

**MOKOLO AND CROCODILE  
WATER AUGMENTATION PROJECT  
PHASE 2 (MCWAP-2)**

**TENDER NO 054/2024/PMID/MCWAP2/RFB**

**PART C3.1  
SPECIFICATION**

**SECTION 28**

**MECHANICAL GENERAL**

**PART C3.1  
SPECIFICATION**

**SECTION 28  
MECHANICAL GENERAL**

**TABLE OF CONTENTS**

	<b>PAGE</b>
<b>SECTION 28</b> .....	<b>1</b>
<b>28.1 SCOPE</b> .....	<b>1</b>
<b>28.2 REFERENCES TO STANDARDS</b> .....	<b>1</b>
<b>28.3 DEFINITIONS</b> .....	<b>1</b>
<b>28.4 OPERATING CONDITIONS AND CLIMATE</b> .....	<b>2</b>
<b>28.4.1 Water Quality</b> .....	<b>2</b>
<b>28.4.2 Water Temperature</b> .....	<b>3</b>
<b>28.4.3 Climate</b> .....	<b>3</b>
<b>28.5 DESIGN AND PERMISSIBLE STRESSES</b> .....	<b>3</b>
<b>28.5.1 General</b> .....	<b>3</b>
<b>28.5.2 Vibration and Design Loads</b> .....	<b>4</b>
<b>28.5.3 Permissible Stresses: General</b> .....	<b>4</b>
<b>28.5.4 Permissible Stresses: Gates and Valves</b> .....	<b>5</b>
<b>28.5.5 Permissible Stresses: Linings</b> .....	<b>5</b>
<b>28.6 DRAWINGS</b> .....	<b>6</b>
<b>28.6.1 Drawings Issued by the Engineer</b> .....	<b>6</b>
<b>28.6.2 Contractor's Drawings</b> .....	<b>6</b>
<b>28.6.3 Manufacturing (Workshop) Drawings</b> .....	<b>6</b>
<b>28.6.4 Drawing Format</b> .....	<b>7</b>
<b>28.7 CONTRACTOR'S SUBMISSIONS</b> .....	<b>8</b>
<b>28.8 MATERIALS AND WORKMANSHIP</b> .....	<b>10</b>
<b>28.8.1 Introduction</b> .....	<b>10</b>
<b>28.8.2 Compliance with Standards</b> .....	<b>10</b>
<b>28.8.3 Materials</b> .....	<b>10</b>
<b>28.8.4 Workmanship</b> .....	<b>11</b>
<b>28.9 SUBCONTRACT ORDERS</b> .....	<b>11</b>
<b>28.10 SPARE PARTS</b> .....	<b>12</b>

## PART C3.1 - SPECIFICATION

<b>28.11</b>	<b>STORAGE, HANDLING AND TRANSPORTATION .....</b>	<b>12</b>
28.11.1	Assembly in Manufacturer's Workshop .....	12
28.11.2	Numbering and Marking of Materials, Plant and Parts .....	12
28.11.3	Packing for Transport and Storage.....	12
28.11.4	Storage.....	13
28.11.5	Delivery .....	14
28.11.6	Supervision.....	14
28.11.7	Handling during Loading, Off-loading and Installation .....	14
28.11.8	Attachments for Transport and Erection Handling.....	14
28.11.9	Plant and Material to be Complete .....	15
28.11.10	Damage.....	15
<b>28.12</b>	<b>STEELWORK .....</b>	<b>15</b>
28.12.1	Minimum Thickness and Corrosion Allowance.....	15
28.12.2	Steel for Fabricated Construction.....	16
28.12.3	Stainless Steel.....	16
28.12.4	Lamellar Tearing .....	16
28.12.5	Structural Steelwork Fabrication .....	16
28.12.6	Surface Defects in Fabricated Steelwork .....	17
<b>28.13</b>	<b>WELDING .....</b>	<b>17</b>
28.13.1	General.....	17
28.13.2	General Weld Quality .....	19
28.13.3	Acceptance Tests for Welding .....	19
28.13.4	Weld Defects and Repair .....	21
<b>28.14</b>	<b>FASTENERS.....</b>	<b>21</b>
28.14.1	General.....	21
28.14.2	Hydrogen Embrittlement in Fasteners.....	22
<b>28.15</b>	<b>FLANGES AND GASKETS .....</b>	<b>22</b>
28.15.1	General.....	22
28.15.2	Restraining Flanges.....	23
28.15.3	Blank (Blind) Flanges.....	23
28.15.4	Insulating Flanges.....	24
<b>28.16</b>	<b>MISCELLANEOUS MATERIALS.....</b>	<b>24</b>
28.16.1	Cast Iron .....	24
28.16.2	Steel Castings .....	25
28.16.3	Forgings.....	25
28.16.4	Fabrics, Wood, etc. ....	25
28.16.5	Bronze.....	26

## PART C3.1 - SPECIFICATION

28.16.6	Bright Parts.....	26
28.16.7	Aluminium and Aluminium Alloys .....	26
28.16.8	Adhesives .....	26
28.16.9	Asbestos.....	26
28.17	CORROSION PROTECTION .....	26
28.18	BEARINGS .....	26
28.18.1	General.....	26
28.18.2	Self-Lubricating Bearings.....	27
28.18.3	Other Bearings .....	28
28.19	LUBRICATION.....	28
28.20	DEWATERING PLANT (SUMP PUMPS) FOR THE LOW- AND HIGH-LIFT PUMPING STATIONS .....	29
28.20.1	General.....	29
28.20.2	Pump / Motor Unit Design.....	29
28.20.3	Control and Alarm .....	30
28.21	OIL WATER SEPARATOR (OWS) FOR THE LOW- AND HIGH-LIFT PUMPING STATIONS .....	30
28.21.1	Scope .....	30
28.21.2	Design Requirements .....	30
28.22	WATER TREATMENT PLANT (WTP) FOR POTABLE WATER .....	31
28.22.1	Scope .....	31
28.22.2	Expected Water Quality .....	31
28.22.3	Design Requirements .....	32
28.23	NAMEPLATES, RATING PLATES AND LABELS.....	35
28.23.1	Lifting Devices.....	36
28.24	ERECTION AND SETTING TO WORK.....	36
28.24.1	General.....	36
28.24.2	Foundations.....	36
28.24.3	Accuracy of Work: Gates, Guides and Mechanical Plant.....	37
28.24.4	Grouting.....	37
28.24.5	Building In .....	37
28.24.6	Drilling the Structure for Fixings.....	38
28.24.7	Instrument Installation .....	38
28.24.8	Protection on Site.....	38
28.24.9	Ready for Commissioning (RFC) .....	38
28.24.10	Period of Instruction .....	38
28.25	INSPECTION, QUALITY CONTROL AND TESTING.....	38
28.25.1	General.....	38

## PART C3.1 - SPECIFICATION

<b>28.25.2</b>	<b>Contractor Qualification .....</b>	<b>40</b>
<b>28.25.3</b>	<b>Factory Acceptance Tests (FAT).....</b>	<b>40</b>
<b>28.25.4</b>	<b>Inspections by the Engineer and/or an Approved Inspection Authority (AIA) .....</b>	<b>40</b>
<b>28.25.5</b>	<b>Quality Control Records .....</b>	<b>42</b>
<b>28.25.6</b>	<b>Substandard Quality Control.....</b>	<b>43</b>
<b>28.25.7</b>	<b>Access for Surveillance .....</b>	<b>43</b>
<b>28.25.8</b>	<b>Submission for Approval.....</b>	<b>44</b>
<b>28.25.9</b>	<b>Cost of Quality Control .....</b>	<b>44</b>
<b>28.25.10</b>	<b>Non-compliance with the Specification .....</b>	<b>45</b>
<b>28.26</b>	<b>OPERATION AND MAINTENANCE MANUALS.....</b>	<b>45</b>
<b>28.27</b>	<b>OCCUPATIONAL HEALTH AND SAFETY.....</b>	<b>45</b>
<b>28.28</b>	<b>APPLICABLE STANDARDS .....</b>	<b>46</b>
<b>28.29</b>	<b>MEASUREMENT AND PAYMENT .....</b>	<b>46</b>

## LIST OF TABLES

<b>TABLE 28/1</b>	<b>WATER QUALITY DATA FOR COCODILE (WEST) RIVER.....</b>	<b>2</b>
<b>TABLE 28/2</b>	<b>MAXIMUM STRESS PERCENTAGES.....</b>	<b>5</b>
<b>TABLE 28/3</b>	<b>EXPECTED BOREHOLE WATER QUALITY.....</b>	<b>31</b>

## LIST OF ANNEXURES

<b>ANNEXURE 28/1</b>	<b>QCP FOR CORROSION PROTECTION OF VALVES .....</b>	<b>49</b>
<b>ANNEXURE 28/2</b>	<b>SURFACE PROFILE AND DRY FILM THICKNESS READINGS .....</b>	<b>52</b>
<b>ANNEXURE 28/3</b>	<b>COATING APPLICATION RECORD.....</b>	<b>55</b>
<b>ANNEXURE 28/4</b>	<b>EXTENDED FLANGE DIMENSIONS SPECIFICATION.....</b>	<b>57</b>

## SECTION 28

### MECHANICAL GENERAL

#### 28.1 SCOPE

This Section deals with the general requirements for mechanical installations and shall be read in conjunction with the remainder of the Contract and in particular with Sections 29 up to and including 37 as well as Section 48. Any particular requirement stated in those Sections shall take precedence over Section 28.

This Section shall be interpreted as follows:

- a) For the Employer design components, it shall be regarded as a specification; and
- b) For the Contractors design components, it shall be regarded as an Employer's requirement.

#### 28.2 REFERENCES TO STANDARDS

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

Plant, materials and operational methods shall, in order of preference, comply with the relevant SANS, SABS, ISO, BSS, DIN or equivalent American Standard whether prescribed or not.

#### 28.3 DEFINITIONS

In this Section the word or words:

- a) **“Design”** includes, as applicable, the submission of design documentation to obtain approval from the Engineer.
- b) **“Supply”** includes, as applicable, the purchase of materials or goods, manufacture and fabrication, any specified corrosion protection measures and any off-site inspection or testing.
- c) **“Installation”** includes, as applicable, all handling and transport from storage, if necessary, all erection and setting to work.
- d) **“Factory Acceptance Test (FAT)”** shall refer to all tests done on Plant or Plant items at the factory to ensure its functionality.
- e) **“Pre-commissioning”** shall refer to the functional field test done on specific part of Plant on Site. This forms part of Tests on Completion as specified in Section 48.

## PART C3.1 - SPECIFICATION

**28.4 OPERATING CONDITIONS AND CLIMATE****28.4.1 Water Quality****28.4.1.1 Suspended Solids**

Flow is drawn off into the Diversion Works from the Crocodile (West) River and hence some coarse solids in suspension, a degree of turbidity, sediment and grit is likely especially after heavy flood run-off.

**28.4.1.2 pH**

The pH of the water may vary from pH = 6.58 to pH = 9.1.

The Plant shall be suitable for operating in the corrosive properties of the water and taking into account the effect of any bacterial corrosion action which may arise. Special consideration shall be given to the corrosion protection of all permanently immersed parts where maintenance painting is not possible.

**28.4.1.3 Water Quality Data**

Water quality data from station A2H128 for the Crocodile (West) River between 2004 and 2018 was obtained from the Department of Water and Sanitation (DWS) and is summarised in Table 28/1 below.

**TABLE 28/1  
WATER QUALITY DATA FOR COCODILE (WEST) RIVER**

<b>PARAMETERS</b>	<b>TOTAL SAMPLE</b>	<b>MAX.</b>	<b>MIN.</b>	<b>AVERAGE</b>	<b>90<sup>TH</sup> PERCENTILE</b>
Conductivity mS/m EC	112	97.50	43.86	74.06	89.94
Total Dissolved solids (mg/l)	62	694.31	322.46	525.72	643.34
pH	113	9.04	6.58	8.40	8.84
Calcium - Ca (mg/l)	108	70.87	26.20	42.91	51.74
Dissolved Mg (mg/l)	108	43.20	15.40	26.35	35.79
Potassium - K (mg/l)	89	10.10	4.40	8.18	9.13
Sodium - Na (mg/l)	90	96.08	37.60	68.07	86.85
TAlkalinity – CaCO <sub>3</sub> (mg/l)	112	243.58	102.70	173.97	208.45
Dissolved Cl (mg/l)	111	144.63	39.99	85.89	130.35
Fluoride – F (mg/l)	86	1.64	0.21	0.47	0.61
Silica – Si (mg/l)	113	8.20	0.34	4.16	6.48
Sulphate SO <sub>4</sub> (mg/l)	113	167.70	41.71	73.43	92.37
Dissolved NH <sub>4</sub> (N) (mg/l)	113	0.30	0.02	0.05	0.04
Nitrate Nitrogen - NO <sub>3</sub> (N) (mg/l)	109	3.87	0.03	0.94	1.38

## PART C3.1 - SPECIFICATION

PARAMETERS	TOTAL SAMPLE	MAX.	MIN.	AVERAGE	90 <sup>TH</sup> PERCENTILE
KN (mg/l)	No Data				
Phosphate – PO <sub>4</sub> (P) (mg/l)	113	0.44	0.01	0.11	0.39
TP (mg/l)	No Data				
Turbidity (NTU)	No Data				

#### 28.4.2 Water Temperature

No data is available of the temperature of the water to be drawn off from the river.

#### 28.4.3 Climate

The Plant shall be suitable for operating satisfactorily under the climatic conditions prevailing in the area of the Works. The Contractor shall ascertain such additional information he considers necessary for the design of the Plant. Refer to Volume 3, Part C4, Section 4.3 for Hydrological Data.

The Plant shall be designed and manufactured with due attention to its position of installation, and to its satisfactory operation, inspection and maintenance aspects under the conditions prevailing at the Site.

### 28.5 DESIGN AND PERMISSIBLE STRESSES

#### 28.5.1 General

- a) The Contractor shall design the relevant parts of the Works to the Engineer's satisfaction and in accordance with the Specification. The Engineer can request and agree such modifications as may be required to facilitate integration and improved operation and maintenance of the Works.
- b) The design shall be in accordance with best practice and shall be such as will facilitate operation, inspection, cleaning, repainting, lubrication, maintenance and repair to ensure the highest reliability of operation under all service conditions.
- c) The Contractor's design calculations shall be submitted to the Engineer with the appropriate drawings for approval. Approval by the Engineer of the Contractor's design and/or drawings shall not relieve the Contractor of any of his obligations or liabilities under the Contract.
- d) Generally, the design shall be such as to provide the maximum reliability under all conditions of service, coupled with safety and convenience of operation and maintenance under all conditions at the Site.
- e) The design dimensions and materials of all parts shall be suitable for the specified service and be such that the stresses to which they may be subjected shall not render them liable to buckling, breaking or excessive wear. The arrangements and details shall be simple and robust.
- f) All moving parts shall work silently and be readily accessible for removal, maintenance and repair. All parts shall be designed, proportioned and supported so as to withstand, without undue deflection or deformation, the forces which may be applied to them.

## PART C3.1 - SPECIFICATION

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- g) Special measures shall be taken to prevent malfunction due to corrosion, to minimise risk of fire and to prevent ingress of dust, dirt, moisture and vermin.
- h) The designs shall be in accordance with the applicable requirements of the Occupational Health and Safety Act, Act 95 of 1993 and its regulations.

**28.5.2 Vibration and Design Loads**

- a) Special care shall be taken to ensure that all items of Plant are free of harmful vibration. Special care shall also be taken to ensure that resonance of any part does not occur as a result of harmonics which, although not apparent when the item in question is tested by itself, nevertheless give rise to objectionable and harmful vibrations when it is installed in its final position.
- b) The Contractor shall, without additional payment, take whatever steps may be necessary after erection to remedy any vibration which the Engineer considers harmful.
- c) All fastenings on Plant which may, notwithstanding the above provisions, be at risk of vibration under certain combinations of loadings and operating conditions, shall be designed, by means of lock washers or by other approved means, not to work loose due to vibration or other cause.
- d) Design loads and load cases shall be those set out in DIN 19704/5: Hydraulic Steel Structures: except that:
- i) Impact by ships and friction by ships shall not be considered;
  - ii) Seismic conditions shall be considered, with the simultaneous application to all parts of the Works of a seismic event having a vertical acceleration of 0.06 g and a horizontal acceleration of 0.08 g (hereinafter referred to as the "Design Basis Earthquake" or DBE) applied in the most adverse combination and direction;
  - iii) In respect of the design of gates (and associated hoist and hoist gantry) the provisions of ii) above shall be applied under the following conditions:
    - Gates closed and subject to the specified maximum water levels; and
    - Gates partially open in still water or in air at any vertical position.
  - iv) In respect of the design of other hoists and cranes the provisions of ii) above shall be applied under fully loaded conditions at any vertical position; and
  - v) The criteria for approval of the response of mechanical Plant to the DBE shall be that all components of the Plant in question shall, after the seismic event, remain broadly operational without the need for other than minor adjustment. In particular, permanently submerged components (such as gate guides) shall not be distorted to such an extent as to prejudice correct operation of the gates after the most adverse combination of gate position and vertical and/or horizontal seismically induced forces.

**28.5.3 Permissible Stresses: General**

- a) The Plant shall be designed such that no part of the Works under any loading condition shall impose any stress greater than those set out below on or in any 30 MPa concrete work:
- For bedded bearing stress: 12 MPa
  - For shearing stress: 1.7 MPa
  - No tensile stress shall be allowed in concrete.

## PART C3.1 - SPECIFICATION

- b) Under the most severe operating and/or erection condition, stresses in castings and forgings expressed as percentages of tensile strength shall not exceed the figures set out in the table below.

