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

TENDER NO 054/2024/PMID/MCWAP2/RFB

PART C3.1
SPECIFICATION

SECTION 30

PUMPS AND ANCILLARY PLANT

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PUMPS AND ANCILLARY PLANT

30.1 SCOPE

30.1.1 Applicable Parts of Works

This complete Section 30 shall be regarded as Employers' requirement in terms of the Conditions of Contract and is applicable to the following Parts:

- Part B2 (Low-Lift Pumping Station); and
- Part E2 (High-Lift Pumping Station).

Raw water is abstracted with the low-lift pumps from the Crocodile (West) River and transferred via two parallel steel pipelines to a Balancing Reservoir (Part D) from where the water is transferred by the high-lift pumps to a Break Pressure Tank (Part G) via a steel pipeline.

30.1.2 Duty points

The duty points applicable to the two pump systems are shown below.

(a) Low-Lift Pump System

Figure 30/1, below, shows the Low-Lift Pumping Station (LLPS) duty points.

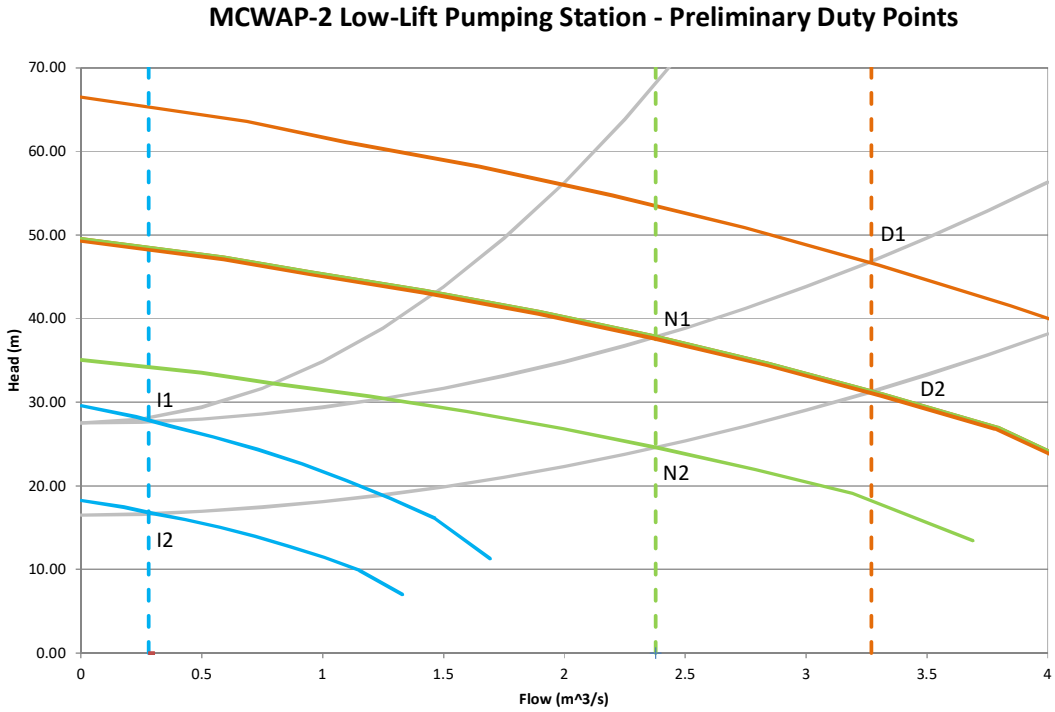

FIGURE 30/1
LOW-LIFT PUMPING STATION DUTY POINTS

The LLPS duty points are defined as follows:

a) **Initial transfer duty points**: Duty points I1 and I2 defines the duty points during the initial stages of the project on the low and higher system curves. Duty points I1 and I2 need to be achieved with a single pump set operation at reduced pump rotational speed. For pumping rates lower than the duty points I1 and I2 single pumpset batch operation will be allowed.

b) **Minimum transfer:** The minimum transfer rate is the minimum transfer rate at which a single pumpset can be operated on a stable and continuous (non-batch) basis. Minimum transfer rates duty points (M) are only defined in terms of minimum flow and pump efficiency. (Refer to Clause 30.5.1.2(d)).

c) **Nominal transfer duty points**: Duty points N1 and N2 defines the duty points for nominal system operation. Pumps should be sized for 100% pole speed and optimum impellor size at duty point N1. Duty point N2 shall be achieved through reduced speed operation. Duty points N1 and N2 shall be achieved with two pumpsets in parallel.

d) **Design transfer duty points**: Duty points D1 and D2 shall be achieved with two pumpsets in parallel and through operating pumpsets at < 110% pole speed.

e) **Future Extended Transfer Capacity**: The duty points required to meet the future Extended Transfer Capacity of 125 Mm^3/a (MCWAP-2B) is addressed by the Diversion Weir design criterion for MCWAP-2A by accommodating the MCWAP-2B transfer requirements in the capacity of the Weir degritting channels and suction pipework to the low-lift pumping system. Ultimately, equal flow is required in all of these channels. Therefore, the pump selection should give consideration to either the replacement or refurbishment of the pumps or increasing the motor speeds (by variable speed drives) or impellers in order to increase the capacity of the proposed Phase 2A pumps, with duty flow of 1.635 m^3/s each, to a duty flow of 1.817 m^3/s each to meet the future Extended Design Transfer Capacity totalling 5.450 m^3/s. This may also require the replacement of the motors and VSD.s.

Two (2) parallel DN1000 raw water transfer pipelines are proposed for accommodating the MCWAP-2A transfer and operational and maintenance requirements. It is assumed that a similar third transfer pipeline between the Low-Lift Pumping Station and the Sedimentation Works will be developed for MCWAP-2B. The proposed Low-Lift Pumping Station layout allows for the installation of a 4th and final pump set which, together with the 3rd pipeline, should meet the Extended Transfer Capacity.

The Contractor shall indicate how the future Extended Design Transfer Capacity can be achieved using the same pumps.

(b) High-Lift Pump System

Figure 30/2 below shows the High-Lift Pumping Station (HLPS) duty points.

