### **Plant, equipment and personnel**

- Night time visibility and low day time visibility.
- Serviceability of equipment in transport of leakages, i.e. oil, diesel, bitumen, spills.
- Flagmen, traffic control and labour force.

#### **Safety Risk**

- Construction personnel and plant.

#### **Finishing**

- Loose aggregate during excavation and seal operations

**END OF SECTION**