**TABLE 28/2  
MAXIMUM STRESS PERCENTAGES**

MATERIAL	TENSION	COMPRESSION	SHEAR
Grey cast iron	10%	20%	6%
Nodular cast iron	20%	20%	12%
Carbon or low alloy cast steel	20%	20%	16%
High alloy cast steel	20%	20%	16%
Carbon and high alloy forgings	25%	25%	20%

- c) The value of tensile strength to which the tabulated percentages shall be applied shall be the tensile strength (as defined in BS EN ISO 6892-1) of the proposed grade of metal as guaranteed by the supplier of the metal on the basis of tests carried out in accordance with BS EN ISO 6892-1.

#### 28.5.4 Permissible Stresses: Gates and Valves

- a) All structural steel parts shall be manufactured from steel conforming to SANS 1431, Grade 300W, or equivalent standard.
- b) Permissible stresses for this steel, as well as for 3CR12, shall be determined according to SANS 10162 "The Structural Use of Steel". These stresses are to be multiplied by the following coefficients to allow for indeterminate factors:
- Valves: 0.85
  - Sliding gates: 0.90
- c) When calculating the stresses including transient and earthquake forces, the primary stresses shall not exceed 80% of the yield stress of the material used and where secondary stresses are included the stress shall not exceed 85% of the yield stress of the material used.

#### 28.5.5 Permissible Stresses: Linings

- a) The permissible working stresses for all steel linings and transitions shall not exceed that given in PD 5500. Where the proposed steel is BS EN 10028 a basic permissible working stress of 223 MPa shall be used. If steels other than the above are proposed the permissible working stresses shall be as obtained from PD 5500, but in this case special consideration must be given to the other requirements of PD 5500 regarding welding details, pre-heating, stress relieving, weld joint factor, handling, etc.
- b) Radiographic inspection shall be done for 100 % of the longitudinal welds and where possible, of the circumferential welds including the joint between the circumferential welds and the adjacent longitudinal welds. In addition all in-situ (field) welds shall be 100 % radiographically inspected. The joint factor to be used in design shall then be taken as 1.0 and the design is based on this factor.

## **28.6 DRAWINGS**

### **28.6.1 Drawings Issued by the Engineer**

The drawings that were issued as part of the Tender documentation are not manufacturing drawings and the dimensions given are only sufficient for tendering purposes or to enable the Contractor to complete his working drawings.

### **28.6.2 Contractor's Drawings**

The Contractor shall submit drawings for the following purposes:

- Concept Design : for assessment
- Manufacturing (Workshop) : for approval
- Installation : for approval
- As-built : for records

#### **28.6.2.1 Concept Design Drawings**

- a) The Contractor shall submit concept design drawings for review by the Engineer before commencing with manufacturing drawings.
- b) Concept drawings submitted by the Contractor shall give sufficient information to make a proper assessment of the Plant offered together with sufficient detail to enable the dimensions and general arrangement of the Plant to be determined. All the important parts shall be shown in detail, i.e. gate body, scaling arrangements, bearing arrangements, guides, wheels, etc.
- c) Drawings shall include details of parts to be built into, and loads to be transferred to, the civil engineering works, routes and sizes of cabling, cable ducts or trunking, hydraulic pipework, description of erection methods, operating and control units, position indicators and details of connections to any other Plant.

#### **28.6.3 Manufacturing (Workshop) Drawings**

- a) Before commencing with fabrication, drawings in triplicate shall be submitted to the Engineer for approval. These drawings shall cover the general arrangement, assembly and supporting detailed drawings of the Plant offered and their related ancillary Plant items.
- b) The drawings shall provide complete information regarding thickness and types of material, finishing of surfaces, fixing and connections, standard parts, tolerances, clearances with regard to other machine parts or building faces and in general everything that may have a bearing on the satisfactory fabrication, erection and operation of the Plant shown on these drawings.
- c) Electrical Plant wiring and or hydraulic diagrams for sub-assemblies such as distribution and control boards, as well as overall integrated cabling and wiring diagrams for the complete installation, shall be prepared and submitted in a similar fashion to these drawings.
- d) These drawings shall be submitted within the period(s) as prescribed in Clause 28.7. All drawings submitted must signify authorisation by the Contractor. Submission of the Contractor's drawings shall be accompanied by one or more updated index sheets prepared on A1-size sheet, listing all drawings with numbers, titles and status of amendments.

## PART C3.1 - SPECIFICATION

- e) Two weeks after submission by the Contractor, or 10 days in the event of re-submission, the Engineer will return one of the above-mentioned prints either with his certified approval or else with his comments regarding any amendments that may be required. A drawing returned to the Contractor for amendment purposes shall be re-submitted in its amended form within 2 weeks of the date of receipt of the drawing by the Contractor.
- f) Approval of the above drawings by the Engineer shall only signify approval of the general design and layout and shall not make the Engineer liable for any error by the Contractor.
- g) Priority shall be given to those drawings regarding items that affect the concrete or other construction work of a civil engineering nature. Those drawings shall detail in full, the necessary provisions to be made in the concrete or other supporting structure(s) for casting in of embedded parts and anchors for fixing of built-in parts and Plant.
- h) All the foundation details and the positions and dimensions of all connecting rods, pockets, vent ducts, cable ducts, anchor bolt holes and similar items, as well as aligning, fixing, anchoring and second stage concrete requirements must be clearly indicated and detailed on these drawings with the general requirements for built-in parts.
- i) The magnitudes and directions of all forces and loads, both static and dynamic, exerted by the Plant on the supporting concrete structure shall be clearly and fully detailed on the Contractor's drawings. Any special requirements to prevent transmitting possible vibrations must also be shown.

**28.6.3.1 Installation Drawings**

- a) Not later than 21 days after the proposed Plant has been given approval, drawings shall be submitted to allow for adequate Site preparation before the arrival of the Plant. These drawings shall offer the necessary details for the programming of civil Works, including foundation details and anchor bolts.
- b) The Engineer has the right to suspend manufacture until a set of drawings, calculations, a draft Operation and Maintenance Manual and Quality Control Plans (for the manufacture and corrosion protection including data sheets of paint and abrasives used) are in his possession and approved in principle.

**28.6.3.2 As-built Drawings**

- a) On completion of the Works, the Contractor shall deliver to the Engineer's office one complete set in triplicate of high quality paper copies together with an electronically saved version preferably on Compact Disc of the Contractor's drawings, updated to reflect the as-built information. These drawings must be clearly marked as "As-built".
- b) These drawings shall contain general arrangements, assemblies, parts lists (including part numbers) and complete component details as well as wiring and hydraulic diagrams. These items are required in draft form before the Tests on Completion are commenced and in final form before Taking Over in terms of the General Conditions of Contract.

**28.6.4 Drawing Format**

- a) Drawings provided by the Contractor shall be to scale size A3 produced in hard copy and electronically in pdf format. Each drawing shall incorporate a standard project title block, to be provided by the Engineer, and shall show the following particulars in the lower right hand corner:
  - Name of Employer;

PART C3.1 - SPECIFICATION

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- Name of Engineer;
  - Name of Contractor;
  - Project title;
  - Contract number;
  - Title of Drawing (Location, item and detail);
  - Scale;
  - Date of Drawing;
  - Details of electrical supply (where applicable);
  - Drawing numbers for both Project and DWS archiving; and
  - Revision identification.
- b) Dimensions on all drawings shall be metric.
- c) A blank space 90 mm by 60 mm shall be provided as an extension of the title block for the Engineer's approval stamp. Provision shall be made for details of revisions to be recorded above the title block. Prints of drawings shall be as described below:

**28.6.4.1 Notes and Part Lists**

- a) Notes on the drawings shall be in English and dimensions in the metric system in SI units with all scales clearly stated.
- b) The Parts List shall be part of the assembly drawing unless otherwise agreed to by the Engineer.

**28.6.4.2 Drawing Identification and Number**

- a) All drawings shall be consecutively numbered.
- b) Each drawing shall be provided with a title block as per the construction drawings issued by the Engineer. A pro-forma drawing frame and title block is available electronically from the Engineer.

**28.6.4.3 Quality and Format of Drawings**

- a) The standard of draughtsmanship and detailing shall conform to the requirements of SANS 10111 and 10143. Drawings shall be clear, black line on white paper and unfolded and suitable for electronic scanning purposes.
- b) Unless otherwise agreed to by the Engineer, the Contractor's drawings shall be prepared on A1-size (594 x 841 mm) high quality paper. The size of the drawing shall not compromise the clarity of the prints.
- c) Drawings shall be submitted in hard copy and electronically in Pdf format.

**28.7 CONTRACTOR'S SUBMISSIONS**

Within 28 days of the date of the notice to commence work, the Contractor shall commence to submit for the Engineer's approval, before any manufacture is started, all the submissions required by the Specification.

## PART C3.1 - SPECIFICATION

Drawings, to be submitted in the manner prescribed in Clause 28.6, shall include those listed below. The Contractor shall continue to make submissions at a reasonable rate so that all designs and drawings are completed within a further 56 days. Manufacture shall not be commenced until the Engineer's approval has been given on all the drawings. The Contractor shall carefully check each submission and those of Subcontractors and before forwarding those to the Engineer for approval shall sign each submission to certify that it has been checked by the Contractor. The Engineer will not examine any submission which has not been so certified. The Engineer shall, within 14 days of receipt of all drawings, signify his approval or otherwise thereof.

Submissions to be made include:

- a) Preliminary drawings, the purpose of which is to enable the Engineer to proceed with or check the design of civil engineering or other Works, shall show the layout and dimensions of the Plant, details of loads to be carried and the positions and dimensions of foundations, supports, ducts, openings in walls and floors and all other necessary details.
- b) Drawings and submissions for approval by the Engineer:
  - i) General arrangement drawings which shall be dimensioned and shall show the Plant and ancillary Plant items to be supplied under the Contract;
  - ii) Contractor's and manufacturer's design and shop drawings of all Plant items showing connections between the various items of Plant;
  - iii) Submissions such as Calculations, Manuals, Programmes, Quality Plans, Progress Reports, Packing Lists, Samples and Test Reports as required by the Specification; and
  - iv) Such other drawings as the Engineer may require.
- c) These drawings and submissions (together with any of the said preliminary drawings which may be suitable), having been corrected or amended as necessary to the Engineer's approval, shall become the drawings and submissions to be used for the execution of the Works and no drawings and submissions other than these drawings and submissions shall be used for such purpose without specific instructions, in writing, from the Engineer.
- d) Copies of all approved drawings and submissions shall be provided for the Engineer's use during the course of the Works. Approval of any drawing or submission will not relieve the Contractor of any of his responsibilities under the Contract.
- e) Copies of all other drawings for all Plant being provided under the Contract shall also be provided to enable the Engineer to have a full understanding of the Plant, but these will not form part of the approved drawings.
- f) The Contractor shall ensure that the approved As-built drawings are marked up to show the condition of the Works as installed and 3 copies of such marked up prints shall be submitted to the Engineer for approval prior to the preparation of the As-built drawings.
- g) Within 84 days of the whole of the Plant or parts thereof having been taken over, the Contractor shall provide one complete set in triplicate of As-built drawings to show the whole of the Plant as installed and shall include all general arrangement and detail drawings, diagrams and schedules produced. Information shown must include tolerances, clearances, loadings, finishes, materials and ratings.
- h) The Contractor shall also provide all drawings in electronic format (.dwg and .pdf) to the Employer.
- i) An updated register of all the Contractor's drawings and documentation shall be provided with each submission of drawings.

## **28.8 MATERIALS AND WORKMANSHIP**

### **28.8.1 Introduction**

- a) This part of Section 28 sets out the general standards of materials to be supplied by the Contractor.
- b) All component parts of the Plant shall, unless otherwise specified, comply with the provisions of this Section and be subject to the approval of the Engineer.
- c) The names of the manufacturers of materials and Plant proposed for incorporation in the Works, together with performance reports, capacities, certified test reports and other significant information pertaining to such manufacturers, shall be furnished when requested by the Engineer.
- d) The Engineer shall have the power to reject any parts which, in his opinion, are unsatisfactory or not in compliance with the Specification and such parts shall be replaced by the Contractor without additional payment.

### **28.8.2 Compliance with Standards**

- a) The materials, design and workmanship shall be in accordance with the appropriate Specification current at the contractual base date unless otherwise specified. Providing the Contractor has stated in his Tender that any part of the Plant offered conforms to some other equal or better Standard and the Employer has accepted such offer, such other Standard shall apply for that part of the Plant.
- b) Should the Contractor desire for any reason to deviate from the Standards specified or the aforesaid equal or better Standard, he shall submit for the Engineer's approval a statement of the exact nature of the deviation, fully supported by copies of the equivalent Standard (in English) and complete Specification of the alternative materials proposed. It shall be the responsibility of the Contractor to demonstrate that any alternative Standards proposed are equal or superior to those specified.
- c) Within this Specification, particular requirements stated in any Section shall take preference over the general Standard/s relevant to any item.

### **28.8.3 Materials**

- a) All material and Plant, where not specified, shall comply with the relevant standard specifications.
- b) 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 imperfection and selected for long life and minimum maintenance.
- c) All parts subject to submergence or subject to relative movement shall be of corrosion-resistant metals. All parts in direct contact with various chemicals shall be completely resistant to corrosion and abrasion by those chemicals. All parts shall maintain their properties with minimum deterioration due to the passage of time, exposure to light or any other cause.
- d) Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion potential is minimised or preferably eliminated by the use of standard isolating procedures.

## PART C3.1 - SPECIFICATION

- e) All materials, supplies or articles used in the Plant shall be new products of recognised reputable manufacturers with established dealerships and/or agencies in the Republic of South Africa and subject to the approval of the Engineer. Products will be approved only when the Engineer has been notified and has satisfied himself as to their strength, reliability, durability and suitability for the application intended.
- f) To assist the Engineer in this matter the Contractor shall provide performance data, references to completed Works and any other relevant information together with samples of materials for approval. Materials, Plant and other articles incorporated in the Works without the approval of the Engineer may be subsequently rejected by the Engineer.

**28.8.4 Workmanship**

- a) Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice.
- b) The fabrication, machining and finish (incl. corrosion protection finishes) of all parts shall be such that when the work is assembled both in the shop and at the Site, the appropriate tolerances and clearances shall be obtained. The clearances used shall be sufficiently small to avoid vibration but all moving parts shall operate freely and shall be such that the risk of undue wear or jamming under load or on account of debris, temperature effects, encrustation or other causes is minimised.
- c) The procedures for fabrication shall be as specified in Clause 4.3 of SANS 2001, Construction Works, Part CS1: Structural Steelwork subject to the specific requirements that all burrs shall be removed, flame cut edges dressed and sharp edges ground off to a radius of at least 2 mm and smoothed. Holes shall be drilled, not punched.
- d) All similar items of Plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same type of materials as the originals and shall fit all similar items of Plant. Machinery fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.
- e) All Plant shall operate without harmful vibration and with minimum noise. All revolving parts shall be statically and dynamically balanced so that when running at all operating speeds and any load up to a maximum, there shall be no vibration due to lack of balance.
- f) All parts which can be worn or damaged by dust shall be totally enclosed in a dust-proof housing.
- g) Manufacturers of stainless steel items shall comply with the "Stainless Steel Good Housekeeping Rules" as issued by SASSDA.

**28.9 SUBCONTRACT ORDERS**

- a) Where the Contractor proposes to supply materials not of his own manufacture or otherwise to subcontract part of the Works, the Subcontractors named by the Contractor when tendering shall not be changed without the prior approval in writing of the Engineer.
- b) All subcontract orders shall be sent to the Engineer at the time of placing orders, each clearly marked with the Contract title and the Contract number.
- c) Purchase orders placed on suppliers of other Plant shall be made available to the Engineer upon request.

**28.10 SPARE PARTS**

- a) A list of essential spare parts required is shown in Section 48 – Tests on Completion and shall be supplied by the Contractor for the operation of the Plant for a minimum period of five years. Other spare parts not indicated on the list and considered as essential by the Contractor can be added.
- b) 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 storage under the climatic conditions prevailing at the Site.
- c) Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container in a waterproof transparent envelope and a detailed list enclosed.
- d) All cases, containers and other packages shall be marked and numbered in an approved manner for purposes of identification.

**28.11 STORAGE, HANDLING AND TRANSPORTATION****28.11.1 Assembly in Manufacturer's Workshop**

Excluding any special deviation approved by the Engineer or his representative, each machine, appliance or assembly of the Plant shall be completely assembled in the manufacturer's workshops. Each part shall be identified so as to ensure the correct assembly of the parts when they are erected on Site. All adjustments and welding which may be made in the workshop shall be made so as to avoid as far as possible adjustments and welding on Site.

**28.11.2 Numbering and Marking of Materials, Plant and Parts**

Before dispatch to Site all items of Plant, parts and materials to be supplied under the Contract shall be clearly numbered and marked to ensure the correct assembling, erection or storage thereof on Site. The numbers and marking shall be punched and/or painted so as to be clearly visible at the time of erection and assembly.

**28.11.3 Packing for Transport and Storage**

- a) The Contractor shall be held responsible for the packing of Plant, materials and parts in such a manner as to conform to the provisions of any and all Regulations in South Africa to ensure freedom from loss or damage in transit from the places of fabrication and supply to the Site. The Contractor shall be held responsible for any loss, damage or breakage during transit up to the storage facility or Site.
- b) The Contractor shall take all the necessary steps to safely store any Plant which cannot be installed directly in its final position and shall ensure its protection and maintenance throughout the storage period.
- c) The Contractor shall obtain all necessary information from the authorities concerned with regard to the carrying capacities of rail and road links to the Site and any special licences that may be required.