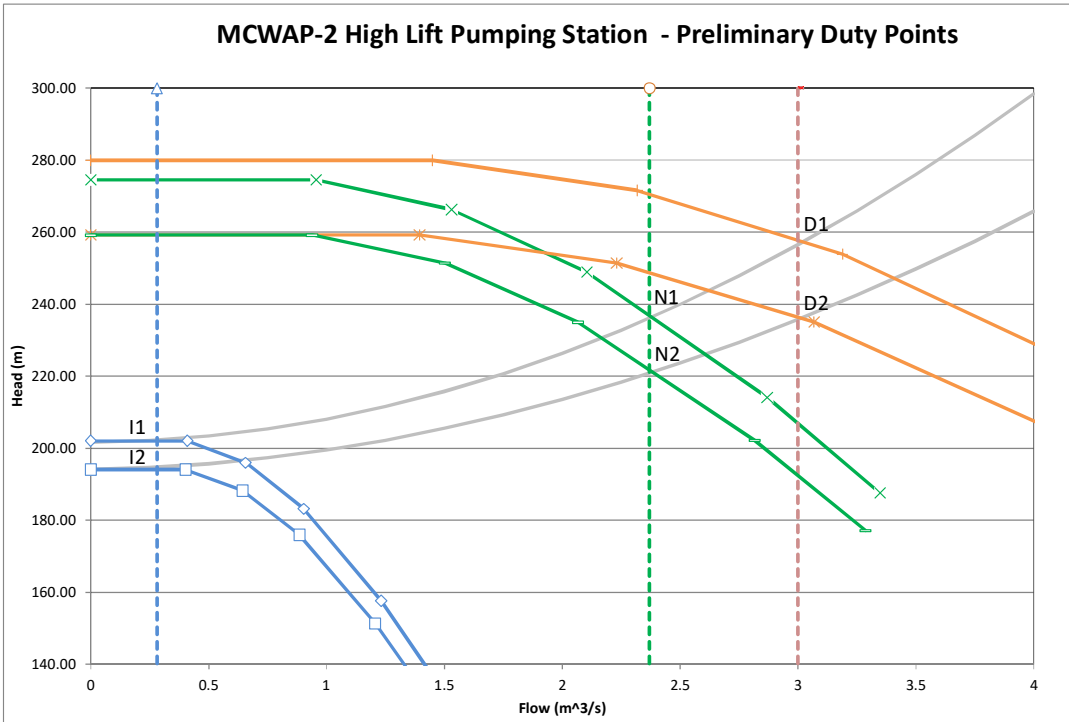

FIGURE 30/2
HIGH-LIFT PUMPING STATION DUTY POINTS

The HLPS duty points are defined as follows:

a) **Initial transfer duty points**: Duty points I1 and I2 defines the duty points during the initial stages of the project on the low and higher system curves. Duty points I1 and I2 need to be achieved either through continuous single pump set operation and reduced pump speed operation or through batch pumping with a single pumpset.

b) **Minimum transfer rates:** The Contractor shall indicate the minimum transfer rate at which a single pumpset can be operated on a stable and continuous basis. Minimum transfer rates duty points (M) are only defined in terms of minimum flow and pump efficiency. (Refer to Clause 30.5.1.2(d)).

c) **Nominal transfer duty points**: Duty points N1 and N2 defines the duty points for nominal system operation. Pumps should be sized for 100% pole speed and optimum impellor size at duty point N1. Duty point N2 shall be achieved through reduced speed operation. Duty points N1 and N2 shall be achieved with two pumpsets in parallel.

d) **Design transfer duty points**: Duty points D1 and D2 shall be achieved with three pumpsets in parallel and through operating pumpsets at < 110% pole speed.

30.1.3 Pumping Station configurations

The design of the Low-Lift Pumping Station shall be configured as follows:

- Pumping Station arrangement: Dry well
- Pump types: Axial split casing centrifugal (single stage)
- Medium: Raw unsettled water
- Duty / standby configuration: 2 plus 1 (plus 1 additional pumpset for future capacity)

- Rotational speed: 6 pole or higher
- Duty point group I (initial)
  - Duty point I_{min}: Q= 0.287 m^3/s ; H = 16.66 m
  - Duty point I_{max}: Q= 0.287 m^3/s ; H = 27.67 m
- Duty point group N (nominal)
  - Duty point N_{min}: Q= 2.378 m^3/s ; H = 24.57 m
  - Duty point N_{max}: Q= 2.378 m^3/s ; H = 37.81 m
- Duty point group D (design)
  - Duty point D_{min}: Q= 3.27 m^3/s ; H = 31.27 m
  - Duty point D_{max}: Q= 3.27 m^3/s ; H = 46.83 m
- Extended Design Transfer Capacity: Q=5.450 m^3/s
- $NPSH_a$: Refer to project Drawings
- VSD operation: 60% to 110% of pole speed

The design of the High-Lift Pumping Station shall be configured as follows:

- Pump station arrangement: Dry well
- Pump types: Axial split casing centrifugal (single or multi-stage)
- Medium: Raw settled water
- Duty/standby configuration: 3 plus 1
- Rotational speed: 6 pole
- Duty point group I (initial)
  - Duty point I_{min}: Q= 0.287 m^3/s ; H = 194.7 m
  - Duty point I_{max}: Q= 0.287 m^3/s ; H = 202.4 m
- Duty point group N (nominal)
  - Duty point N_{min}: Q= 2.378 m^3/s ; H = 220.8 m
  - Duty point N_{max}: Q= 2.378 m^3/s ; H = 236.4 m
- Duty point group D (design)
  - Duty point D_{min}: Q= 2.97 m^3/s ; H = 234.1 m
  - Duty point D_{max}: Q= 2.97 m^3/s ; H = 253.7 m
- $NPSH_a$: Refer to project Drawings
- VSD operation: 60% to 110% of pole speed

30.1.4 Drawings

The following Drawings outline the Employer's preliminary assembly, layout and functional requirements:

Low-Lift Pumping Station

- General Plan Layout – 3D View: Drawing no. 2B-C7-210
- Pipework General Arrangement: Drawing no 2B-C3-003
- Pipework Sections: Drawing no 2B-C4-003
- P&ID: Drawing no's 2B-E2.1-001 to -003

High-Lift Pumping Station

- Isometric View: Drawing no 2E-C7-101
- Pipework General Arrangement: Drawing no 2E-C3-006
- Pipework Sections: Drawing no 2E-C4-001
- P&ID: Drawing no's 2E-E2.1-001 to -003

30.1.5 General requirements

The Contractor shall be responsible for the design, manufacture, delivery, installation, pre-commissioning, testing, trial operation and activities during the Defects Notification Period of the pumping Plants.