## PART C3.1 - SPECIFICATION

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- d) The transport of the Plant from the Works of the Contractor or of his Subcontractors and the offloading on Site shall be carried out at the sole expense and under the responsibility of the Contractor.
- e) Packing materials and packaging shall be adequate for complete protection of all items of Plant, materials and parts against any possible damage by handling, sand, dust, moisture and other atmospheric conditions or any other possible damage while they are being shipped and/or transported to Site.
- f) For goods manufactured overseas, the packing shall be suitable for shipment, i.e. sea or air freight including road transport up to Site.
- g) Plant liable to marine corrosion, such as electrical Plant items, shall be placed inside the packing cases within watertight envelopes provided with desiccators.
- h) Plant sensitive to vibrations, such as electrical cabinets shall be additionally placed in "vibration proof" packaging material.
- i) Satisfactory temporary end covers shall be provided for the protection of flanges, prepared ends of plain-ended pipes, specials and fittings, and threads, to prevent damage to the internal lining during transportation and during handling on Site.
- j) In addition to the normal shipping and transport markings, all items and packages shall be clearly identified with at least the following information:
- Name and locality of the Scheme;
  - Contract number;
  - Component description; and
  - Mass (gross and nett.)
- k) Bolts and other small parts shall be sewn up in strong bags and crated. The bags shall be tagged using metallic tags and indicate the following information:
- Manufacturer's/supplier's identification and contract number;
  - Part numbers;
  - description of content;
  - Sizes; and
  - Quantities.

Each bag shall have the delivery address listed on a separate metallic tag.

#### **28.11.4 Storage**

- a) The Contractor shall ensure that during the period awaiting delivery to Site and or installation, all Plant, Plant items, materials and parts are suitably stored in a safe place above ground and under cover (where necessary), and shall be protected against any damage by sand, dust, stormwater, moisture, weather conditions, insects, vermin or fungal growth.
- b) Should mechanical Plant be ready for installation but e.g. the civil structure is not completed or there are other factors that prevent the mechanical installation from commencing, the Plant must be stored at a facility or facilities approved by the Engineer. The Contractor must if requested provide a schedule for care and turning of the rotors of the pumps and motors and other preservation tasks that may be necessary. The Contractor will be responsible for insuring the Plant and maintaining and caring for them during the storage period. This will be monitored by the Engineer.

PART C3.1 - SPECIFICATION

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- c) Grass or other vegetation shall not be allowed to grow in the storage area within three metres of the Works and Plant stored.
- d) The Contractor shall be responsible for any loss or damage to Plant, Plant items, materials and parts stored at places of fabrication and supply as well as any Plant stored on Site.

**28.11.5 Delivery**

- a) All items transported shall be effectively supported and fastened down to prevent knocking against each other. The type and positioning of fasteners shall be such that items will not be damaged by the fasteners themselves.
- b) All items shall be handled throughout the process of delivery with all necessary care to prevent damage and or overstressing of components. Containers such as for lubricants and paint shall for instance not be stacked on top of other fabricated items while being transported, but shall be completely separated from the fabricated items.
- c) The Engineer shall be notified of the delivery date and of any special requirements regarding off loading and storage at Site.
- d) The Engineer's representatives on Site will check in detail the contents of each delivery and sign delivery notes. Plant that was not released from the factory following the correct procedure will not be received on Site. Documentary proof of release from the factory (signed by the Engineer or his representative) must accompany the Plant to Site.

**28.11.6 Supervision**

The Contractor shall be responsible for supervision during all transportation and off-loading.

**28.11.7 Handling during Loading, Off-loading and Installation**

- a) Care shall be taken to ensure the corrosion protection system is in no way damaged and/or the parts are not overstressed in any manner. The materials shall at all times be handled with approved equipment, employing stout, wide canvas or rubber-covered slings and wide padded skids designed to prevent damage to the exterior coating. Bare cables, chains, hooks, metal bars, or narrow skids shall not be allowed to come into contact with either the exterior coating or the interior lining of any item.
- b) Under no circumstances shall coated Plant be allowed to rest directly on the ground. The Contractor shall provide all the necessary beams of timber and sawdust bags to support the Plant and components on soil, concrete or other hard surface and to separate them from each other at his Works, during transportation and on Site.
- c) The final delivery inspection and acceptance of Plant supplied shall be undertaken on Site after off-loading has been completed. The Engineer reserves the right to reject any damaged Plant, components and materials which have been delivered and off-loaded at Site.

**28.11.8 Attachments for Transport and Erection Handling**

- a) The Contractor shall submit for the Engineer's approval proposals for such properly designed supports, lifting attachments or handling points as the Contractor considers necessary or desirable for assistance in handling fabricated sections for cleaning, applying protection, assembly, transportation, storage, erection, and subsequent maintenance. All such lifting attachments or handling points shall be such as to avoid overstressing or deforming the steel members of fabrications. Lifting attachments shall be designed for not less than the applicable mass reaction plus 50% allowance for impact.

## PART C3.1 - SPECIFICATION

- b) Temporary supports, lifting attachments or handling points shall be removed or filled in as required, and by approved methods to the satisfaction of the Engineer. Surfaces of the permanent steelwork in these localities shall be dressed, cleaned and painted as specified elsewhere. Where tapped holes are provided for lifting devices (such as eyebolts) the tapped holes shall be plugged with stainless steel socket head screws (the thread of which shall be covered with an anti-seize compound).
- c) Supports, lifting attachments or handling points may be left, if so approved by the Engineer, provided that in his opinion:
- There is no deleterious long term effect on the structural integrity or operational use of the fabricated item;
  - The steelwork protective system is continuous over or around the lifting attachments or handling points and there is no undue risk of breaks or cracks occurring in the protection at such areas; and
  - There is no significant effect on the visual appearance of the fabricated item.
- d) Attachments to steel items to assist in the future inspection and maintenance of the steelwork and associated Plant may be required. Such attachments (e.g. supports for ladders, scaffolding cradles and ropes) may be combined with the Contractor's temporary handling and lifting requirements during fabrication and erection and agreement on additional attachments shall be subject to the approval of the Engineer before fabrication of the steelwork is commenced.

**28.11.9 Plant and Material to be Complete**

The Plant and materials to be supplied by the Contractor shall be complete with respect to all parts, fixing bolts, seals and all other items so as to ensure a complete, adequate and satisfactory permanent installation at the Site.

**28.11.10 Damage**

The final inspection and acceptance of Plant supplied will be undertaken on Site after off-loading has been completed. Any damage that occurs during the handling, assembly and storage of Plant at the Manufacturer/Contractor's Works, including transportation to Site, shall be repaired by the Contractor at his own cost and to the satisfaction of the Engineer.

**28.12 STEELWORK****28.12.1 Minimum Thickness and Corrosion Allowance**

- a) Stainless steel and 3CR12 (except for that which is used for cladding) subject to a river water environment, an outdoor environment or an indoor environment shall have a minimum thickness of 8 mm, 6 mm and 3 mm respectively.
- b) All other steel, with the exception of machinery house claddings, gear covers, etc., subject to an outdoor environment and subject to corrosion (even though painted on both faces or one face only), shall have minimum thickness of 6 mm.
- c) Steelwork (except stainless steel) shall be thicker, by not less than 0.8 mm for each exposed face, than that required when calculated in accordance with this Section to resist the applied loads, to allow for corrosion.

**28.12.2 Steel for Fabricated Construction**

- a) Mild steel for welded, riveted and bolted construction shall comply with SANS 1431: Weldable Structural Steels. Mild steel for load-bearing components shall not be inferior to Grade 300W.
- b) Corrosion resistant steels used in construction shall comply with EN 10088 and that used for pressure linings shall comply with EN 10028-7.
- c) The Contractor shall provide the Engineer with copies of mill rolling sheets for all sections incorporated in the Works, together with test certificates certifying that the steel has been tested and found to comply with the appropriate Standards. The Engineer reserves the right to test samples of steel independently and the results of these tests shall take precedence over the tests carried out by the rolling mill. Marking by the steel maker and the mills shall comply with BS 4360.

**28.12.3 Stainless Steel**

- a) Unless otherwise specified, stainless steel shall have resistance to atmospheric corrosion not less than that provided by BS 970, Grade 304L and BS ISO 16143.
- b) 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.
- c) Stainless steel shall be pickled and passivated after fabrication and welding. Re-passivation may be ordered, post-installation, at no additional cost should there be evidence of ferrous re-contamination. Refer also in this regard to Section 37 - Painting and Corrosion Protection.

**28.12.4 Lamellar Tearing**

The Contractor shall design, detail and fabricate all junctions in steelwork in such a way as to prevent failure by lamellar tearing.

**28.12.5 Structural Steelwork Fabrication**

- a) Fabrication of structural steelwork shall be generally in accordance with BS 5400 unless otherwise specified.
- b) The Contractor shall ensure that all surfaces requiring corrosion protection are either:
  - i) Accessible, to the satisfaction of the Engineer, for maintenance of the protection by reasonable methods when in position in the Works; or
  - ii) Enclosed in hermetically sealed voids, where it is structurally safe to seal such voids, and as agreed in writing by the Engineer. The voids shall be proved to be sealed by air pressure testing if required by the Engineer.
- c) All permanently exposed edges and corners of members of fabricated steelwork shall be formed or dressed to a rounded profile with a minimum radius of approximately 2 mm to ensure an even coating of the protection to such parts of the fabrication.
- d) All cutting, chamfering and other shaping of metals necessary for Site connections shall be done in the shop. Adequate provision for temporary bolted Site connections or clamps shall be provided to hold assemblies rigid and in proper alignment during Site welding. After welding, all temporary connections and clamps shall be removed and all bolt holes shall be plugged, welded over and ground down flush with the adjacent metal on both faces, all to the satisfaction of the Engineer.

PART C3.1 - SPECIFICATION

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- e) Bending and pressing of plates may be by either the hot or cold process. In no case shall the internal radius of bends in cold-bent plates be less than twice the thickness of the metal. The procedures used, including temperature control in the case of hot-forming, shall be to the approval of the Engineer. Where necessary, allowance shall be made in the design for possible modification of material properties.
- f) Edges of all plates and members shall be square, clean, free from burrs and true to dimensions. If flame cutting is employed, edges shall be dressed smooth and true.
- g) All bolts and nuts shall be in accordance with SANS 1700.
- h) All bolt holes shall be drilled, not punched. Templates shall be used where applicable.
- i) Large washers of at least twice the thickness of a standard washer shall be used on all fasteners going through slotted holes.

**28.12.6 Surface Defects in Fabricated Steelwork**

- a) All fabricated steelwork shall be free of surface defects in the steel, burrs, sharp or rough edges, crevices, cracks or discontinuities in welded joints and depressions, hollows or moisture retaining features in locations where rain, spray or condensed moisture left in contact with the structure may promote corrosion of the steel. The dressing of the steel to remove burrs and rough edges from holes or cut lines shall be carried out as soon as possible after their presence has been detected consistent with the need to clean and give initial protection to exposed steel elsewhere on the plate, section or fabrication concerned.
- b) Surface defects shall be ground out. The extent and depth of laminations shall be determined before any rectification is carried out. Provided the size and extent of any surface defect or lamination is not such as to warrant rejection of the steel plate or member on structural or other grounds, the area affected by the remedial work shall be cleaned and protected to the same standard as the rest of the plate or member.
- c) Where necessary (e.g. to meet dimensional tolerances) the steel surface at such defective areas may be built up by welding including any preheating that might be required and ground flush with the surrounding steel surface before being cleaned and protected. This welding is to be stress-relieved by an approved post-weld heat treatment as approved by the Engineer.

**28.13 WELDING****28.13.1 General**

Welding of pipes and pipe specials shall be done in accordance with Section 32 – Pipes and Pipe Specials and Section 33 – Laying and Pressure Testing of Steel Pipes. All other welding of mechanical Plant shall be done to the following requirements.

**28.13.1.1 Primary Requirements for Welding****(a) Welder's Qualification**

- a) The Contractor shall only use welders suitably qualified in terms of the relevant part of SANS Standards 10044, and shall submit to the Engineer copies of the qualifications of all welders to be employed in the fabrication of items prior to commencement of any such fabrication.

PART C3.1 - SPECIFICATION

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- b) The Engineer shall have the authority to order that any welder whose work he deems to be questionable shall be re-tested in his presence. No separate payment shall be made for such tests. Welders will be required to be re-qualified for the welding procedures in respect of which they have approved qualifications should they not have been employed on work involving these procedures for a period of six months or longer.

**(b) Weld Procedure Specification**

- a) The Contractor shall also submit to the Engineer for this acceptance a copy of his Weld Procedure Specifications in terms of the relevant part of the aforementioned SANS Code. These documents shall contain full details of welding procedure, detail drawings of welds and weld preparations. The Contractor shall carry out, without additional payment, such welding procedure tests as the Engineer may order to prove the sufficiency of his proposed procedures.
- b) No welding shall commence until all welding procedures have been approved by the Engineer in writing. No alteration shall be made to any previously approved procedure without prior approval of the Engineer.
- c) Shop and Field Fabrication Method Statements / QCP's shall be provided detailing welding distortion mitigation or elimination strategies before manufacture commences. The Engineer reserves the right to halt any work should this issue not receive the necessary attention.
- d) All welds shall be identified to enable each weld to be traced to the welder by whom it was made. The form and location of all identification marks shall be proposed by the Contractor and shall be subject to the approval of the Engineer.
- e) The preparation of joint faces shall be by machining except as otherwise approved by the Engineer. Where errors in joint preparation lead to larger gaps between fusion faces than permissible, these shall not be bridged over but the faces shall be made up with weld metal and re-machined as necessary to the correct profile before welding proper commences.
- f) Where deviation from true profile of fusion faces occurs due to mill tolerances in rolled sections, fitting up and welding shall be in accordance with a procedure to be agreed between the Contractor and the Engineer. To this end the Contractor's method statement of welding procedures shall contain proposals for dealing with such deviations.
- g) Pre-heating shall be carried out as recommended in BS EN 1011 PART 2 (2001) read in conjunction with PART 1 (1998) or other appropriate British Standard.
- h) Full throat thickness shall be ensured at the ends of butt welds by the use of extension pieces or by other approved means. If extension pieces are used they shall be clamped to the work and not welded. To ensure full penetration in butt welds, the use of backing material shall not be permitted except as approved by the Engineer.

**(c) Welding Standards and Heat Treatment**

- a) All welding of the various types of steel used in fabrication under this Contract shall be in accordance with the relevant South African or British Standards, or as specified below, and shall include for preheating of the components where required.
- b) In particular the requirement for materials, details of butt and fillet welds, welding procedure details, inspection and testing and heat treatment as specified in BS EN 1011 PART 2 read in conjunction with PART 1 for the welding of mild steel and carbon manganese steels, respectively, shall apply. The welding of stainless steel shall be in accordance with the various most recent welding guidelines published by Columbus Stainless, SASSDA or equivalent publications, at the time of Tender.

PART C3.1 - SPECIFICATION

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- c) Welding equipment, electrodes and rods shall conform to the requirements of the appropriate SANS and BS Standards such as SANS 954 for metal-arc welding equipment, SANS 455 for covered electrodes for manual arc welding of carbon and carbon manganese steels and BS EN ISO 3581 for chromium and chromium-nickel steel electrodes for manual metal-arc welding of stainless steel. The storage and handling of all consumables shall be in accordance with BS EN 1011 PART 2 read in conjunction with PART 1.
- d) All components subjected to heat during fabrication shall be properly stress relieved in accordance with the requirements in the relevant SANS or BS Standards and in particular the most recent guidelines published by Columbus Stainless in the case of stainless steels.
- e) All welds between plates 12 mm or greater in thickness whether carried out in the shop or at the Site shall be stress-relieved by an approved post-weld heat treatment unless otherwise agreed in writing by the Engineer.

**28.13.2 General Weld Quality**

- a) All welds shall be continuous and even, with no contact gaps or crevices left between members or unfilled re-entrant corners which would harbour moisture or dirt and prevent the satisfactory application and retention of the corrosion protective system.
- b) Removal of slag from welds which will be subject to tensile stresses shall be carried out by grinding or blast cleaning. Peening shall be carried out only where approved by the Engineer.
- c) The finish of the welded joint shall be free from irregularities, weld splatter, grooves and depressions. Undercutting at the welded joint shall not be permitted. Where welds are ground smooth, grinding shall where possible be in the direction of the principle stress. All fabrications which are subsequently to be machined in any way shall be stress relieved prior to machining.
- d) If welds or portions of a weld or welds are deemed to be of an unacceptable standard of quality total repair or re-welding shall be carried out as directed by the Engineer. No repair shall be carried out after the radiographic examination without the prior approval of the Engineer.

**28.13.3 Acceptance Tests for Welding****28.13.3.1 General Requirements for Quality Assurance**

- a) The soundness of welding shall be meticulously confirmed by the Contractor by means of examinations and non-destructive testing as described below:
  - i) All welds shall be visually examined and shall conform to the requirements stated in Section 8 of SANS 10044: Part 3. In addition to the visual examination the welds shall also be inspected and tested by other non-destructive methods referred to below with the extent of additional testing varying with the type of loading and exposure to which the weld will be subjected; and
  - ii) The Contractor shall keep a complete record of all examinations and testing of welds, copies of which shall be submitted to the Engineer on request. Any rectification of faulty welds as a consequence of the above examination procedures shall also be recorded and filed with the test records.