The Contractor shall be responsible for all operations necessary for the adjustment and testing of the complete pumping system until it has been handed over to the Employer. During the entire commissioning of the Plant, the Contractor shall be wholly responsible for the operating and maintenance of the pumping Plant and remedying of any defective parts of the pumping Plant.

The Contractor shall permit and facilitate the Engineer's observation during manufacturing, delivery, erection, installation and testing of the complete pumping system. The Contractor shall ensure that specialist personnel are on hand for the entire duration of the tests.

The Contractor shall supply all necessary items to provide complete working installations including all built-in parts and anchors, with performance guarantees.

The Contractor shall also carry out all civil engineering work, including forming and preparing box-outs, chases etc. to receive the built-in parts, establish concrete around them, and grouting-in base plates, holding down bolts and the like.

This Section shall be read in conjunction with Section 1 – General, Section 28 – Mechanical General, Section 32 – Pipes and Pipe Specials, Section 37 – Painting and Corrosion Protection, Section 38 – Electrical General, Section 39 – Electrical - Plant and Installation and Section 48 – Tests on Completion.

30.2 REFERENCES

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.

30.3 DEFINITIONS AND ABBREVIATIONS

30.3.1 Definitions

For the purpose of this Section:

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

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

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

d) **"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.

e) **"Commissioning"** as defined in Section 48 – Tests on Completion.

f) **"Trial operation"** as defined in Section 48 – Tests on Completion.

g) **"Preliminary Acceptance Test"** as defined in Section 48 – Tests on Completion.

h) **"Final Acceptance Test"** as defined in Section 48 – Tests on Completion.

i) **"RL"** means reduced level in metres above mean sea level.

j) **"Flow rate"** means the volume of liquid passing through the pump per unit of time.

k) **"Materials"** includes the basic materials used in the manufacture and fabrication of the pump-sets themselves and ancillary Plant as finished products that are to be installed and commissioned.

l) **"Nominal diameter (DN)"** means a numerical, nominal designation of size that is common to all components in the piping system other than components designated by outside diameters. It is a convenient round number for reference purposes and is only loosely related to the manufacturing dimensions. Nominal size is designated by DN followed by the size in millimetres. All Plant of the same size (DN) designated by the same PN number shall have compatible mating dimensions.

m) **"Nominal pressure (PN)"** means a numerical designation of a pressure rating which is a convenient round number for reference purposes. The maximum allowable working pressure depends upon the materials design and working temperature and shall be selected from the pressure / temperature rating table in the appropriate standards. It is the internal pressure corresponding to the maximum allowable working pressure.

n) **"Static head"** means the difference between the free water surface levels on the suction and delivery sides of the pump.

o) **"External friction head"** means the head required to overcome the friction external to the limits of pump supply.

p) **"Plant losses"** means the friction losses in all pipe-work, specials and valves within the limits of pump supply.

q) **"Velocity head"** means the head given by ($v^2/2g$) at the point of pressure measurement.

r) **"Total manometric head"** is the sum of n), o), p), and q).

s) **"NPSH Available ($NPSH_A$)"** defines the total absolute pressure above the vapour pressure at the suction nozzle for a given liquid at a certain flow rate and is independent of the pump itself.

t) **"NPSH Required ($NPSH_R$)"** is a pressure characteristic of the particular pump and is given by the pump manufacturer. The head in metres of water required above the reference plane, according to BS 5316 (impeller centre line for horizontally mounted centrifugal pumps) to ensure that cavitation does not occur.

u) **"Duty point"** means that point on the pump H-Q (head-flow) characteristic curve for the required performance of the pump as stated in terms of total manometric head in metres and required flow rate in m^3/s or ℓ/s. In some cases, more than one Duty Point may be specified to accommodate system characteristics. The Duty Point(s) applicable to pump system(s) is (are) defined in the Project Scope (Clause 30.1).

v) **"Motor power input"** means the power absorbed by the motor that is driving the pump.

w) **"Coupling"** means any process of jointing (except welding) the pump shaft to the motor shaft.

x) **"Special"** means all sizes and shapes of pipe work such as closure pieces, bends, tees, crosses, angle branches, reducers, and tapers.

y) **"Pumpset"** means one pump unit together with its associated motor, coupling, base plate and auxiliaries to deliver the specified quantity at the specified head, and all ancillary Plant.

z) **"BEP"** means best efficiency point which is the point on the pump characteristic curve at which the efficiency of the pump is the highest.

30.3.2 Abbreviations and Material Symbols

For the purpose of this Section, the following shall have the meaning given:

AC	:	Alternating current
BEP	:	Best Efficiency Point
CI	:	Cast Iron
DC	:	Direct current
DFT	:	Dry film thickness
DN	:	Nominal diameter
DS	:	Downstream
H-Q	:	Head – flow relationship
HLPS	:	High-Lift Pumping Station
IP	:	A symbol which, followed by two characteristic numerals, signifies the degree of mechanical protection to ingress of foreign bodies and water as defined in SANS 60529.
LCD	:	Liquid crystal display
LLPS	:	Low-Lift Pumping Station
$NPSH_A$	:	Net Positive Suction Head Available
$NPSH_R$	:	Net Positive Suction Head Required

P&ID : Process and Instrumentation Diagram
PN : Nominal pressure
Q : Flow rate
rms : root mean square
TMH : Total manometric head
TP : Test pressure
US : Upstream
VSD : Variable Speed Drive

30.4 GENERAL REQUIREMENTS

30.4.1 Scope of Design Work

Based on the Employer's requirements, the Contractor shall be responsible for the integrated design of a pumping system and the required ancillary components that integrates with the bulk water transfer scheme required by the Employer. The battery limits are indicated on the Project Structure Diagram (Drawing no 2A-P2-001) and the relevant layout Drawings (Drawing no's 2B-C3-003 and 2E-C3-006).

The scope of the detail design shall include but not necessary be limited to:

a) The final pump selection;

b) The integration of the pump, motor, VSD and starter configuration;

c) The integration of the relevant power supply;

d) The integration of the pump control and the rising main surge conditions;

e) The integration of the pump control and the suction pipeline surge conditions;

f) Shaft couplings;

g) Ancillary Plant: seal water flow control valves and protection Plant items;

h) Valves;

i) Actuator systems for all valves in the pumping station(s);

j) Integration of instrumentation with reference to Section 40 - Control and Instrumentation General as required to render the Plant safe in operation;

k) Cranes, confirming span, long travel and cross travel with reference to Section 31 – Cranes, hoists and winches; and

l) The design shall take into account the given control philosophy as set out in Section 40 – Control and Instrumentation General.

30.4.2 Early Submission of Design Information

The following detail design information submitted during Tender stage regarding mechanical Plant shall be included in the design confirmation documentation to be submitted within 28 days from the Commencement Date for approval by the Engineer prior to ordering the Plant:

a) General arrangement Drawings defining the Plant arrangement. Note: Unless clearly stated and indicated on a Drawing, the pumping station well size and depth proposed in this Section will be considered as agreed upon by the Contractor;

b) Pumpset layouts: To scale, dimensioned Drawing, giving overall dimensions of the pump set and the required base plates and concrete plinths with typical pump construction details defining pump seals, shaft sleeves, sealing rings, bearings etc.;

c) Pump general cross-sections: To scale, dimensioned Drawings showing materials of construction including general dimensions of the pump impellers;

d) Characteristic performance curves for pumps, including as a function of discharge head, pump efficiency, overall efficiency, pumpset power required, NPSH required for 0% and 3% head drop, NPSH available;

e) Typical motor details: Drawings showing for each type of motor offered, general motor arrangement, details of bearings, windings, terminal box, cable entry box, ventilation, insulation system, method used to lock the rotor bars in the slots, thermal characteristics of temperature sensors, air filtering, water cooling etc.;

f) VSD details: Drawings showing layout, ventilation arrangement, cable routes etc.;

g) Characteristic curves of motors;

h) Motor / pump – speed / torque curves expressed in absolute terms - not only percentage of full load; and

i) The motors shall be subjected to full load tests and test reports shall be available after testing; including loads expected at the rotational speed control limits of VSD range 60% to 110%.

30.4.3 Operating Temperature

Each pump and electric motor shall be capable of operating satisfactorily at maximum shade temperature of 45°C. The temperature of the pumped liquid will not exceed 25°C.

30.4.4 Vibration Standards

A machine will not be acceptable if vibration is outside the limits prescribed in Clause 30.10.4.1. Maximum vibration amplitudes are specified on bearing housings measured in the horizontal, vertical and axial planes. Machined surfaces (50 mm x 50 mm) shall be provided for these measurements on the housings.

Pumpsets shall be accurately balanced statically, dynamically and hydraulically in accordance with SANS 948, Table 25 or an approved internationally recognised Standard.

30.4.5 Noise Limits

Plant or a combination of Plant shall not exceed the maximum noise limit of 75 dBA. (Refer to BS 4999: Part 51 Test Method II).

30.4.6 Pumped Liquid

The pumps shall be able to handle raw water from the Crocodile River with a chemical composition specified in Section 28 – Mechanical General.

30.4.7 Interchange Ability

All pumps, motors, valves, spares, etc., of the same size for the specified duty shall be interchangeable without the necessity of additional machining or fitting.

30.4.8 Dismantling Ability

Preference will be given to a design and arrangement of the pump casing which ensures that it is not necessary to disconnect the delivery pipework or interfere with the alignment, when removing or replacing the complete rotating element.

30.4.9 Insulating Flanges

Insulating flanges (IF) complete with spark-gap arrestors shall be supplied and installed at the flanges of the manifold branches as indicated on the Drawings. The testing of the insulating joints shall be witnessed by the Engineer. The proposed test method and sequence shall be agreed with the Engineer in order to ensure the efficiency and compliance regarding electrical isolation. Refer to Section 28 – Mechanical General and Section 34 – AC Mitigation and Cathodic Protection.

30.4.10 Connecting Pipework

All pipework and flanges upstream and downstream of the low-lift pumps and shall be rated for pressures of 1000 kPa and 1600 kPa respectively. All reducers directly upstream and downstream of the pumps shall be of concentric design. Flanges shall be flat face and shall be supplied with non-asbestos full face gaskets.

All pipework and flanges upstream and downstream of the high-lift pumps shall be rated for pressures of 1600 kPa and 4000 kPa respectively. 1600 kPa flanges shall be flat face and shall be supplied with tanged graphite full face gaskets whilst 4000 kPa flanges shall be raised face supplied with aramid and glass fibre with nitrile rubber binder to BS 7531 ring face gaskets.

Attention shall be given to the corrosion protection requirements for raised face flanges. Corrosion protection for the area not clamped shall be similar in all respects to that applied externally to the pipework / valve / pump.

Provision shall be made for DN100 scour branches, ½" BSP stainless steel tapping points upstream and downstream of each of the pumps for pressure transducers, pressure gauges and 1" BSP stainless steel tapping points upstream and downstream of each of the pumps for thermodynamic efficiency testing points fitted with ¼ turn stainless steel ball valves for isolation and a 1” BSP steel tapping point upstream for a flow switch.

The Contractor shall provide the Engineer with detailed designs (including stress and hydraulic calculations where appropriate) of all the connecting pipework between the valves and pumps etc. The Contractor shall submit Drawings indicating positions and details of where flange adapters will be installed, positions of scours, positions of off-takes for bypasses, tapping points for thermodynamic monitoring connections, pressure gauges and pressure transducers etc.

30.4.11 Dimensions and Assembly

All parts shall be robust and of the most suitable material, corrosion-resistant, free from flaws, accurately machined, properly assembled and fitted so as to avoid initial stresses and to ensure free running of all rotating parts. All fittings such as packing glands, shaft assemblies, thrust bearings and plummer blocks shall be of adequate size and sound design.

30.4.12 Drawings

The Contractor shall submit relevant Drawings to the Engineer for approval within 12 weeks of the award of the Contract. The Drawings shall confirm the Tender information and conform to the following requirements:

a) Fully dimensioned Drawings showing pump plinths, foundation and holding down and other fixing bolt sizes and positions and sizes of openings to be left in the civil structure to accommodate the Plant; and

b) Diagrams indicating the interconnection of the electrical operation of all the Plant to be installed by the Contractor.

Drawings submitted to the Engineer shall be in accordance with the requirements as specified under Section 28 – Mechanical General.