**28.13.3.2 Fillet Welds**

- a) The fabricator shall place at the disposal of the Engineer's representative a set of gauges to allow for fillet welds to be checked for throat thickness and profile.
- b) Highly stressed fillet welds, and fillet welds exposed to water either on a permanent or intermittent basis, notwithstanding the protection system to be applied, shall be checked by means of magnetic particle or penetrant testing to prove that the weld metal, the heat affected zones and the surrounding parent metal are all free from cracks. Magnetic particle testing of welds shall be carried out in accordance with BS EN ISO 9934-1 while the method for penetrant testing shall conform to the requirements of BS EN ISO 3452-1.
- c) These tests shall constitute at least 10 percent of the total length of the weld. The length of weld actually examined shall include the sections at the start and end of the weld, sections at any weld junctions and further sections evenly spaced between the aforementioned sections. If any test section shows defects the untested length of weld on both sides of the tested section, extending up to a test section found to be free from defects, shall be tested in full.

**28.13.3.3 Butt Welds**

- a) The quality of butt welded joints which are under stress or exposed to water (as for fillet welds above) or in plate exceeding 10 mm in thickness, shall be tested by means of radiographic examination in accordance with BS EN ISO 17636.
- b) All butt welds in plates 10 mm thick and over shall be tested radiographically in full. For highly stressed or butt welds exposed to water (as referred to above) at least 20 percent of the length of individual butt welds shall be examined radiographically. The length of weld examined shall include the particular sections referred to above for fillet welds.
- c) When examined radiographically, butt welds shall comply with the requirements for Grade B welds stated in Clause 8.2 of SANS 10044: Part 3. If any radiograph reveals one of the unacceptable defects referred to in the aforementioned Code, a further radiograph of about 300 mm minimum length shall be taken on both sides (if applicable) and adjacent to the section of weld showing the defects. If these two additional tests reveal no unacceptable defects, the defects in the middle section shall be repaired and fully re-examined radiographically. Providing that the repair is satisfactory in terms of the foregoing, the relevant section of weld shall be accepted. If any one or both of the additional radiographs reveal unacceptable defects, the whole untested section of weld up to the next tested section, which showed no unacceptable defects on first stage radiography, shall be radiographed. Unacceptable defects shall then be repaired and again re-examined by radiography.

**28.13.3.4 Independent Inspectors and Additional Tests**

- a) All stages of welding work at the places of fabrication and on Site may also be monitored if deemed necessary by one or more independent inspectors from either the SABS or other quality assurance organisation as approved by the Engineer, for confirmation that the specified quality has been achieved. The appointment of these inspectors shall be arranged by the Engineer in consultation with the Contractor. These inspectors will advise the Contractor as to their findings and shall report to the Engineer.
- b) The Engineer may also order additional examinations or testing of welds either by the Contractor or by others. This may take the form of actual testing or also checking the interpretation of existing test records such as radiography films.

**28.13.4 Weld Defects and Repair**

- a) The Engineer shall be notified of all defects before any repair work is commenced and the repair technique shall be subject to the approval of the Engineer. Where ordered by the Engineer repairs shall be subject to radiographic and/or ultrasonic testing.
- b) Where the re-radiographing of a repaired weld reveals further unacceptable defects then the whole weld shall be cut out, re-welded and re-tested. No weld shall be repaired more than twice.
- c) All repairs shall, if practicable, be carried out by the same process as was used for the original weld. An alternative process for repair may only be used with the full knowledge and approval of the Engineer.
- d) Where the defective part has been cut out, the Engineer shall be entitled to make an examination before re-welding is commenced.
- e) Repaired sections of welds shall be re-subjected to radiographic examination and radiographs shall be identified as having been carried out after the repair.

**28.14 FASTENERS****28.14.1 General**

- a) Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirement of the appropriate British or other approved standard. Nuts and bolts for pressure parts shall be the best quality bright steel, machined on the shank and under the head and nut.
- b) Bolts shall be of such standard length that a minimum of two to four complete threads shall protrude beyond the nut when in the fully tightened condition. The same applies to stud units. Mating surfaces shall be adequately protected against corrosion whilst awaiting assembly of the faces and bolting all to the approval of the Engineer.
- c) All bolting shall comply with the general requirements of BS 5400.
- d) Mild steel bolts, rag bolts, nuts and washers shall conform to BS 4360 grade 43D or such higher grade as may be required for steel temperatures down to -30°C as regards material. Nuts and bolts shall conform to BS 4190 as regards dimensions. Washers shall conform to BS 4320 as regards dimensions unless otherwise specified.
- e) All high tensile bolts and studs used shall bear the letter HTS stamped or engraved on the end.
- f) Washers shall be provided under all bolt heads and nuts.
- g) The threads of bolts and studs shall be cleaned and coated with a Molybdenum Disulphide lubricant or Nickel Anti-seize compound before assembly.
- h) Stainless steel bolts, nuts and washers shall be in accordance with SANS 1700 A70 and from a grade of stainless steel approved by the Engineer. Threads shall be rolled and of a high quality surface finish.
- i) Hot Dip Galvanised fasteners shall comply with the requirements of SANS 121.
- j) High strength friction grip bolts, nuts, load indicator washers and washers shall comply with BS EN 14399 and BS 4604 and shall be hot dip galvanised. High strength friction grip bolts shall be tightened in accordance with the manufacturer's recommendations and the tension shall be re-checked not less than 3 hours after first tightening and then the bolts shall be re-tightened to the initial load all to the approval of the Engineer.

## PART C3.1 - SPECIFICATION

- k) Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the threaded 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. Unless otherwise specified the tolerance on the specified diameter of dowels shall be -0.05 mm to -0.20 mm for use in holes for fitted bolts.
- l) Service bolts shall have the same nominal diameter as the specified permanent bolts. Where it is important that there shall be no movement prior to final connection, sufficient dowels, close tolerance bolts or high strength friction grip bolts shall be used to locate the work. All service bolts shall be replaced by the specified permanent bolts.
- m) Washers, locking devices and anti-vibration arrangements shall be provided where necessary and shall be subject to the approval of the Engineer.
- n) Where bolts pass through tapered structural members matching taper washers shall be fitted where necessary and be orientated correctly to ensure that no bending stress is caused in the bolt.
- o) Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt and nut does not exceed half of the yield stress of the bolt material under all conditions. The shear value of high strength friction grip bolts shall be reduced in proportion to the reduced tensile stress compared with the normal design stress.
- p) No tapped holes in mild steel shall be allowed. Where tapped holes are unavoidable, this shall be done into stainless steel.
- q) Where bolts and nuts are required to be removed and re-assembled on a regular basis, these shall be of stainless steel.

#### 28.14.2 Hydrogen Embrittlement in Fasteners

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

### 28.15 FLANGES AND GASKETS

#### 28.15.1 General

- a) Flanges shall be designed and manufactured to BS EN 1092 Part 1 for steel flanges and Part 2 for cast iron flanges, unless otherwise specified on the drawings. Flanges not covered by BS EN 1092 shall be manufactured according to NWS 1676 Revision 0 dated May 1981 (included as Annexure 28/4 to this section). Unless otherwise indicated on the drawings or specified in the Bill of Quantities, flanges shall be of forged Grade 300WA steel or ASTM A105.
- b) Sealing faces shall be machined flat to a tool-mark of 0.8 mm to 1.25 mm pitch spiral or concentric serrations and back of flanges to be either machined or spot-faced around holes with sufficient clearance to ensure proper seating of bolt heads and nuts. All bolt holes shall be drilled perpendicular to the flange face. Bolt holes shall be positioned off-centre and symmetrically off-set from the vertical centre lines of the flange and flanges shall be installed truly square to the axis of the pipe. The Contractor shall check the compatibility of drilling of all flanges to be connected together.
- c) Flange thicknesses and bolt sizes shall conform to the appropriate table of BS EN 1092 or NWS 1676 Revision 0 dated May 1981 for flanges not covered by BS EN 1092. (Annexure 28/4)

## PART C3.1 - SPECIFICATION

- d) The Contractor shall satisfy himself that the flanges in his supply shall match the flanges supplied by others or at interfaces between Subcontractors, if any. The Contractor shall refer to Section 35 – Valves and Section 41 – Control and Instrumentation to confirm that the drilling patterns of pipe specials to be installed on both sides of valves and flow meters will match that of the appropriate supplied valve and flow meter.
- e) All flanges designed for pressure ratings up to and including 1600 kPa, shall be flat faced with full face gaskets. Flanges designed for pressure rating exceeding 1600 kPa shall be raised face flanges supplied with ring gaskets. Flanges with pressure ratings of 6400 kPa and higher and flange sizes of 2500 mm diameter and larger, irrespective of pressure rating, shall incorporate an “O” ring groove. Details of the “O” ring groove shall be furnished by the Contractor for consideration by the Engineer.
- All gaskets supplied under this Contract shall be of tanged graphite full face for flat joint faces and aramid and glass fibre with nitrile rubber binder to BS 7531 ring face for raised faces. Gaskets shall be suitable for the specified pressures with a minimum thickness of 3 mm and purpose made to the dimensions of the matching flanges. Joints in gaskets shall be kept to the minimum. Where not avoidable, joints shall be a tight fitting dovetail design.
- f) Corrosion protection for the area not clamped shall be similar in all respects to that applied externally to the pipework/valve/pump.
- g) All mill scale on flanges shall be removed by abrasive blasting before flanges are fitted and welded to pipes and fittings.
- h) All flanges shall be supplied complete with bolts, nuts, washers and gaskets. Fasteners shall comply with SANS 1700 Grade 8.8 minimum and shall be hot dip galvanized to SANS 121 standards or stainless steel grade 316L where specified. Washers shall be installed under the nut as well as the bolt head to protect the paintwork. A minimum of two and maximum of four screw threads of any bolt or stud shall protrude above the nut.
- i) Rubber joint rings shall comply with SANS 4633.
- j) Puddle flanges shall not be drilled.

**28.15.2 Restraining Flanges**

- a) The longitudinal movement of certain flexible couplings (where shown on the drawings) shall be restrained by means of a restraining flange and associated restraining bolts. Unless the diameter, number and length of the long restraining bolts as well as any possible pipe wall thickening are shown on the drawings, these parameters shall be specified by the Contractor with the assistance of the manufacturer. The effect of cyclic loading and fatigue must also be taken into consideration.
- b) Restraining flanges do not require all the bolt holes specified in the applicable flange drilling table. Only those required for the long restraining bolts need to be provided. These holes must comply with the applicable flange drilling table and be spaced equally on the restraining flange and symmetrically around the flange centre lines.
- c) Restraining bolts to be positioned to avoid interference with any stubs specified for an item.

**28.15.3 Blank (Blind) Flanges**

Blank flanges for pipes equal to or greater than 400 mm diameter (including the ones with pipe stubs welded on it) shall be provided with two suitable lifting handles with coating similar than the blind flange.

**28.15.4 Insulating Flanges**

- a) Where called for, insulating flanges and materials shall be arranged as set out in Section 34 Clauses 34.3.5.4, 34.4.11, 34.8.2 and 34.10.
- b) The design, manufacturing, supplying, installation and testing of the insulating flanges complete with spark gap arrestors shall be in accordance with the drawings and to the approval of the Engineer. Insulating flanges shall be provided at locations as indicated on the drawings.

**28.16 MISCELLANEOUS MATERIALS****28.16.1 Cast Iron**

- a) Cast iron shall be of the nodular or spheroidal graphite type to SANS 936/937 grade SG42 or to such other grade as is approved by the Engineer.
- b) Cast iron shall not be used for components subject to impact stresses unless otherwise approved by the Engineer.
- c) Before proceeding with foundry work for any castings which will be subject to hydraulic pressure and for all other important components, the Contractor shall submit to the Engineer for his approval drawings of such castings, showing the proposed locations for taking specimens for tensile, impact, fatigue, bending and any other appropriate tests. Castings shall be clearly marked by the manufacturer.
- d) The Contractor shall give the Engineer not less than 14 days' notice in writing of the date when such castings will be cleaned to enable the Engineer to inspect the castings immediately after they have been cleaned. Whether or not the Engineer attends such inspection, no repair work shall be undertaken without the Engineer's prior approval.
- e) Castings shall be true to the drawings and any castings in which any dimension is so much reduced as to impair the strength of the casting by more than 10% or to increase the stresses above specified limits may be rejected by the Engineer.
- f) The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions and other injurious defects. Excessive segregation of impurities or alloys at critical points in a casting will be sufficient cause for its rejection.
- g) The Contractor shall perform all tests listed in SANS 936/937 together with the following additional tests on specimens from each batch:
  - i) Each tensile test shall include determination of the 0.2% proof stress value; and
  - ii) Three impact tests shall be performed on samples from each batch of castings at normal ambient temperatures and 3 further tests at an ambient temperature of -30°C. The average impact value of each set of tests shall be such as will be suitable for the operational temperatures of each item made from the batch, as agreed with the Engineer.
- h) The Contractor shall non-destructively test all castings using radiographic, magnetic particle, penetrant and ultrasonic flaw detection methods as appropriate, similar to those specified in BS 4080 and as agreed with the Engineer.
- i) Subject to the approval of the Engineer, minor defects shall be chipped or grooved out by a carbon arc air process to sound clear metal and repaired by welding. Castings with defects which do not otherwise affect the performance of the castings but which necessitate the removal of metal resulting in a reduction in the stress-bearing cross-section of a component by more than 20% may be rejected by the Engineer.

PART C3.1 - SPECIFICATION

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- j) Welding shall only be carried out by properly qualified welders and all such repairs shall, unless otherwise agreed by the Engineer, be subject to stress relief.
- k) Before carrying out any repairs the Contractor shall submit to the Engineer for his approval a complete statement of procedure for such repairs together with, where appropriate, stress calculations and no repair work shall commence until the Engineer's written approval of such statement and calculations has been received.
- l) In addition to tests carried out under Clause 28.16.1(g), and if so instructed by the Engineer radiographic and/or ultrasonic testing and/or other approved non-destructive testing shall be carried out on the areas around all defects in any casting after removal of metal to ensure that each defect has been properly removed.
- m) Certified copies of the results of any test required shall be furnished to the Engineer.

**28.16.2 Steel Castings**

- a) The steel used for castings shall be of the quality appropriate to each particular item as approved by the Engineer and shall comply with Clause 28.12.1 and with the relevant British Standards included in BS EN 10293. Castings shall be heat treated as agreed in writing by the Engineer.
- b) The Contractor shall perform all the tests listed in BS EN 10293, together with the following additional tests on specimens from each batch:
  - i) Brinell hardness tests together with copies of test certificates; and
  - ii) The impact tests specified in Clause 28.16.1(g).

**28.16.3 Forgings**

- a) Steel for forging shall be of the quality appropriate to each particular item, shall comply with BS 970, as appropriate and shall be subject to the approval of the Engineer.
- b) All forging shall be heat-treated for the relief of residual stresses before the start of machining and the Contractor shall submit details of his proposed method to the Engineer for his approval in writing before starting the treatment.
- c) The forging shall be inspected by the Contractor using radiographic methods similar to those set out in BS 4080 for steel castings and also using the ultrasonic, magnetic particle and penetrant flaw detection testing techniques set out in BS EN 10228.
- d) The Engineer shall be informed in writing of all flaws found by the inspection and the Contractor shall not use in the Works any forging containing flaws unless remedial action is agreed with the Engineer and carried out by the Contractor to the satisfaction of the Engineer.

**28.16.4 Fabrics, Wood, etc.**

- a) Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated with an approved fungicide. Sleeving and fabrics treated with linseed oil varnish shall not be used.
- b) The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating.
- c) The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood which is resistant to fungal decay and free from shakes and warp, sap and wane, knots, faults and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, bacteria or chemical attack,

PART C3.1 - SPECIFICATION

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unless it is naturally resistant to those causes of deterioration. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types which are impervious to moisture. Synthetic resin cement only shall be used for joining wood. Casein cement shall not be used.

**28.16.5 Bronze**

Where bronze is specified or used it shall be zinc free.

**28.16.6 Bright Parts**

Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

**28.16.7 Aluminium and Aluminium Alloys**

Aluminium and aluminium alloys used in mechanical parts shall be approved by the Engineer before use.

**28.16.8 Adhesives**

All adhesives shall be specially selected to ensure use of types which are impervious to moisture and are resistant to mould growth and other forms of attack or deterioration.

**28.16.9 Asbestos**

Asbestos and materials containing asbestos shall not be used.

**28.17 CORROSION PROTECTION**

All Plant shall be designed to suppress corrosion in an exposed environment. Preparation works and corrosion protection of all mechanical Plant shall strictly be done in accordance with Section 37 – Painting and Corrosion Protection. Special attention shall be given to the compatibility of materials.

**28.18 BEARINGS****28.18.1 General**

- a) The material from which all parts of bearings, including housing, spigots and bedplates are to be made shall be in accordance with the bearing manufacturer's recommendations and as approved by the Engineer.
- b) The surface finishes, dimension and tolerance of all parts of bearings including the shafts and housing shall be similarly approved.