30.5 DESIGN, MATERIALS AND MANUFACTURING

30.5.1 Pumps

Pumps and ancillary Plant shall be capable of withstanding the applicable test pressure specified in Clause 30.11.

The design, materials used and the protection provided shall comply with the relevant requirements set out below.

The manufacturer shall operate a quality assurance system according to BS EN ISO 9001 (and ISO 9002) (latest edition) for the manufacture of pumps and pumping systems.

Spilt Casing pumps shall be able to operate in the vertical or horizontal position, as specified or shown on the Drawings. Pumps shall be coupled by approved metal flexible couplings to standard motors.

All horizontal pumps with two or more stages and all horizontal single (in the case of multi-stage pumps) or double suction (in the case of single stage) pumps shall have the impellers mounted between bearings.

The details of the pumpsets supplied shall be in accordance with those set out on the Schedules submitted at Tender stage and as approved when the Tender is awarded.

30.5.1.1 Permissible Design Stresses

In the design calculations, the Contractor shall make provision for the worst possible conditions that may have to be withstood by the Plant, whether during operation or during fabrication, transport or installation.

The following for permissible stresses shall apply:

a) “Normal permissible stress” in steel: 50% elastic limit; and

b) “Exceptional permissible stress” in steel: 75% elastic limit.

In the case of a component subjected to stress in several directions, the equivalent permissible stress shall be equal to the “exceptional permissible stress”.

For pump casings the design stress used for any material shall not be in excess of the values given in ASME Section VIII, Division 1 for "Unfired Pressure Vessels" for that material. For cast materials, the factor specified in the ASME Boiler and Pressure Vessel Code shall be applied. Pressure casings of forged steel, rolled and welded plate, or seamless pipe with welded cover shall comply with the applicable standards of ASME Section VIII, Division 1.

30.5.1.2 Pump Selection

(a) Impeller Size

No pump, with a constant speed driver, which requires a maximum or minimum diameter impeller to meet the rated pumping conditions, will be accepted.

The impeller diameter shall be such that at least a 5% increase in head at the rated capacity can be obtained by installing a larger diameter impeller of the same pattern. Minimum allowable impeller diameter shall be 105% of the pump supplier's minimum catalogue diameter.

(b) Operating Characteristics

The pumps shall be capable of operating over the full operating head range between all defined Duty Points, without motor overload or perceptible signs of cavitation.

Pump impellers shall have the characteristic of generally decreasing head with increasing capacity from shut-off to maximum capacity.

Throttling will not be permitted.

Variable Speed Drives (VSD's) shall be fitted to ALL pumpsets in order to obtain the required Duty Points defined in Clause 30.1.

(c) $NPSH_R$

$NPSH_R$ curves for both 0% and 3% cavitation shall be included with the pump characteristic curves.

Should the pump manufacturer not have made such tests, the Engineer will make the following assumptions to obtain an approximate 0% head drop curve to ensure that cavitation does not occur because of insufficient suction pressure when the $NPSH_A$ calculations are made:

a) On the left hand side of the 3% curve, 150% will be added to the value shown;

b) At the BEP of the 3% curve, 40% will be added to the value shown;

c) On the right hand side of the 3% curve, 50% will be added to the value shown; and

d) Atmospheric pressures shall be measured at site RL above sea level less 1 m, to allow for low atmospheric pressure conditions.

(d) Efficiency

The efficiency curve shall be flat over a wide range in order to provide efficient working with various pump operating conditions. The BEP should preferably be to the right of the duty points.

The duty point minimum efficiency shall be guaranteed as follows:

- LLPS
  - I duty points : Contractor to indicate
  - M duty points : >80%
  - N duty points : >85%
  - D duty points : >85%
- HLPS
  - I duty points : Contractor to indicate
  - M duty points : >80%
  - N duty points : >85%
  - D duty points : >85%

(e) Operating Speed

The pump shaft rotational speed shall not exceed 1500 rpm (4 pole speed).

30.5.1.3 Specific Speed

Specific Speed, N_S, (defined hereunder) shall have a value of between 10 and 30 per impeller, unless detailed and acceptable justification is given:

$$N_S = \frac{n \cdot \sqrt{Q}}{H^{0.75}}$$

Where:

n = rotational speed in revolutions per minute.

Q = capacity in m^3/s (if single suction, equals capacity of the pump).

H = dynamic head in metres at any speed.

30.5.1.4 Suction Specific Speed

Suction Specific Speed, S, (defined hereunder) shall under no circumstances exceed the value of 160 per impeller inlet, unless detailed and acceptable justification is given:

$$S = \frac{n \cdot \sqrt{Q}}{NPSH_R^{0.75}}$$

Where:

n = rotational speed in revolutions per minute.

Q = capacity in m^3/s (if single suction, equals capacity of the pump).

$NPSH_R$ = Net positive suction head required.

H_a = atmospheric pressure at the elevation of the pump in metres of water.

H_s = difference in level of the highest point of the impeller entry above the water level on suction side, increased by the head losses in the suction line in metres of water.

H_v = Velocity head ($v^2/2g$).

H_{vp} = vapour pressure in metres of water.

30.5.1.5 Materials Requirements

(a) General

All materials shall be suitable for pumping the quality of water to be pumped from the Crocodile River. Properties claimed for these materials shall, unless specified otherwise in this document, comply with the requirements of the most recent edition of the appropriate South African or other internationally recognized standard specification. For water quality of Crocodile River refer to Section 28 – Mechanical General.

For each type of Plant, the manufacturer shall specify the materials to be used for each of the proposed sub-assemblies.

The Plant shall be manufactured using new prime quality materials taking into account the latest technical innovations.

All components shall have a surface finish in relation to their importance, their position and their intended purpose.

Rolled steels and all castings shall be clean and free of blisters, porosity, shrinkage, holes, cracks or other flaws which may be detrimental to their use.

(b) Compatibility of Materials

The responsibility for selecting materials which are compatible with (able to prevent corrosion and/or abrasion) the liquids or surroundings with which they come into contact rests with the Contractor. The materials used shall be at least equal to those specified in this Section and shall be approved by the Engineer if different from the Specification. The responsibility for selecting suitable materials of construction rests with the Contractor.

(c) Castings

Any repairs to defective castings shall be approved by the Engineer.

Castings shall be sound, free from shrink or blow holes, scale blisters and other similar defects. The surfaces shall be cleaned by the supplier's standard methods. All casting burrs shall be filed or ground flush with the surface of the casting.

Porous castings shall be rejected. The repair of leaks and defects in pressure castings shall only be allowed after the approval of the Engineer had been obtained. It shall then be executed strictly in accordance with rules of Section VIII of the ASME Code.

The filling of casting defects shall be carried out by highly qualified welders only, according to latest welding techniques.

Any cast component requiring filling at any fabrication stage after the first anneal shall be subjected to further annealing treatment unless stipulated otherwise. Cast components shall not be warped or distorted in any way and shall not show any increase in dimensions after casting (beyond that shown on the fabrication Drawings) likely to cause interference with other components in the erection of the item of Plant for which they were made. The structure of cast components shall be homogeneous and free of slag intrusions. If, at critical points of a cast component, there is too great a concentration of impurities or alloy, the component shall be rejected. Casting materials shall be homogenous and stress relieved.

(d) Stainless Steels

Stainless steel shall be of the type easily jointed or filled by electric welding. Stainless steel which cannot withstand the effects of welding or associated heat treatment will not be accepted.

30.5.1.6 Pump Casing

(a) General

The pump casing shall be manufactured in normal SG Iron to grade GGG.

All pressure casings shall be of such thickness as will be suitable for the maximum discharge pressure (plus surge pressure) at pumping temperature and hydrostatic test pressure at ambient temperature, with a 3.2 mm minimum corrosion allowance. Casings shall have stiffening ribs at all points of high stress. Particular care shall be exercised in designing a pump casing to resist the tendency to crack through the cutwater or guide passage walls during pressure tests.

Pumps shall be furnished with suction and discharge flanges integrally cast with the casing. Where the pump supplier's standard pattern offers a flange thickness and diameter greater than that specified, the heavier flange may be furnished, but it shall be drilled as specified. All cast iron casings with flanges or other bolted mating surfaces shall have a full width gasket surface.

Pumps shall be provided with a vent connection unless the pump is made self-venting. All horizontal drive pumps shall be provided with a drain connection.

The backs of all flanges shall be machined full-face or spot-face and bolt holes shall straddle the horizontal and vertical centrelines.

Provision shall be made on each pump for removing the pump casing cover and the shaft assembly without disturbing the motor drive or having to disconnect any pipework apart from small bore pipes such as vent pipework and the like. Lifting facilities for the casing cover and shaft assembly shall be provided where these cannot be reached by overhead crane.

All vent, lantern ring, case drain, or seal recirculation connections on pumps shall be threaded according to SANS 1109.

Each pump shall be provided with a cast-in or permanently attached metal plate with direction-of-rotation arrow.

(b) Internal Protection

In order to increase its life the inside of the pump casing shall be lined with an approved Vinyl Ester Glass Flake Epoxy or Ceramic Epoxy lining (or equal approved by Engineer) to give a smooth, high quality surface which will protect the steel against abrasion and corrosion and also improve the pump efficiency over an extended period.

(c) Casing Eye Rings

Renewable phosphor-bronze (PB1) (or similar approved material) eye rings shall be provided on all pumps.

30.5.1.7 Impellers, Wear Plates and Wear Rings

Multi-channel, shrouded impellers with optimum vane geometry to provide high efficiency, low $NPSH_R$ and minimised pulsations in the discharge are preferred.

The arrangement of the impellers shall be such as to reduce the residual axial thrust to a minimum. Designs incorporating a balanced, double suction arrangement are preferred.

Impellers shall be made of stainless steel of an approved grade from new ingot material unless otherwise approved. Materials highly resistant (such as high chrome iron) to abrasion resulting from grit contained in the pumped liquid, shall be used in making the wear plates, wear rings and liners (as applicable).

All water passages shall be polished to a smooth finish; water passages which cannot be machined shall be hand ground and filed to a template.

Entrance to the vanes at the eye of the impeller shall be smooth and leading edges of the vanes shall be ground to the optimum profile consistent with best efficiency and cavitation-free operation.

Lines showing the designed width of the water passage at the outlet shall be scribed on the impeller periphery when the impeller is being machined. The internal surfaces of the impeller shall be finished off to these machined lines smoothly and symmetrically; bevelling the metal to conform to the scribed lines will not be accepted.

Impeller shrouds shall be of adequate thickness after they have been machined, the thickness depending on the impeller diameter. Impellers for similar pumps shall have the same outside diameter and shall be interchangeable.

Where impeller eyerings are not fitted, the design of the impeller eye shall be such that sufficient thickness is left so that material can be machined away at a later stage and either impeller eyerings, or undersize casing eyerings fitted. Replaceable wearing rings shall be made of the same material as the impeller. Unless otherwise approved by the Engineer these rings, which shall be "L" cross-section, shall be secured to the impeller with non-corroding screws and mechanically locked.

Each impeller shall, after final machining and dressing be independently statically balanced, and the completely assembled rotating element, with coupling shall be dynamically balanced, the latter at not less than half the maximum rated speed for which the specific pump has been designed.

Drilling holes in the impeller to balance it with regard to mass distribution is not acceptable. After completion of the balancing procedure, results of the test in the form of a certificate shall formally be submitted to the Engineer.

The first critical speed of the rotating element shall be at least 15% higher than the maximum running speed.

The impeller shall be suitable for pumping raw water as specified in Section 28 – Mechanical General.

30.5.1.8 Diffusers

Where fitted, diffusers shall be cast in an approved zinc-free bronze or stainless steel and shall be provided with a smooth finish through the hydraulic passages.

30.5.1.9 Shafts

Pump shafts shall be suitably heat treated and of sufficient dimensions to transmit the power to which they will be subjected without undue torsional or bending stresses and deflection. Shafts shall be designed of such material as to be resistant to pitting corrosion and fatigue failure, i.e. EN57 or similar approved by the Engineer.

The shafts shall be stress-relieved after initial machining, and ground to final size. The shafts shall be suitably designed for the reception of the impeller which shall be adequately secured to the shaft in such a manner as to be readily removable without damage to either the shaft or the impeller.

The Contractor shall ensure that both the critical speed and torsional oscillation characteristics of the combined pump and motor rotating elements are satisfactory for all possible conditions of operation.

Provision shall be made on each pump shaft or coupling for checking speed by means of a hand tachometer of the reflective digital read-out type.