## PART C3.1 - SPECIFICATION

- c) Each bearing shall be designed to transmit safely axial and radial loads likely to be applied to it under all conditions both during operation and at rest. The L10 design life of rolling bearings shall not be less than 10 000 hours based on the most severe dynamic and static load condition, whichever is the more severe, for the particular bearing. Bearings shall be designed and manufactured from materials suitable for carrying static loads for not less than 50 years with very infrequent operation.
- d) Each bearing shall be so installed that it can be removed for maintenance or replacement without damage to either the bearing or the adjacent parts of the installation.
- e) All bearings including self-lubricating bearings shall be sealed against the ingress of deleterious contaminants and shall be provided where necessary with means of lubrication to the centre of the bearing so that any foreign matter is expelled through the end seals during the lubrication process.
- f) Each bearing shall be lubricated as specified, the lubrication stations being situated in weather-proof and accessible positions.
- g) Except in the case of roller bearings which shall be installed generally in accordance with the bearing manufacturer's recommendations, the backing plates, outer sleeves (or housing) and the inner sleeves (where provided) of bearings shall be fixed to their respective adjacent structural members by such positive mechanical means as keying or similar, so that the movement in the bearing shall take place only between the bearing surfaces.
- h) Where the housing of any bearing is welded to steelwork the housing shall be machined to the required tolerances to receive the bearing after completion of fabrication and heat treatment.
- i) Where bearing housings are bolted into steelwork the design of the connection shall be such that distortion of the bearing housing does not occur when it is tightened down.
- j) All bearings except self-lubricating bearings, which when in use will be subject to small displacements or small angular rotations only, shall be run-in before incorporation in the Plant. Each self-lubricating bearing shall either be run-in or prepared and pre-coated so that the lubricant is evenly distributed over the whole bearing surface. All other bearings shall be run-in before the start of or during the Site tests. The Contractor shall not start running-in any bearing or group of bearings until he has received the approval of the Engineer of the intended duration and method of such running-in.

**28.18.2 Self-Lubricating Bearings**

- a) Self-lubricating bearings shall be of the Lubrite type as manufactured by Merriman Inc., of Hingham, Massachusetts, USA or similar approved by the Engineer. These bearings may be of the plain type or, where the alignment of the bearing is subject to change under varying loads due to structural deformations of the gates or other parts of the Plant shall be of the self-aligning type.
- b) Self-aligning bearings shall have an inner spherical section manufactured from aluminium nickel bronze and a split outer housing of stainless steel all to the approval of the Engineer.
- c) The spherical surface shall be for taking up misalignment and the bearing shall run on the cylindrical inner surface; the split housing shall be locked against rotation.
- d) The spherical and cylindrical surfaces shall be inlaid with and covered with solid lubricant.
- e) The lubricant shall have non-deteriorating characteristics and shall be capable of withstanding the effects of long term exposure to atmospheric pollution and submerged environments at the Site. The Contractor shall satisfy himself as to the atmospheric and submerged environments at the Site.

PART C3.1 - SPECIFICATION

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- f) The lubricant shall be epoxy based and shall be free of graphite and all other constituents which may lead to fretting corrosion, electrolytic corrosion or chemical action of any part of the bearing.
- g) The lubricant shall be contained in recesses machined in the inner diameter and spherical surface of the bronze ball section. The recesses shall cover an area of not less than 30% of the projected area of the bearing surfaces. The lubricant shall be compressed into the recessing by a pressure of at least twice the designed unit loading.
- h) The lubricant shall be compatible with greases used during assembly and subsequently injected during operation for the exclusion of moisture and dirt.
- i) The surfaces on which bearings rotate and or slide shall have a hardness exceeding that of the bearing material by 100 points on the Brinell hardness scale or as otherwise required by the bearing manufacturer and as agreed by the Engineer.

**28.18.3 Other Bearings**

- a) Where large pedestal type roller bearings are used to support slow moving parts the bearings shall be, where practicable, heavy duty self-aligning split roller bearings. Bearings shall have cast steel or fabricated steel housings or plumber blocks. Cast iron housings and plumber blocks shall not be used.
- b) All high speed shafts shall be provided with ball or roller bearings and they shall be mounted in dustproof housings and lubricated by grease gun.
- c) Other bearings shall be of the adjustable cap type where practicable and shall be fitted with grease lubricators.
- d) All cylindrical journal bearings shall be bushed with bronze or white metal and shall be accurately bedded and grooved.
- e) The underside of the base of each bearing shall be machined and shall bear against a machined surface.

**28.19 LUBRICATION**

- a) Lubrication shall be provided to all moving parts using either oil or grease. A separate oil cup or grease nipple shall be used to lubricate each point. Grease lubrication shall be provided with stainless steel button head type (1/8" BSP) and shall, together with oil filler caps or plugs, be painted red for easy identification. Lubricating nipples and adapters shall conform to the requirements of BS 1486.
- b) Where necessary for accessibility, the nipples shall be placed at the end of a short extension piping. Where possible such nipples shall be grouped together and each group shall be mounted on a plate situated at a convenient point for the use of a grease gun which shall be provided under the Contract.
- c) A grease gun with connections to suit the nipples shall be provided with each unit of Plant.
- d) Before putting the Plant to work all grease points and gearboxes, etc., shall be charged as required with the appropriate lubricant.
- e) Attention is drawn to the climatic conditions as per Clause 28.4.3 and all oils and greases must be suitable for those conditions.

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**28.20 DEWATERING PLANT (SUMP PUMPS) FOR THE LOW- AND HIGH-LIFT PUMPING STATIONS****28.20.1 General**

Similar automatic, fully submersible dewatering sump pumps shall be wall mounted over a collecting sump fixed to the bottom of the sump pit inside each pumping station. Each high flowrate dewatering pumps shall deliver 45 litres/second against a head of approximately 19 meters in the Low-Lift Pumping Station and 11 m in the High-Lift Pumping Station. Each floor drainage pump shall deliver 4 litres/second against similar heads. The Contractor shall confirm the head of the pumps after calculating the friction losses through the valves supplied and the pipework to the outside of the pumping stations. The pumps shall be float or electrode controlled by the water level in the collecting sump and shall be of a reliable and robust type. Sump pumps shall be factory tested in accordance with BS specifications Class C before transporting to Site.

Only hot dip galvanised pipework shall be used. Each pump shall have a dedicated discharge pipe. In line isolation valves are not required. Each pipe shall discharge water from the pump well into atmosphere outside the pumping station on the river side of the buildings.

The sump pumps shall be capable of handling dirty and sludgy water and shall be required to operate after empty dry sump periods. The pump intake shall be protected by either an adequately sized stainless steel screen capable of passing solids not more than 20 mm in diameter or the impeller shall have ample free passage as to eliminate the problem of clogging.

The switchboard of the dewatering Plant shall be located on the entrance level of the pumping station. The supply cable of the pumps shall be of sufficient length as to connect from the pumps to the control panel in one length.

**28.20.2 Pump / Motor Unit Design**

The pump and motor shall be fully submersible, capable of operating in 17 m and 9 m water depth in the Low-Lift and High-Lift Pumping Stations respectively and shall be a single unit with no shaft coupling between the pump and motor.

The sump pumps shall be of an automatic-coupling system that requires a base plate with a 90 degree bend, fixed to the bottom of the pit. Installation and removal of the sump pumps shall be done using the auxiliary hoist of the DGEOT. When lowered into the pit along the guide rails, the pumps shall automatically connect to the base plate. There shall be no need for personnel to enter the sump to secure the pump in position. It shall be possible to remove either one of the two pumps for repairs without interrupting the operation of the remaining unit.

Sealing of the pump unit to the discharge connection shall be accomplished by a machined metal-to-metal watertight contact or flexible neoprene O-ring type seal situated in the pump discharge flange for ease of replacement. The connection between the pump and the auto-coupling shall ensure a leak-proof connection.

The floor drainage and dewatering pumps shall be required to operate continuously in ambient temperatures of up to 45 degrees Celsius. Motor cooling of the sump pumps shall be independent of the pumped liquid level, i.e. shall be equipped with cooling jacket, thus providing heat dissipation for the motor in case of the motor not being completely submerged in liquid. Impeller back vanes shall provide the necessary circulation of the liquid through the water jacket. The cooling media channels and ports shall be non-clogging by virtue of their dimensions. External cooling and seal flushing shall be provided.

### **28.20.3 Control and Alarm**

Any rise in water level in the drainage sump above a predetermined level shall operate the floor drainage pump and at a predetermined sump-empty level the floor drainage pump shall stop, ready for the next drainage cycle. A continuous rise in water level above the floor drainage pump start level will alarm operations. The further rise of water in the sump will at a predetermined water level trigger the operation of the dewatering pump. Continued rise of water shall operate the station audible alarm indicating either a system malfunction or a non-functioning or malfunctioning of a sump pump.

## **28.21 OIL WATER SEPARATOR (OWS) FOR THE LOW- AND HIGH-LIFT PUMPING STATIONS**

### **28.21.1 Scope**

An Oil Water Separator (OWS) is required to extract the oil from the water in the drainage sump of the proposed Low- and High-Lift Pumping Stations. The OWS shall be of the centrifugal type, i.e. hydro-cyclone fitted with a suction hose and surface suction device. Fixed weir, rope, belt, disc or similar skimmers will not be considered.

### **28.21.2 Design Requirements**

The effluent shall be drawn through a floating self-adjusting oil skimmer in the sump pit and then drawn through a strainer to the OWS. The strainer shall remove small amounts of debris and particles. A pump shall provide the pressure to drive the fluid through the OWS with the treated water discharged under pressure back into the drainage sump. The separated oil, which may include some water, shall be sent to an oil collection tank. Any excess water in the oil collection tank shall automatically be drained from the tank back into the sump pit. When the oil level in the oil collection tank reaches maximum level a micro switch shall stop the separator, turn on an indicator light on the separator and relay a signal to that effect to the SCADA. The main drainage pumps shall switch off when the water level in the sump is sufficiently low for the surface suction device to operate effectively.

The pump shall be protected by use of low and high-pressure switches. Low-pressure protection shall indicate low or no pump flow conditions and prevent dry running. In addition to the switches overpressure protection shall also be achieved with a mechanical pressure relief valve. The system shall be configured to operate via an isolation switch on the local control box. The IP rating of the local control box shall be IP56. The OWS should run continuously or in response to level or process controls. A local isolation switch shall be required to turn the unit off for maintenance and/or repair purposes. The OWS shall be configured to operate automatically and with little operator attention.

The OWS shall be designed to operate for an average of 4 hours per day with a primary design life of greater than 20 years.

The Contractor shall ensure that his supplier furnish all components and ancillary Plant necessary to meet the requirements and to make a complete, functional, safe and reliable unit.

The Contractor's scope shall include, but not limited to, the following:

- a) Oil Separator;
- b) Automated backflush including actuated valves and control logic;
- c) Suction and feed pump;

## PART C3.1 - SPECIFICATION

- d) Floating skimmer assembly with hydrocarbon resistant hose;
- e) Feed strainer;
- f) OWS controls;
- g) Oil collection and decant tank;
- h) Spare parts and special tools for start-up and commissioning;
- i) Packaging and transport; and
- j) Installation, operation and maintenance manual.

## 28.22 WATER TREATMENT PLANT (WTP) FOR POTABLE WATER

### 28.22.1 Scope

A Water Treatment Plant (WTP) is required to treat raw water being extracted from a new borehole at the High-Lift Pumping Station and supply a containerised potable water treatment Plant with an operational capacity of 1 m<sup>3</sup>/h for domestic use at the proposed High-Lift Pumping Station site including the Operational Control Centre and guard houses.

### 28.22.2 Expected Water Quality

Although a new borehole will be drilled as part of the project, Table 28/3 indicates the expected groundwater quality at the High-Lift Pumping Station site from an existing borehole in the same geohydrological formation.

**TABLE 28/3  
EXPECTED BOREHOLE WATER QUALITY**

PARAMETER	EXPECTED CONCENTRATION
Conductivity mS/m EC at 25° C	148.3
Total Dissolved solids (mg/l)	964
pH	7.4
Bicarbonate alkalinity (as CaCO <sub>3</sub> )	434.2
Carbonate alkalinity (as CaCO <sub>3</sub> )	0
Total hardness (as CaCO <sub>3</sub> )	750.48
Calcium - Ca (mg/l) (as CaCO <sub>3</sub> )	353.35
Dissolved Mg (mg/l) (as CaCO <sub>3</sub> )	397.13
Calcium - Ca (mg/l)	141.34
Dissolved Mg (mg/l)	96.86
Potassium - K (mg/l)	3.36
Sodium - Na (mg/l)	26.20
Chlorides Cl (mg/l)	177.1
Fluoride – F (mg/l)	0.15

## PART C3.1 - SPECIFICATION

PARAMETER	EXPECTED CONCENTRATION
Silica – Si (mg/l)	11.12
Sulphate SO <sub>4</sub> (mg/l)	57.74
Dissolved NH <sub>4</sub> (N) (mg/l)	<0.2
Nitrate Nitrogen - NO <sub>3</sub> (N) (mg/l)	12.61
Phosphate – PO <sub>4</sub> (P) (mg/l)	<0.05
Aluminium – Al (mg/l)	0.05
Arsenic – As (mg/l)	<0.03
Copper – Cu (mg/l)	<0.01

### 28.22.3 Design Requirements

#### 28.22.3.1 General

The WTP shall be designed for 20 hour per day operation, which means that the Plant will be subjected to no inflow conditions on a daily basis.

The treated water shall conform to the requirements of a Class 1 quality according to SANS 241:2015.

The raw water for the Plant will be supplied from a new borehole to be drilled at a suitable position on the High-Lift Pumping Station site.

The Plant shall be designed to allow flexibility to optimise the operation in accordance with the variation in the raw water quality. The Plant shall include a Nano Filtration (NF) membrane process step (with suitable screens and filters upstream of the NF) to reduce the Nitrates to the required Class 1 quality. Granular chlorine (chlorine hypochlorite) shall be used as disinfectant and to provide a chlorine residual in the distribution system.

The unit supplied shall be complete with backwash facility incorporating valves for the function of backwash, filter rinse and re-start. A suitable clean-in-place (CIP) system will be provided for the membrane system.

The WTP shall be supplied complete with filter media incorporating dual media hydro-anthracite sand for the primary filtration contained inside a glass reinforced polyester tank with backwash valves, pressure gauges, potable water sight glass and sampling points both sides of the filter system.

The Contractor's scope shall include, but not limited to, the following:

- a) Raw water borehole pump and filter system;
- b) 5000 litre potable water storage tank;
- c) Treatment processing units (filters, membranes, settling tanks);
- d) All valves and pipework necessary to complete the pipe network;
- e) Pressure and level transmitters;
- f) Pressure gauges;

PART C3.1 - SPECIFICATION

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- g) Adjusting chemical dosing pumps;
- h) 1 drum (25 litre) of flocculant;
- i) 1 drum (25 litre) of chlorine disinfectant;
- j) pH/Chlorine residual test kit;
- k) Spare parts and special tools for start-up and commissioning;
- l) Packaging and transport; and
- m) Installation, operation and maintenance manual.

**28.22.3.2 Chemical Dosing and Coagulation**

Allowance shall be made for the dosing of a primary coagulant such as alum, ferric chloride or polyelectrolyte, pH correction in the form of lime and a flocculation aid such as a polyelectrolyte. The Plant items shall also be suitable for the dosing of products such as Poly-aluminium Chloride (PAC) or Ferrifloc.

The selection of the correct coagulants shall be done during the commissioning of Plant.

The coagulants can be either pumped into a piped system connected to the flocculation section of the Plant, or a dedicated flash mixing unit can be provided. The total mean velocity gradient (G) for the coagulation section of the Plant shall be variable between  $500 \text{ s}^{-1}$  and  $1,000 \text{ s}^{-1}$ . In-line mixing units are preferred in the piped systems.

**28.22.3.3 Flocculation**

The flocculation section of the Plant shall be directly linked to the coagulation section. The flocculation system may comprise out a series of uPVC pipes and bends, or alternatively a flocculation column can be provided. A G-value of between  $10 \text{ s}^{-1}$  and  $100 \text{ s}^{-1}$ , and a GT value varying between 104 and 105 are required for flocculation. The flocculation system shall be tapered, allowing for at least three significant steps in reduction of the G-value.

The pipe system shall allow for draw-off points for taking samples at the beginning of the flocculation step, and after each change in the G-value. Whatever the configuration of the flocculation system, a minimum of four sampling points shall be provided.

**28.22.3.4 Filtration**

The filters shall be designed for the operation in the direct filtration process configuration.

The water shall be pumped through the filtration section of the Plant for further treatment to a potable water storage tank downstream of the filtration section. The pumps shall be arranged in a duty / standby configuration. The control system of the pumps shall allow for automatic duty rotation between the pumps.

The effective size of the sand shall be 0.5 to 0.8 mm with a uniformity coefficient of 1.4 to 1.6, whereas the hydro-anthracite shall have an effective size of 1.2 to 1.4 mm with a uniformity coefficient of 1.2 to 1.4. The filter media and the backwash rates shall be adequately designed to prevent the intermixing of the filter media during the backwashing process.

The filtration rate shall not exceed  $20 \text{ m}^3/\text{m}^2/\text{h}$  during backwashing of a filter, and  $5 \text{ m}^3/\text{m}^2/\text{h}$  during normal operation.

### **28.22.3.5 Membranes**

The minimum requirements for the membrane filtration system offered are as follows:

- a) The membrane filtration system must be pressurised;
- b) Filtration membranes must be homogeneous hollow fibre membranes with a nominal pore size not greater than 0.001 µm;
- c) Membrane material must be PVDF and both membrane material and module components must be chlorine resistant to at least 100 mg/l;
- d) Membrane material and module components must have NSF certification;
- e) The membrane manufacturer must have design and manufacturing facilities that meet all the requirements of ISO 9001;
- f) Mass of wet membrane modules must not exceed 11 kg for safe handling;
- g) Membrane backwash must use a filtrate backwash (reverse flow) combined with external air scouring to remove accumulated particulates and maintain the design filtrate production rate. Filtrate backwash only without the use of aeration is not acceptable;
- h) The backwash process must be capable of completely draining or flushing backwash waste from each MF Unit for efficient removal of waste solids;
- i) All operational sequences must be fully automated and suitable for unattended operation, including but not limited to backwash. Maintenance wash (MW), membrane integrity monitoring and clean in place (CIP) sequences can be semi-automated; and
- j) Module design must allow field isolation of filtrate from a single module without removal of membranes from the membrane Unit.