30.5.1.10 Shaft Sleeves

The shafts shall be fully protected with replaceable sleeves of an approved bronze, stainless steel or other similar approved non-corrodible material at all areas where wear and/or corrosion could possibly be expected. These sleeves shall be readily removable without causing damage to either the shaft or the sleeve. Sleeves shall be ground with a polished finish on the wearing surface. They shall be fitted to all pumps where the shaft passes through the stuffing box. The sleeve shall extend a minimum of 3 mm beyond the gland plate.

30.5.1.11 Bearings and Lubrication

(a) Bearings

The bearings in the pump casing together with the lubricating system shall be suitable for the particular circumstances described in the Section. Where pumps are required to operate in any plane (horizontal, inclined or vertical) the bearings shall be specially designed for the specific operating conditions. The Contractor shall submit to the Engineer full details of the type of bearings and lubrication system offered.

Split type journal bearings with oil lubrication shall have preference. The journal bearings of large, slow revving and multi-stage horizontal pumps shall generally be white-metal lined bronze sleeves, split on the horizontal centre line, and/or “Glacier” type bearings as specified by the pump manufacturer.

Ball and/or roller bearings in pumps shall be of the sealed or re-greasable lubricated type. Ball or roller bearings shall be loaded conservatively in order that the grease may be renewed at intervals of not less than one year and they shall not be equipped with grease nipples or cups. If these are supplied, they shall be replaced with threaded plugs. For purposes of maintenance, end shielded bearings are preferred. A minimum bearing life of 40 000 hours is required.

The pump shaft shall be located in the axial direction. Where necessary a thrust bearing shall be provided to accommodate the end thrust of the impeller(s), and the mass of the rotating element. Thrust bearings for vertical pumps may be located in the drivers.

All bearings shall be equipped with pockets for RTD's for temperature monitoring.

All bearings shall be suitable for shaft rotation in both directions.

To facilitate replacement, the bearing numbers for all bearings shall be given together with other data to be provided by the Contractor.

(b) Cooling

All bearings shall be designed to run continuously in ambient temperatures as specified in Section 28 - General Mechanical.

The cooling of the bearing shall preferably be natural or by forced air circulation.

If water cooling is necessary, stainless steel oil / water coolers shall be incorporated in the bearing oil reservoirs. The system shall make use of water of the same quality as the water being pumped unless otherwise approved by the Engineer. All cooling water pipework, valves and fittings shall be of compatible material. The water side of the cooler tube assembly shall be hydraulically tested after installation has been completed, to 3 times the maximum working pressure. Test pressures shall be maintained for 30 minutes and the tests witnessed by the Engineer.

If cooling water is required for the bearings, the supply shall be provided by a cooling water pump which serves the motor cooling system and a water flow relay shall be fitted in each heat exchanger circuit (also refer to Clause 30.5.3.1).

(c) Lubrication

Bearings shall be either oil-bath or grease-lubricated.

30.5.1.12 Mechanical Seals

Large pumps (larger than 50 kW) shall be fitted with mechanical seals, unless otherwise specified.

The Contractor shall obtain a full guarantee from the seal manufacturer for the seals provided. Mechanical seals shall be balanced and written confirmation shall be submitted to the Engineer to prove that the selected seals are suitable for the water pumped. Seals shall comply with a) or b) below.

The mechanical seals shall be capable of resisting, without leakage, both the suction and discharge pressure as specified. The seals shall require neither maintenance nor adjustment and shall operate without water being pumped.

Seals requiring an independent source of cooling water are not favoured. If cooling water is required for the mechanical seal, full details shall have been submitted by the Contractor at Tender stage. If the quality of the water necessitates filtration, the Contractor shall provide the appropriate Plant. Filters shall (as a minimum), be of the “twin-barrel” (quick change-over) type and must default automatically to “bypass” in the event of blockage. The flow of water to or from the seals shall be clearly visible. For cooling water flow the control unit (flow and pressure) shall be adequately sized to allow sufficient flow rate through the seals as recommended by the seal manufacturer.

The design of the seal shall be such that the static head on the pump discharge induces a closing action on the seal to ensure that no leakage occurs during pump shut-down.

(a) Potable Water

A single self-aligning balanced mechanical seal manufactured in grade 316 stainless steel and fitted with at least matched solid tungsten carbide (or other approved) rotating and stationary faces shall be supplied.

An external flush shall be provided to ensure heat dissipation through circulation. Where raw water is being pumped, a cyclone separator shall be fitted.

(b) Raw Water and Abrasive Liquids

A double self-aligning mechanical seal manufactured in grade 316 stainless steel and fitted with at least either carbon on ceramic (for water lubrication) or carbon on solid tungsten carbide (for oil lubrication) shall be fitted on the end of the seal not in contact with the liquid being pumped. At least solid tungsten carbide on solid tungsten carbide shall be fitted on the end in contact with the pumped liquid. Should the Contractor consider it to be necessary, seals of greater technical sophistication (than tungsten carbide) shall be fitted.

If required, an independent fresh water (or oil) flush shall be provided. Care shall be taken to ensure that the pressure of the cooling fluid is at least 100 kPa greater than the pressure of the liquid on the inboard side of the seal. Built-in or integral type seals are unacceptable.

30.5.1.13 Flanges and Accessories

All pumps and ancillaries shall be supplied complete with couplings and jointing material. Each flange and fitting shall be supplied complete with one insertion piece of the appropriate diameter and made of compressed non-asbestos or other approved material for medium to large diameter flanges and medium to high (4.0 MPa and over) pressure pipelines, and one set of bolts, nuts and washers.

The drilling patterns and thicknesses of steel and CI flanges shall conform to the requirements of BS EN 1092 Part 1 and BS EN 1092 Part 2 respectively. The minimum pressure rating of flanges shall be 1000 kPa.

Sealing faces shall be machined flat to a toolmark of 0.8 mm to 1.25 mm pitch spiral or concentric serrations, and backs of flanges shall be either machined or spot-faced around holes with sufficient clearance to ensure proper seating of bolt heads and nuts.

The Contractor shall check the compatibility of the drilling pattern of all flanges that are to be connected together. The Contractor shall satisfy himself that the flanges in a subcontractor's supply will match the flanges supplied by others or at interfaces between subcontracts, if any.

All flanges designed for pressure ratings up to and including Table 16, shall be flat faced with full face tanged graphite gaskets. Flanges designed for pressure rating of Table 25 and higher shall be raised face flanges supplied with glass fibre with nitrile rubber binder to BS 7531 ring face gaskets.