### **28.22.3.6 Pumps**

All pumping Plant shall be manufactured in South Africa, except for the chemical dosing pumps, which may be imported.

All pumps shall be supplied in a duty / standby configuration and the choice between pumps shall be made at the controlling switchgear. Under no circumstances may both pumps be operated. All pumps shall be controlled by level indicators, which shall switch off the pumps when the water level has reached a low level in the dam, or when the receiving potable storage tank has reached the predetermined high level setting.

All pumps shall be fitted with isolation valves at the suction side and non-return valves and isolation valves at the delivery side.

The Contractor shall furnish the Engineer with a complete design of the pumps including system curves showing the calculated duty point of the pumps.

All pumps shall be supplied with easy accessible packed seals. No pumps manufactured out of plastic or any other non-metallic material shall be considered acceptable.

### **28.22.3.7 Disinfection**

The treated water shall be disinfected by means of dosing hypochlorite dissolved in water to the treated effluent. The hypochlorite shall be supplied as calcium hypochlorite in 20 kg drums.

## PART C3.1 - SPECIFICATION

The dosing Plant shall consist of a mixing tank for preparing the hypochlorite solution and dosing pumps in a duty / standby configuration.

The dosing pumps supplied shall have a capacity of achieving a chlorine concentration in the treated effluent of between 2 and 6 mg/l in the water.

The disinfection installation shall be complete, including all protective Plant, the booster pumps and the interconnecting pipe work.

### **28.22.3.8 Electrical**

Electrical installations shall in general comply with the requirements of Section 39 – Electrical Plant and Installation.

A robust local control box, manufactured from stainless steel, shall be included that incorporates the pump starters, level units for low level protection in the raw water system. The WFP shall be configured to operate via an isolation switch on the local control box, which shall be required to turn the unit off for maintenance and/or repair purposes. The IP rating of the local control box shall be IP56. The WTP shall be configured to operate automatically and with little operator attention.

The Contractor shall include for the incoming cable to the local control box, low voltage cables from the local control box to the pressure transmitter in the raw water system and level transmitters of the potable water tank.

## **28.23 NAMEPLATES, RATING PLATES AND LABELS**

- a) Where appropriate, each item of Plant shall have permanently attached to it in a conspicuous position a nameplate upon which shall be engraved or stamped the manufacturer's name, type and serial number of Plant, Part number, Contract number, order number, date of manufacture, mass, material and all necessary information relating to the supply and replacement of parts and details of the loading and duty at which the item of Plant has been designed to operate. A nameplate denoting the Plant or function identification number shall also be attached. Such nameplates shall be of stainless steel.
- b) Labels shall be provided for every panel to describe the duty of or otherwise identify every instrument, relay or item of control Plant mounted externally and internally.
- c) Externally fitted panel labels shall be of non-plastic, durable, weather resistant material with letters and numbers engraved and filled with black.
- d) Internally fitted panel labels shall be finished white and engraved letters and numbers filled with black, laminated material such as "Trifoliolate" or rear engraved and filled plastic may be used. Embossed materials and techniques will not be accepted.
- e) Labels shall also be provided in conformity with the above requirements or by other approved means wherever necessary to designate panels or panel sections, to provide warnings or reminders of dangerous or potentially dangerous circumstances and wherever called for elsewhere in this Section.
- f) Danger labels e.g. "DANGER – 400 V AC" shall be coloured red with white lettering.
- g) Caution labels e.g. "CAUTION-ISOLATE BEFORE REMOVING COVER" shall be white with red lettering.
- h) Where withdrawable Plant is provided both fixed and moving portions shall be suitably identified.

PART C3.1 - SPECIFICATION

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- i) Labels shall be of uniform design and the display of manufacturers' standard nameplates on panel external surfaces shall be subject to the approval of the Engineer.
- j) Details of proposed inscriptions shall be submitted to the Engineer for approval before any labels are manufactured.
- k) All nameplates and labels shall be fixed using non-corrosive fasteners to the approval of the Engineer. Adhesive only shall not be acceptable.

**28.23.1 Lifting Devices**

- a) The Contractor shall prepare and submit for approval drawings and full instructions as to the means to be employed for inserting and withdrawing the gates and other Plant. These drawings shall include a table listing the requirements for all lifting operations, means of identification of grappling beams, slings, etc.
- b) All special apparatus, including one set of such grappling beams, slings, lifting beams, spreader beams and attachments as may be necessary for lifting any part of the Plant and Plant items shall be provided by the Contractor. Attachments shall be permanently tagged or marked for identification purposes. Any special lifting apparatus employed in the erection of the Plant shall be handed over to the Employer in "as new" condition on completion of the work.
- c) A load plate showing the safe working load shall be fixed to each lifting device by means of stainless steel fasteners and in a position easily legible from the operating level.

**28.24 ERECTION AND SETTING TO WORK****28.24.1 General**

- a) The Contractor's Representative and workmen referred to in the Conditions of Contract shall include approved specialist skilled working erectors and sufficient skilled, semi-skilled and unskilled labour to ensure completion of the Works in the time required. The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer's prior approval.
- b) The Contractor's erection staff shall arrive at the Site on dates to be agreed by the Engineer. Before they proceed to the Site the Contractor shall satisfy himself that sufficient items have arrived on Site so that no delay will be incurred on this account.
- c) The Contractor shall be responsible for setting up and erecting the Plant to the line and level required and shall ensure that, where items are to be built-in they are kept in position whilst being built-in.
- d) Where a specialist Subcontractor is in attendance during the building in of first-stage built-in parts the sums and rates entered in the Bill of Quantities shall be deemed to include for all Site visits made by the specialist Subcontractor for this purpose.

**28.24.2 Foundations**

Foundations, where required, shall be provided by the Contractor for the erection of the Plant and shall comply with any requirements of specialist Subcontractors, the Contractor and with any drawings supplied by them and approved by the Engineer. Where necessary, the Contractor shall prepare floors and plinths to accept foundation bolts or mounting channels to the requirements and approval of the Contractor and the Engineer.

**28.24.2.1 Foundation Bolts and Fittings**

- a) The Contractor shall supply all holding down, alignment and levelling bolts complete with anchorages, nuts, washers and packing required to attach the items of Plant to the foundations, and all bed-plates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.
- b) All bed plates and machinery shall be connected to concrete plinths by means of grout arranged so as to transmit all vertical and horizontal loads into the foundations by means of direct compressive stress.
- c) The bed plates and machinery shall be provided with means of adjustment for line and level to maintain the items of Plant in correct alignment during grouting. Packers used for adjustment shall be of non-corrosive material to the approval of the Engineer.
- d) Holding down bolts which are to be tightened after grouting shall be provided with bond breakers where they pass through the grout.
- e) Unless otherwise specified, holding down bolts, nuts and washers shall be of stainless steel and provided with isolating washers and sleeves where appropriate to prevent galvanic corrosion.

**28.24.3 Accuracy of Work: Gates, Guides and Mechanical Plant**

The required accuracy and tolerances for the erection of gates, guides and mechanical Plant shall be stated by the Contractor in his design submissions. These shall not be less than the requirements stated in the Specification for that particular Plant and shall be subject to approval by the Engineer. No deviation from the approved tolerances will be permitted.

**28.24.4 Grouting**

- a) Concrete for embedding second stage built-in parts shall be supplied, mixed and placed in accordance with specified requirements as approved by the Engineer.
- b) Grout for the connection between bed plates and machinery and concrete shall be non-shrink epoxy grout and shall be mixed and placed in accordance with the approved drawings.
- c) Non-shrink grout shall:
  - i) Have a compressive strength not less than four times the maximum stress to be transmitted;
  - ii) Be subject only to compressive stress;
  - iii) Be such that air voids are eliminated between bed plates and machinery and concrete;
  - iv) Be completely resistant to lubricants, hydraulic fluids and diesel fuel;
  - v) Have bond strength to concrete exceeding the tensile strength of the concrete; and
  - vi) Have bond strength to steel not less than (v) above.

**28.24.5 Building In**

The provision of trenches, backfilling and reinstating holes through walls and floors, chases or ducts in walls and floors, making good and final decorative finishes shall be undertaken by the Contractor. For this purpose, the Contractor shall make all necessary arrangements with his specialist workmen

PART C3.1 - SPECIFICATION

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who shall mark out all such work and shall provide all necessary information concerning preformed holes, chases, ducts, etc. The Contractor shall be responsible for the accuracy of all building in.

**28.24.6 Drilling the Structure for Fixings**

- a) The drilling of holes for fixing devices shall be carried out by specialist workmen. Holes shall be made with a rotary drill or a rotary / percussion type drill such that no damage or spalling is caused to the concrete and/or brickwork being drilled. Explosion or impact devices such as single shot cartridge tools shall not be used.
- b) No structural steel, reinforcement or timber work shall be drilled without the prior approval of the Engineer.
- c) Any damage to surfaces caused by the Contractor or his specialist during erection shall be made good by the Contractor without additional payment and to the satisfaction of the Engineer.

**28.24.7 Instrument Installation**

All measuring instruments shall be installed in accordance with the recommendations or instructions of the instrument manufacturer, for the particular application. Each mounting position shall be chosen to give correct operation of the Plant, faithful reproduction of the quantity to be measured, ease of operation, reading, maintenance and servicing, and freedom from any condition which could have adverse effects.

**28.24.8 Protection on Site**

Factory finished parts shall be adequately protected during installation against damage to finished surfaces and fitted components. It may be necessary for structural finishing operations to be carried out in the vicinity of installed items of Plant before it is taken over and the Contractor shall take this into consideration in complying with the requirements of this clause.

**28.24.9 Ready for Commissioning (RFC)**

After the Plant has been erected and the specified Pre-commissioning tests have been carried and when the Contractor is satisfied that the Plant is working correctly he shall inform the Engineer that he is "Ready for Commissioning". For the requirements of "Ready for Commissioning" (RFC), refer to Section 48.

**28.24.10 Period of Instruction**

The Contractor shall allow for a "period of instruction" of two weeks duration during which time the Contractor shall provide for 40 hours each week such skilled operators as are necessary to instruct the Employer's own operators to operate and maintain the Plant. Verbal instructions relating to operating procedures additional to any given in the instruction manuals shall be confirmed in writing.

**28.25 INSPECTION, QUALITY CONTROL AND TESTING****28.25.1 General**

- a) The Contractor's Quality Management System shall be in accordance with ISO 9000.

## PART C3.1 - SPECIFICATION

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- b) The Contractor shall implement a comprehensive Quality Control programme and accept full responsibility for the quality of his workmanship and material used, irrespective of any quality surveillance that may be carried out by the Engineer or his appointed assistants.
- c) In keeping with the principles contained in the above mentioned ISO 9000 code of practice, the Contractor and Subcontractor(s) shall:
- i) Be responsible for compliance with all the requirements of the Specification in every respect;
  - ii) Carry out all inspections and tests called for in the Specification in the presence of the Engineer or his appointed assistant. The cost of these inspections and tests shall be carried out at the sole expense and under the responsibility of the Contractor;
  - iii) Draft a Quality Control Plan for manufacture for approval by the Engineer and comply with the approved Quality Plan during manufacturing process of all components indicating all the intended stages of testing during manufacture, cleaning and preparation for application as well as necessary hold points for independent quality surveillance;
  - iv) Draft a Quality Control Plan for corrosion protection for approval by the Engineer and comply with the approved Quality Plan during corrosion protection process of all components indicating all the intended stages of testing during corrosion protection as well as necessary hold points for independent quality surveillance;
  - v) Draft a Quality Control Plan for installation for approval by the Engineer and comply with the approved Quality Plan during installation process of all components indicating all the intended stages of testing during installation as well as necessary hold points for independent quality surveillance; and
  - vi) Draft Quality Control Plans for any other construction process as may be required for approval by the Engineer and comply with the approved Quality Plan during the execution of the process indicating all the intended stages of testing as well as necessary hold points for independent quality surveillance.
- d) The Quality Control Plans will not be compromised once approved and shall be adhered to at all times. The Contractor shall operate approved quality assurance and control programmes in the Supplier's and Manufacturer's premises and on Site in order to verify that the Works comply with this Section. Prior to the commencement of any work, the Contractor shall prepare and submit to the Engineer for approval, quality plans describing the procedures, standards of acceptance, hold point inspections, routine and type tests to be carried out for each component both during manufacture and on Site.
- e) Although it shall remain the responsibility of the Contractor to ensure that the Works conform to the Specification, the Engineer shall be entitled to inspect, examine and test the materials, workmanship and performance of every item of Plant. The Engineer will notify the Contractor which tests or inspections, detailed in the quality plan, he will attend.
- f) The Contractor shall give the Engineer not less than 14 days' notice in writing of the date and the place of impending inspections or when cleaning and first coat application are to be carried out as well as for witnessing the points in terms of the agreed Quality Control Plans and he shall give the Engineer full facilities for witnessing such tests.
- g) Approval by the Engineer of materials, workmanship, etc., during manufacture or at Site will not relieve the Contractor of his obligations to comply with all the requirements of the Contract.
- h) All instruments and appliances necessary for the complete inspection and testing shall be provided by the Contractor. Calibration certificates for instruments shall be produced to the Engineer for review prior to the commencement of any tests and, if required by the Engineer, instruments shall be re-calibrated at the Contractor's own account before commencement of the tests.
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**28.25.2 Contractor Qualification**

- a) The Contractor and Subcontractor(s) shall satisfy the Engineer that they have the management, facilities and equipment, skilled staff, a quality control procedure and required test methods and standards to carry out effective quality control during the manufacturing, corrosion protection, installation and testing stages.
- b) The qualifications of the skilled staff may be subject to audits by the Engineer as and when required. The cost associated with such audit will be for the Contractors account.

**28.25.3 Factory Acceptance Tests (FAT)**

- a) All Plant shall be subject to a Factory Acceptance Test (FAT) by the Engineer at the Manufacturer's premises before despatch. No material shall be delivered to the Site without inspection having being carried out or waived by the Engineer in writing.
- b) The Engineer's inspection shall in no way relieve the Contractor or Subcontractors of any of their obligations to design, manufacture and supply Plant items of superior quality and workmanship in accordance with the Specification.
- c) Materials may only be despatch from factory once all relevant "hold points" on QCP's have been signed off by the Engineer and/or the Approved Inspection Authority (AIA).

**28.25.4 Inspections by the Engineer and/or an Approved Inspection Authority (AIA)**

The Engineer and/or the AIA has the right to inspect any item covered in the Contract at any stage of execution of the Contract.

Where imported supplies are to be inspected before shipment, the Contractor shall notify his suppliers abroad of the conditions applicable to inspections and also notify the Engineer and the AIA when consignments are ready so that arrangements for inspection can be made.

**28.25.4.1 Material Tests**

- a) The Manufacturer's material test data and the Contractor's quality records shall be subject to examination by the Engineer or his assistant. Reasonable samples of the cleaning and coating materials to be used may be taken for testing.
- b) Rejection of the samples shall place a hold on the use of the materials of the same batch number and any components that have already been cleaned / coated with rejected material shall be re-cleaned and coated.

**28.25.4.2 Type Tests**

- a) Where the Contractor offers Plant selected from the standard range of products from a specialist manufacturer, type tests in accordance with a recognised international standard are required on one unit of each type to prove satisfactory design and quality of manufacture of that Plant.
- b) The Engineer may waive the requirement for type tests if he is satisfied that tests have previously been performed on identical Plant. The Contractor shall submit the data and results with his Quality Plan in sufficient time to allow for repeat tests without delaying the Works should the Engineer not approve the evidence submitted.

**28.25.4.3 Routine Tests**

- a) The Contractor shall carry out routine tests in accordance with the requirements of the Quality Control Plan on all items of Plant during manufacture to demonstrate satisfactory materials, workmanship, assembly and functionality of Plant.
- b) Detailed proposals for routine tests shall be included in the Contractor's Quality Plan, and shall include, where applicable:
  - i) Material tests;
  - ii) Non-destructive tests;
  - iii) Dimension and finish checks;
  - iv) Pressure tests;
  - v) Assembly checks;
  - vi) Paintwork tests;
  - vii) Electrical tests;
  - viii) Functional tests;
  - ix) Load tests; and
  - x) Performance tests.
- c) After assembly, each unit shall be carefully checked to ensure that it is in accordance with the approved dimensions.
- d) Each section of the work such as the isolating gate reception frames and guides, radial gate bearing trunnions and sealing frames, etc., shall be assembled as is necessary in position so that the Engineer can adequately test and check that all parts are to the correct dimensions and square, and that all moving parts work easily.
- e) Welds shall be physically examined and non-destructively tested by radiographic, ultrasonic, magnetic particle or dye penetrant methods as appropriate and/or specified.

**28.25.4.4 Tests at the Site**

- a) The Contractor shall repeat such routine tests as are necessary to confirm that the Plant has not been damaged in transit, has been satisfactorily erected, and is ready for Pre-commissioning.
- b) For the purpose of carrying out Pre-commissioning on the Plant at the Site all labour, materials, power, apparatus and ancillary equipment as may be requisite for the tests shall be provided by the Contractor.
- c) The Engineer will not be obliged to witness Ready for Commissioning (RFC) tests on any part of a Plant unless draft copy of the Operation and Maintenance Manuals have been presented, reviewed and formally been approved by the Engineer. The Engineer may order that tests which have to be aborted because of major malfunctions of Plant or Plant items shall be repeated in their entirety once the malfunctions have been corrected.

**28.25.4.5 Destructive Testing**

The Engineer and/or AIA may carry out reasonable destructive tests to ascertain compliance with the Specification. Areas thus damaged shall be repaired by the Contractor to the satisfaction of the Engineer at no additional cost.

**28.25.4.6 Non-destructive Testing During Manufacture**

- a) All welds on Plant shall be physically checked for compliance with the Specification and for throat thickness in the case of fillet welds. If judged to be satisfactory from a physical external examination they shall then be non-destructively tested by means of radiographic, ultrasonic, magnetic particle or dye penetrant methods, as appropriate. If post weld heat treatment is required non-destructive tests shall be done after completion of heat treatment. Prior approval for the use of ultrasonic (or other) methods in place of radiographic methods shall be obtained from the Engineer by way of the approval of welding procedure submissions in the method statements.
- b) Radiographic examination shall be in accordance with BS EN ISO 17636. Normally X-ray techniques shall be used with ultra-fine-grain-high-contrast direct-type film.
- c) The standards of acceptance shall be as defined in PD 5500 Table 5.7 - Acceptance Levels. Unacceptable defects shall be rejected or repaired as directed by the Engineer.
- d) The Contractor shall supply all apparatus, materials and labour required for his own non-destructive examinations and for non-destructive examinations ordered by the Engineer.

**28.25.4.7 Non-destructive Testing on Site**

- a) In addition to the requirements of Clause 28.25.4.6 should any Site welding be necessary then ultrasonic examination of in-situ welds may be ordered for welds where radiographic examination is not practicable. Prior approval for the use of ultrasonic (or other) methods in place of radiographic methods shall be obtained from the Engineer by way of the approval of welding procedure submissions.
- b) Ultrasonic examination shall be in accordance with BS EN ISO 17640. Adjacent parent metal shall be ultrasonically examined to locate any imperfections which might prevent effective examination of the weld.

**28.25.5 Quality Control Records****28.25.5.1 General**

- a) Accurate and detailed quality control records shall be kept by the Contractor for all stages of the work.
- b) Data of corrosion protection shall be recorded on the Employer Record sheets for manufacturing and corrosion protection. Examples of QCP's for valves are attached at end of this Section:
  - Quality Control Plan for Corrosion Protection (Annexure 28/1);
  - Coating Application Records (Annexure 28/2); and
  - Surface Profile and Dry Film Thickness readings (Annexure 28/3).
- c) All the quality control records shall be available for inspection by the Engineer or his assistant.
- d) Incomplete, inaccurate or inadequate records shall be regarded as non-compliance with the Specification.
- e) The collection of record documents for each item of Plant shall be collated and bound in a logical manner and retained by the Contractor as proof of quality achieved. These shall be available on demand for quality control and part payment releases.

PART C3.1 - SPECIFICATION

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- f) The records shall be neatly filed and handed over to the Engineer on completion of the work in the form of a Data Pack together with all relevant material and test certificates. Only after the Data Pack has been approved and signed off by the Engineer, shall Plant be dispatched to Site.

**28.25.5.2 Coating and Material Records**

- a) Quality control, material and coating records for all stages of the work, i.e. batch numbers of materials used, environmental conditions and all test data shall be recorded on the record sheets attached to the approved Quality Control Plan for manufacture and the approved Quality Control Plan for corrosion protection.
- b) Certificates for all materials used shall also be required.

**28.25.5.3 Data Sheets, Specifications and Codes of Practice**

The Contractor shall have available the latest issues of the following:

- a) A copy of this Section;
- b) Relevant Standards and Codes of Practice; and
- c) Manufacturer's data sheets for materials to be used.

This information shall be available to all the Contractor's quality control and production personnel.

**28.25.6 Substandard Quality Control**

- a) All material, certification and records of the Contractor shall be subject to examination by the Engineer.
- b) This shall include the checking and testing of the Plant at the Works and on Site, installation and pre-acceptance testing. If any deviation is found, additional testing and quality surveillance shall be carried out at the Contractor's own costs until approved by the Engineer.
- c) If the additional testing confirms inaccurate quality control by the Contractor on an item of Plant, all work shall be stopped on that item of Plant and shall only proceed after remedial action in the quality control system has been implemented.

**28.25.7 Access for Surveillance**

- a) For the purpose of carrying out quality surveillance, the Engineer or his assistant shall be granted access to any part of the Contractor's premises relevant to the work being carried out, at any reasonable time.
- b) The Contractor shall provide, at his own cost, any equipment or labour necessary to gain access for the Engineer or his assistant to surfaces which are coated, to be coated or are in the process of being coated.

**28.25.8 Submission for Approval**

The Contractor shall submit the following to the Engineer, including data sheets where applicable, for approval:

**28.25.8.1 For Manufacture**

- a) Drawings;
- b) A programme;
- c) A quality control plan; and
- d) A draft Operation and Maintenance Manual.

**28.25.8.2 For Corrosion Protection**

- a) A programme;
- b) The Quality Control Plan for corrosion protection;
- c) Blast material data sheet;
- d) Coating products data sheet; and
- e) Pickling and passivating products data sheet.

**28.25.8.3 Manufacture and Corrosion Protection Programmes**

The manufacture and corrosion protection programmes shall state the time and place when the following will be conducted:

- a) Inspection of material;
- b) Hydrostatic testing of uncoated castings, pipes and fittings;
- c) Manufacture of components;
- d) Fettling or dressing;
- e) Degreasing;
- f) Water soluble salts test;
- g) Blast cleaning and application of the first coat;
- h) Application of intermediate and final coats; and
- i) The commencement of Site repairs.

**28.25.9 Cost of Quality Control**

- a) The cost of quality control has already been included by the Contractor as was requested in the Technical Schedules during Tendering stage.
- b) When surveillance results in rejection of an item of Plant or when notice by the Contractor results in a fruitless trip, the cost borne by the Employer / Engineer shall be debited to the Contractor's account.

## PART C3.1 - SPECIFICATION

- c) If additional inspections, tests and analyses requested by the Employer / Engineer prove that the corrosion protection of the Plant is in accordance with the Specification, the costs of the inspections and/or tests including transport will be defrayed by the Employer. However, should the additional investigations prove that the manufacture and/or corrosion protection of the Plant does not conform to the Specification, the cost shall be defrayed by the Contractor.
- d) The Engineer shall have the right, without prejudice to any other legal remedy, to deduct such costs from payments due to the Contractor under the Contract.
- e) Where Plant or services fail to meet the Contract requirements but are nevertheless accepted at an agreed revised rate, the costs with regard to inspections, test and analyses shall be for the Contractor's account unless otherwise directed by the Employer.

**28.25.10 Non-compliance with the Specification**

- a) Plant, materials and services that do not conform to the requirements of the Section shall be rejected.
- b) Such rejected Plant shall be held at the cost and risk of the Contractor who shall, when called upon, and at his own cost, repair the defects or corrosion protection according to the Contract.
- c) Failing satisfactory repair of rejected Plant items, the Plant shall be returned to the Contractor at his cost and risk. Alternative Plant may be purchased at the Contractor's expense or an approved Contractor may be employed to do the repair to the corrosion protection.
- d) Should the Contractor fail to comply with the provisions of Section 37 - Painting and Corrosion Protection, the Taking-Over Certificate will not be issued.

**28.26 OPERATION AND MAINTENANCE MANUALS**

Submission of O&M Manuals shall be as required under Section 48 – Tests on Completion.

**28.27 OCCUPATIONAL HEALTH AND SAFETY**

This clause shall be read in conjunction with Section 2 – Occupational Health and Safety.

- a) All Plant and equipment shall comply with the OHS Act (No 85 of 1993) and its Regulations.
- b) All shafts, couplings, collars, projecting key heads, gear wheels, chain drives and other moving machinery shall be guarded to give complete protection to all persons. All set screws on revolving shafts shall be countersunk or suitably protected. The guards shall be of approved design and shall be fitted where necessary with inspection doors. All guards shall be arranged so that they can be removed without disturbing the parts of the gears and Plant they protect. The guards shall comply with the requirements of BS 1649 or equivalent standard.
- c) Any permanent fencing or other safeguards required to be erected around electrical Plant shall be completed as far as practicable before connection is made to the electricity supply, but where this is not practicable, the Engineer may permit the use of temporary fencing or other safeguards.
- d) If work in the vicinity of electrical Plant has to be carried out after connection has been made to the electricity supply, the Contractor shall comply with any "Permit to Work" system approved by the Engineer.

## PART C3.1 - SPECIFICATION

- e) All Plant shall be designed and arranged to minimise the risk of fire and any damage which might be caused in the event of fire.
- f) No protruding items of a permanent nature shall be allowed on the deck or any other moving part within the working area.

**28.28 APPLICABLE STANDARDS**

Standards applicable shall be as covered under each individual Section.

**28.29 MEASUREMENT AND PAYMENT**

The rates tendered under this Section shall not include for the general obligations, Contractor's equipment and work deemed to be covered by the items provided in Section 1 - General.

**28.001 Design and documentation****Unit: Lump Sum (Sum)**

Payment for Design and other documentation will be made under the relevant Sections for the different Parts of the Work.

**28.002 General – Supply and delivery to Site**

Payment for the requirements of Supply and Delivery to Site will be included in the payment item for the particular item supplied.

The rates tendered for a particular item supplied shall include full compensation for the cost of supply and delivery including supply of raw materials and bought-out items, fabrication / manufacture / assembly, inspections / quality assurance / quality control and factory acceptance tests witnessed by the Engineer and/or Approved Inspection Authority (AIA), type and routine tests, application of finishes (paint or corrosion protection), trial erection and dismantling, preparation and packing for transport, transport from place of manufacture to the Site, insurance, harbour dues etc., during transport, loading and unloading, storage under appropriate conditions from date of delivery until commencement of erection and any other work as specified.

**28.003 General - Installation**

Payment for the requirements of Installation on Site will be included in the payment item for the particular item supplied.

The rates tendered shall include full compensation for the cost of installation including the provision of all labour, tools, transport, materials and Temporary Works necessary to install the complete Works, on-site quality assurance and quality control, inspection and testing (including attendance at tests witnessed by the Engineer), the installation, pre-commissioning, supply of all consumables (electricity, fuel, oil and lubricants etc.) necessary for the operation of the installation until taken over by the Engineer, the putting into service of the complete installation and any other work as specified.

**28.004 Design, procurement / manufacture, delivery to Site of complete Dewatering Plant** **Unit: number (No.)**

The rate tendered shall include for full compensation of all costs incurred for the design of the complete installation, manufacture and procurement of a complete dewatering Plant for each pumping station and shall cover the cost of the supply and delivery to Site, inspections, quality assurance and quality control, as well as installation drawings and instructions and where applicable, wiring diagrams of the complete system.

**28.005 Installation and pre-commissioning of complete Dewatering Plant** **Unit: number (No.)**

The rate shall also include for full compensation of all costs incurred for installation, inspections, on-site quality assurance and quality control, pressure testing and pre-commissioning of the complete Plant, all mounting brackets and interconnecting wiring. One copy of the installation instructions, detailed dimension drawings and wiring diagrams shall be supplied and delivered to the Engineer's office.

**28.006 Design, procurement / manufacture, delivery to Site of complete Oil Water Separator (OWS) Plant** **Unit: number (No.)**

The rate tendered shall include for full compensation of all costs incurred for the design of the complete installation, manufacture and procurement of the complete Oil Water Separator (OWS) Plant for each pumping station and shall cover the cost of the supply and delivery to Site, inspections, quality assurance and quality control, as well as installation drawings and instructions and where applicable, wiring diagrams of the complete system.

**28.007 Installation and pre-commissioning of complete Oil Water Separator (OWS) Plant** **Unit: number (No.)**

The rate shall also include for full compensation of all costs incurred for installation, inspections, on-site quality assurance and quality control, testing and pre-commissioning of the complete Plant, all mounting brackets and interconnecting wiring. One copy of the installation instructions, detailed dimension drawings and wiring diagrams shall be supplied and delivered to the Engineer's office.

**28.008 Design, procurement / manufacture, delivery to Site of complete Water Treatment Plant (WTP)** **Unit: number (No.)**

The rate tendered shall include for full compensation of all costs incurred for the design of the complete installation, manufacture and procurement of the complete Water Treatment Plant (WTP) and shall cover the cost of the supply and delivery to Site, inspections, quality assurance and quality control, as well as drawings and installation instructions and where applicable, wiring diagrams of the complete system.

**28.009 Installation and pre-commissioning of complete Water Treatment Plant (WTP) Unit: number (No.)**

The rate shall also include for full compensation of all costs incurred for installation, inspections, on-site quality assurance and quality control, testing and pre-commissioning of the complete Plant, all mounting brackets, complete pipework, valves, pumps, pressure gauges and interconnecting wiring. One copy of the installation instructions, detailed dimension drawings and wiring diagrams shall be supplied and delivered to the Engineer's office.

**ANNEXURE 28/1**  
**QCP FOR CORROSION PROTECTION OF VALVES**

PART C3.1 - SPECIFICATION

<b>QUALITY CONTROL PLAN FOR CORROSION PROTECTION OF VALVES</b>						
PROJECT:			SECTION:		QCP NO.	
EQUIPMENT:			FACTORY ID NO.:		REVISION:	
DRAWING NO.:		QTY:			COMPILED BY:	
CLIENT:			CONTACT NO.:		DATE:	
CONTRACTOR:			CONTACT PERSON:		ORDER NO.:	
APPLICATOR:			CONTACT PERSON:			
<b>APPROVALS</b>						
CONTRACTOR NAME:		ENGINEER NAME:		INSPECTOR NAME:		
SIGNATURE:		SIGNATURE:		SIGNATURE:		
DATE:		DATE:		DATE:		
<b>LEGEND</b>						
H - HOLD POINT		W - WITNESS POINT		S - SURVEILLANCE		R - REVIEW
<b>INSPECTION CODE</b>						
1 - APPROVAL		3 - TESTING		5 - REPORT REQUIRED		
2 - MATERIAL CERTIFICATE		4 - VISUAL		6 - RECORD REVIEW		
<b>QUALITY CONTROL</b>						
OPERATION	INSP. CODE	INSPECTION INTERVENTIONS			ACCEPTANCE CRITERIA	
		CONTRACTOR	ENGINEER	INSPECTOR		
<b>1. DOCUMENTATION APPROVAL</b>						
1.1	Quality Control Plan	1				
1.2	Corrosion Protection Programme	1				
1.3	Coating Material	1				Data sheets
1.4	Pickling and Passivation Material	1				Data sheets
1.5	Rough Blast Material	1				Data sheets
1.6	Final Blast Material	1				Data sheets
<b>2. PRE-PREPARATION</b>						
2.1	Dress Protrusions and Pits	4				Smooth surface
2.2	Radius Sharp Edges	4				2 mm minimum radius
2.3	Repair Blowholes in Castings	4				To be approved by Engineer
2.4	Fettle Welds	4				Smooth contour
2.5	Remove Weld Spatter, Burrs, Laminations, Scabs and Scale	4				
<b>3. DEGREASING</b>						
3.1	Remove Oil/Grease Contaminations	3				Water break-free
<b>4. ROUGH BLAST CLEANING</b>						
4.1	Blasting Material					
4.2	Cleanliness					
<b>5. MEASUREMENT OF SOLUBLE SALTS</b>						
					Wet surface	Dry surface
5.1	Max. at any point				100 mg/m <sup>2</sup>	500 mg/m <sup>2</sup>
5.2	Average over 250 cm <sup>2</sup>				<100 mg/m <sup>2</sup>	100 mg/m <sup>2</sup>
5.3	Wet cleaning/Re-blasting				Clean soft water	
<b>6. FINAL BLAST CLEANING</b>						
6.1	Blasting Material	5				Data Sheet
6.2	Cleanliness: Lining	4				Sa 3
6.3	Cleanliness: Coating	4				Sa 2½
6.4	Surface Profile	3				50-100 µm
6.5	Residual Dust and Debris	3				0.3%
<b>7. AMBIENT CONDITIONS</b>						
7.1	Records	6				
<b>8. APPLICATION OF FIRST COAT</b>						
8.1	Dry Film Thickness (DFT) - Lining	3				µm
8.1	Dry Film Thickness (DFT) - Coating	3				µm

PART C3.1 - SPECIFICATION

<b>QUALITY CONTROL PLAN FOR CORROSION PROTECTION OF VALVES</b>						
PROJECT:			SECTION:		QCP NO. REVISION: COMPILED BY: DATE:	
EQUIPMENT:		FACTORY ID NO.:				
DRAWING NO.:		QTY:	CONTACT NO.:			ORDER NO.:
CLIENT:			CONTACT PERSON:			
CONTRACTOR:			CONTACT PERSON:			
APPLICATOR:			CONTACT PERSON:			
<b>APPROVALS</b>						
CONTRACTOR NAME: SIGNATURE: DATE:		ENGINEER NAME: SIGNATURE: DATE:			INSPECTOR NAME: SIGNATURE: DATE:	
<b>LEGEND</b>						
H - HOLD POINT		W - WITNESS POINT		S - SURVEILLANCE		R - REVIEW
<b>INSPECTION CODE</b>						
1 - APPROVAL		3 - TESTING		5 - REPORT REQUIRED		
2 - MATERIAL CERTIFICATE		4 - VISUAL		6 - RECORD REVIEW		
<b>QUALITY CONTROL</b>						
OPERATION	INSP. CODE	INSPECTION INTERVENTIONS			ACCEPTANCE CRITERIA	
		CONTRACTOR	ENGINEER	INSPECTOR		
<b>9. APPLICATION OF SECOND COAT</b>						
9.1	Dry Film Thickness (DFT) - Lining	3				µm
9.1	Dry Film Thickness (DFT) - Coating	3				µm
<b>10. APPLICATION OF FINAL COAT</b>						
10.1	Dry Film Thickness (DFT) - Coating	3				Brilliant Green SANS 1091 Code - H10 (25µm minimum)
<b>11. COMPLETED SYSTEM</b>						
11.1	Visual appearance	4				
11.2	Dry Film Thickness (DFT) - Lining	3				400 µm minimum
10.3	Dry Film Thickness (DFT) - Coating	3				300 µm minimum
10.4	Dry Film Thickness (DFT) - Flange/ Mating Surfaces	3				60 - 90 µm minimum
10.5	Electrical Insulation Defect (EID)	3				Wet surface
10.6	Adhesion Test	3				Where required
<b>12. STAINLESS STEEL UN-COATED COMPONENTS</b>						
11.1	Degreasing	5				
11.2	Pickling	5				
11.3	Passivation	5				

**ANNEXURE 28/2**  
**SURFACE PROFILE AND DRY FILM THICKNESS READINGS**

PART C3.1 - SPECIFICATION

		<b>SURFACE PROFILE AND DRY FILM THICKNESS READINGS</b>	
PROJECT:			
EQUIPMENT:		SECTION:	
DRAWING NO.:	QTY:	FACTORY ID NO.:	ORDER NO.:
CLIENT:		CONTACT PERSON:	
CONTRACTOR:		CONTACT PERSON:	
APPLICATOR:		CONTACT PERSON:	

**SURFACE PROFILE**

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

**DFT FIRST COAT**

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

**DFT SECOND COAT**

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

**DFT THIRD COAT**

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

**DFT FINAL COAT**

DATE:

WET SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

DRY SURFACE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE
TOP														
MIDDLE														
BOTTOM														

PART C3.1 - SPECIFICATION

---

**FLANGE FACES**

DATE:

FLANGE SIZE	1	2	3	4	5	6	7	8	9	10	TOTAL	MIN.	MAX.	AVERAGE

COMMENTS:

.....  
.....  
.....

**ANNEXURE 28/3  
COATING APPLICATION RECORD**

PART C3.1 - SPECIFICATION

 <p style="text-align: center;"><b>COATING APPLICATION RECORD</b></p>														
<b>1. Pre-preparation</b>														
Dress protrusions & pits:														
Radius sharp edges:														
Repair blowholes in castings:														
Fettle welds:														
Remove weld spatter, burrs, laminations, scale & scabs:														
Primary cleaning:														
<b>2. Degreasing</b>														
Material reference									Batch number:					
"Water break free" test														
<b>3. Rough blast cleaning</b>														
Date of rough blast cleaning						Blasting material:								
<b>4. Measurement of soluble salts</b>														
Maximum at any point				mg/m <sup>2</sup>		Average over 250 cm <sup>2</sup>				mg/m <sup>2</sup>				
Maximum at any point – final reading				mg/m <sup>2</sup>		Average over 250 cm <sup>2</sup> - final reading				mg/m <sup>2</sup>				
Wet cleaning/Re-blasting														
Blasting material:														
<b>5. Final blast cleaning</b>														
Blasting material:						Cleanliness - wet surface: Sa								
Material certificate No.:						Cleanliness - dry surface: Sa								
Material pH			Hardness			Moh's scale			Residual dust & debris:					
									%					
Surface profile:			Maximum:			µm			Minimum					
									µm					
Date of final blast cleaning:						Time completed:								
<b>6. Ambient conditions</b>														
			First coat			Second coat			Third coat			Final coat		
Time			08:00 12:00 16:00			08:00 12:00 16:00			08:00 12:00 16:00			08:00 12:00 16:00		
Rain: Yes/No														
Ambient temperature °C														
Substrate temperature °C														
Relative Humidity %														
Dew point °C														
<b>7. Application of coats</b>														
			First coat			Second coat			Third coat			Final coat		
Base : Material reference														
: Batch number														
Activator: Material reference														
: Batch number														
Thinner/solvent : Type														
: Batch number														
Application equipment:														
Colour:														
Surface preparation:														
Areas stripe coated:														
Date of application:														
Time application started:														
Time application completed:														
Wet film thickness:														
Wet surface DFT: Min / Ave			µm			µm			µm			µm		
No-off readings														
Dry surface DFT: Min / Ave			µm			µm			µm			µm		
No-off readings														
Flange/mating surface DFT:Min/Max			µm			µm			µm			µm		
No-off readings														
<b>8. Completed system</b>														
Visual appearance:														
Electrical Insulation Defect at						V								
Adhesion test:														
Cure test:														
<b>9. Stainless steel – uncoated components</b>														
Degreasing														
Date of degreasing				Material reference:				Batch No.						
<b>10. Pickling and passivation</b>														
Date of pickling				Material reference:				Batch No.						
Date of passivation:				Material reference:				Batch No.						

**ANNEXURE 28/4**  
**EXTENDED FLANGE DIMENSIONS SPECIFICATION**

(NWS 1676 based on BS 4504/BS EN 1092)

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PART C3.1 - SPECIFICATION

NDP/MvdM(1)S170

MAY 1981

NWS 1676 REVISION 0  
DISTRIBUTION CODE 2.0/6.1

ELECTRICITY SUPPLY COMMISSION  
 NEW WORKS DEPARTMENT STANDARD  
 SPECIFICATION  
 FOR  
 DIMENSIONS AND DRILLING  
 OF STEEL PLATE FLANGES  
 FOR WELDING

CONTENTS

	PAGE
1. SCOPE .....	1
2. GENERAL .....	1
TABLE 1 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 0,8MPa ..	2
TABLE 2 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 1,0MPa ..	3
TABLE 3 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 1,6MPa ..	4
TABLE 4 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 2,5MPa ..	5
TABLE 5 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 4,0MPa ..	6
TABLE 6 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 6,4MPa ..	7
TABLE 7 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 10,0MPa ..	8
TABLE 8 : STEEL PLATE FLANGES FOR WELDING NOMINAL PRESSURE 16,0MPa ..	9

170002

## PART C3.1 - SPECIFICATION

- 1 -

NWS 1676 REVISION 0

## 1. SCOPE

This specification defines Escom's dimensional requirements for steel plate flanges for welding, when such flanges fall outside the range of BS 4504 : Part 1 : 1969. The dimensions specified are fully compatible with other types of flanges manufactured to BS 4504 : Part 1 : 1969.

## 2. GENERAL

## 2.1 Reference Documents

- 2.1.1 NWS 1459 : Specification for the design and manufacture of carbon steel pipe and specials.
- 2.1.2 BS 4504 : Flanges and bolting for pipes, valves and fittings. Metric series (Part 1).

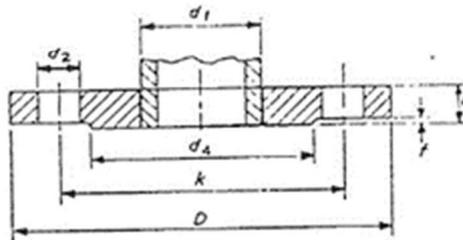
170002

PART C3.1 - SPECIFICATION

- 2 -

NWS 1676 REVISION 0

TABLE 1  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE 6/3 OF BS4504:PART 1:1969  
 NOMINAL PRESSURE 0,6 MPa



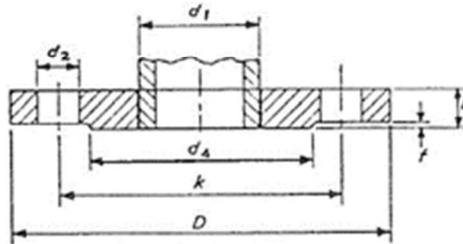
NOM. SIZE	PIPE OD $d_1$	FLANGE RAISED FACE				BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
225	246,1	345	22	282	3	M16	8	18	305
550	558,8	705	30	620	4	M24	20	26	655
650	660,4	810	34	725	5	M24	20	26	760
750	762,0	920	36	825	5	M27	24	30	865
1100	1118,0	1305	52	1195	5	M30	28	33	1240
1300	1320,0	1520	60	1400	5	M33	32	36	1450
1500	1520,0	1730	70	1610	5	M33	36	36	1660
2200	2230,0	2475	96	2335	6	M39	52	42	2390
2400	2430,0	2685	106	2545	6	M39	56	42	2600
2600	2640,0	2905	112	2750	6	M45	60	48	2810
2800	2840,0	3115	122	2960	6	M45	64	48	3020
3000	3040,0	3315	130	3160	6	M45	68	48	3220
3200	3240,0	3525	138	3370	6	M45	72	48	3430
3400	3450,0	3735	146	3580	6	M45	76	48	3640
3600	3650,0	3970	154	3790	6	M52	80	56	3860

PART C3.1 - SPECIFICATION

- 3 -

NWS 1676 REVISION 0

TABLE 2  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE 10/3 OF BS4504:PART 1:1969  
 NOMINAL PRESSURE = 1,0 MPa



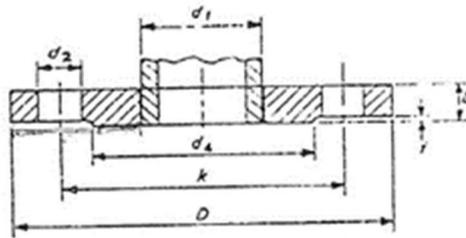
NOM. SIZE	PIPE OD $d_1$	FLANGE		RAISED FACE		BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
225	246,1	370	24	295	3	M20	8	22	325
550	558,8	730	40	635	4	M27	20	30	675
650	660,4	835	44	740	5	M27	24	30	780
750	762,0	965	50	855	5	M30	24	33	900
1100	1118,0	1340	68	1215	5	M33	32	36	1270
1300	1320,0	1575	78	1430	5	M39	32	42	1490
1400	1420,0	1675	84	1535	5	M39	36	42	1590
1500	1520,0	1785	90	1640	5	M39	36	42	1700
1600	1620,0	1915	96	1760	5	M45	40	48	1820
1800	1820,0	2115	106	1960	5	M45	44	48	2020
2000	2020,0	2325	118	2170	5	M45	48	48	2230
2200	2230,0	2550	126	2370	6	M52	52	56	2440
2400	2430,0	2760	138	2570	6	M52	56	56	2650
2600	2640,0	2960	148	2780	6	M52	60	56	2850
2800	2840,0	3180	162	3000	6	M52	64	56	3070
3000	3040,0	3405	174	3210	6	M56	68	62	3290

PART C3.1 - SPECIFICATION

- 4 -

NWS 1676 REVISION 0

TABLE 3  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE 16/3 IF BS4504:PART 1:1969  
 NOMINAL PRESSURE 1,6 MPa



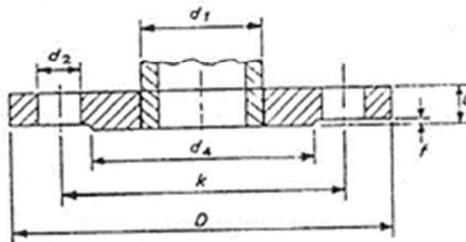
NOM. SIZE	PIPE OD $d_1$	FLANGE		RAISED FACE		BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
225	246,1	370	24	295	3	M20	12	22	325
550	558,8	775	48	635	4	M30	20	33	710
650	660,4	860	56	740	5	M33	24	36	790
750	762,0	970	60	855	5	M33	24	36	900
1100	1118,0	1355	84	1215	5	M39	32	42	1270
1300	1320,0	1585	98	1430	5	M45	32	48	1490
1400	1420,0	1685	104	1530	5	M45	36	48	1590
1500	1520,0	1820	110	1640	5	M52	36	56	1710
1600	1620,0	1930	118	1750	5	M52	40	56	1820
1800	1820,0	2130	132	1950	5	M52	44	56	2020
2000	2020,0	2345	146	2150	5	M56	48	62	2230
2200	2230,0	2555	158	2370	6	M56	52	62	2440
2400	2430,0	2765	174	2570	6	M56	56	62	2650

PART C3.1 - SPECIFICATION

- 5 -

NWS 1676 REVISION 0

TABLE 4  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE WITH, 25/3 OF BS4504:PART 1:1969  
 NOMINAL PRESSURE 2,5 MPa



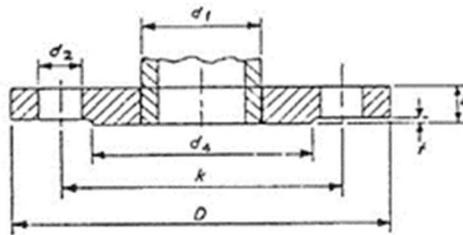
NOM. SIZE	PIPE OD $d_1$	FLANGE		RAISED FACE		BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
150	168,3	300	24	218	3	M24	8	26	250
225	246,1	395	30	305	3	M27	12	30	340
550	558,8	785	60	680	4	M36	20	39	710
650	660,4	895	70	770	5	M36	24	39	820
700	711,2	960	74	820	5	M39	24	42	875
750	762,0	1020	78	880	5	M39	24	42	935
800	812,8	1085	82	930	5	M45	24	48	990
900	914,4	1185	90	1030	5	M45	28	48	1090
1000	1016,0	1320	98	1140	5	M52	28	56	1210
1100	1118,0	1420	106	1240	5	M52	32	56	1310
1200	1220,0	1530	116	1350	5	M52	32	56	1420
1300	1320,0	1645	124	1450	5	M56	32	62	1530
1400	1420,0	1755	134	1560	5	M56	36	62	1640
1500	1520,0	1865	144	1670	5	M56	36	62	1750
1600	1620,0	1975	154	1780	5	M56	40	62	1860
1800	1820,0	2195	170	1985	5	M64	44	70	2070

PART C3.1 - SPECIFICATION

- 6 -

NWS 1676 REVISION 0

TABLE 5  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE 40/3 OF BS4504:PART 1:1969  
 NOMINAL PRESSURE 4,0 MPa



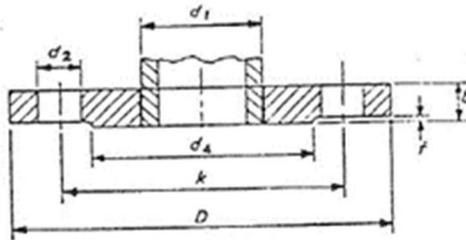
NOM. SIZE	PIPE OD $d_1$	FLANGE		RAISED FACE		BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
225	246,1	420	38	315	3	M30	12	33	355
550	558,8	835	78	680	4	M45	20	48	740
600	609,6	890	84	735	5	M45	20	48	795
650	660,4	945	90	790	5	M45	24	48	850
700	711,2	995	96	840	5	M45	24	48	900
750	762,0	1080	102	900	5	M52	24	56	970
800	812,8	1140	108	960	5	M52	24	56	1030
900	914,4	1250	120	1070	5	M52	28	56	1140
1000	1016,0	1360	132	1180	5	M52	28	56	1250
1100	1118,0	1460	142	1280	5	M52	32	56	1350
1200	1220,0	1575	154	1380	5	M56	32	62	1460
1300	1320,0	1685	166	1490	5	M56	32	62	1570
1400	1420,0	1795	178	1600	5	M56	36	62	1680

PART C3.1 - SPECIFICATION

- 7 -

NWS 1676 REVISION 0

TABLE 6  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE 64/3 OF BS4504:PART 1:1969  
 NOMINAL PRESSURE 6,4 MPa



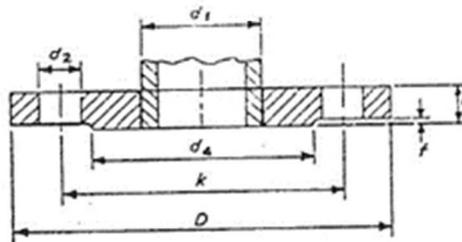
NOM. SIZE	PIPE OD $d_1$	FLANGE		RAISED FACE		BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
225	246,1	440	50	315	3	M33	12	36	370
450	457,2	715	84	560	4	M39	20	42	630
500	508,0	800	94	615	4	M45	20	48	705
550	558,8	855	102	680	4	M45	20	48	760
600	609,6	930	108	735	5	M52	20	56	820
650	660,4	985	116	790	5	M52	24	56	875
700	711,2	1045	124	840	5	M52	24	56	935
750	762,0	1100	132	900	5	M52	24	56	990
800	812,8	1165	140	960	5	M56	24	62	1050
900	914,4	1285	156	1070	5	M56	28	62	1170
1000	1016,0	1415	172	1180	5	M64	28	70	1290

PART C3.1 - SPECIFICATION

- 8 -

NWS 1676 REVISION 0

TABLE 7  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE 100/3 OF BS4504:PART 1:1969  
 NOMINAL PRESSURE 10,0 MPa



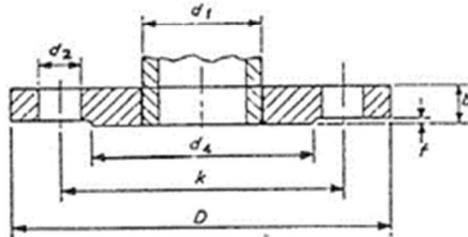
NOM. SIZE	PIPE OD $d_1$	FLANGE		RAISED FACE		BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
225	246,1	475	66	315	3	M36	12	39	400
450	457,2	770	112	560	4	M45	20	48	675
550	558,8	935	134	680	4	M56	20	62	820
600	609,6	990	144	735	5	M56	20	62	875

PART C3.1 - SPECIFICATION

- 9 -

NWS 1676 REVISION 0

TABLE 8  
 STEEL PLATE FLANGES FOR WELDING  
 CONSISTENT WITH, BUT NOT COVERED BY,  
 TABLE 160/3 OF BS4505:PART 1:1969  
 NOMINAL PRESSURE 16,0 MPa



NOM. SIZE	PIPE OF $d_1$	FLANGE		RAISED FACE		BOLTING	DRILLING		
		D	b	$d_4$	f		No.	$d_2$	k
225	246,1	475	84	315	3	M36	12	39	400