For insulating flanges refer to Clause 30.4.9.

30.5.1.14 Fasteners

All high tensile bolts and studs used shall bear the letters HTS stamped or engraved on the end. Washers shall be provided under all bolt heads and nuts. The threads of bolts and studs shall be

cleaned and coated with a Molybdenum Disulphide or Nickel Anti-seize compound before assembly. The threads of all bolts and studs used with the Plant supplied shall be to the same standard. All black steel fasteners shall be Hot Dip Galvanised in accordance with SANS 121.

30.5.1.15 Couplings

The pumps and motors shall be direct coupled with an approved type of flexible coupling which will take up minor misalignment or off-setting of the motor and pump shaft satisfactorily. Flexible tyre-type couplings are acceptable for pumps coupled to motors up to 100 kW. Where motors are rated above 100 kW, all metal (curved tooth or similar) couplings shall be used in all horizontal drive units. Where applicable, provision for adequate lubrication shall be made.

The coupling shall be designed in such a manner that no axial or radial loads will be imposed on the motor and pump bearings in excess of the loads approved by the motor and pump manufacturers respectively for the installation offered. Spacer couplings shall be provided with pumps of the back pull out type, where mechanical seals are fitted or where frequent maintenance is likely to be required.

Couplings shall be mounted on shafts with cylindrical fit conforming to ANSI B4.1 and keyed in place. The couplings shall be robust, shall be readily dismantled and reassembled, and shall have a service factor of at least 1.5.

For coupling alignment, see Clause 30.9.2.

30.5.1.16 Safety Instrumentation

All pump-motor-sets rated 110 kW and over, shall be fitted with vibration detectors on the bearings and automatically shut off the motor in the event the amplitude exceeds the manufacturer's recommended limit.

The main bearings shall be fitted with the necessary safety instrumentation and trips as follows:

(a) Temperature

Resistance Temperature Detectors shall be provided for motor stator windings as specified in Section 39 - Electrical - Plant and Installation and the bearings for both motors and pumps shall be as specified in Section 41 – Control and Instrumentation Plant and Installation.

All motors shall have embedded in their stator windings, two RTD's per phase, which shall automatically shut off the motor in the event of overheating of the stator windings.

All pump-motor-sets rated 55 kW and over shall be fitted with RTD, thermal sensors in the drive-end and non-drive-end bearings to give a warning and automatically shut off the motor in the event the bearing temperature exceeds 80°C, or as recommended by the manufacturer.

(b) Vibration Sensors

Suitable vibration sensors shall be mounted on each pumpset to stop it on detection of excessive vibration. At least two detectors shall be provided on each pumpset, i.e. one on the motor and one on the pump, situated as close as possible to those bearings where the highest vibration levels are

encountered. The indicating instruments shall be suitably calibrated. They shall be of a type such that it is possible to set different tripping levels corresponding to different RMS velocities.

The monitoring of vibration shall be made via a suitable timing device in order to avoid tripping when starting the pumpset or during other transitory conditions.

30.5.2 Motors

Motors for pumps shall form part of the Contractor's design and comply with Section 39 – Electrical - Plant and Installation.

Guaranteed torque / speed characteristics for motors from zero to full speed shall be supplied.

Motor bearings shall comply with Clause 30.5.1.11. All bearings shall be equipped with RTD type temperature sensors, and leads from the RTD's shall be wired to a separate terminal box.

Motor winding temperatures shall be continuously monitored by means of RTD's embedded in the windings.

The motors shall be equipped with 240 V anti-condensation heaters to keep the motor windings free of ingress of moisture when motors are switched off. A special terminal box mounted on the motor shall be fitted with a red pilot lamp to indicate when the heaters are on. The heaters shall be wired such that they turn off when motor power is applied.

Motor winding terminal boxes shall accommodate surge arrestors. The surge arrestors shall be included in the offers for the motors.

30.5.3 Ancillary Plant

30.5.3.1 Cooling Water System (CWS) and Flushing Water to Motors and Bearings

Pump motors will be air-cooled and a cooling water system (CWS) is not preferred. Should the Contractor require a cooling water systems for the pump motors offered, the following requirements will be applicable.

(a) General

Two circulation pumps are required, one running one standby. The complete CWS shall be an open loop system. The pumps shall extract water from the main suction pipeline and pump it through the motor cooling system and bearing cooling system of both pump and motor and back into the main suction pipeline. The Contractor shall be responsible for installing a water conditioning system (if the Contractor deems it to be necessary), as the water being pumped to the motors, bearings and seals will be unfiltered raw water from the Crocodile River.

(b) Cooling Water Pumps

Two cooling water pumps, one running and one standby, are required for the water cooling circuit. These pumpsets shall be of the close coupled back pull out design in which a standard motor is flange mounted on the pump, the pump impeller and motor shaft being coupled by means of a spigoted flange coupling. One spare pump unit (not connected) complete with motor shall be provided for the cooling water circulation, water conditioning and sealing required in the pumping station.

Monoblock pumps with an extended motor shaft on which the impeller is directly mounted are not acceptable.

The pumps shall be sized to supply adequate flow and pressure for the complete cooling water, water conditioning and sealing requirements of the entire pumpsets inside the pump station.

The cooling pumps shall operate on a four pole motor speed. They shall be fitted with stainless steel shafts, bronze impellers, and mechanical seals. They shall be fitted with removable perforated coupling guards fixed over the openings giving access to the pump / motor coupling. They shall be mounted on neat concrete plinths not less than 150 mm high.

(c) Cooling Water Piping and Fittings

All cooling water piping shall be galvanised steel piping except where pipes are passing through concrete or are buried under concrete in which case they shall be stainless steel 316L. Care must be taken to avoid galvanic cells between different materials. For auxiliary pipes to seals and bearings refer to Clause 30.6.5.

All piping shall be sized to supply adequate flow and pressure for the complete cooling, water conditioning and sealing water requirements of all the pumpsets inside the pumping station.

All valves shall be full way brass or stainless steel bodied ball valves with chromium plated brass or stainless steel balls. The use of gate valves is not permitted.

Reflux valves may be or the wafer or bronze flap type with flange connections.

Unions and pipe sockets shall only be used for 15 to 40 mm piping; all larger sized piping shall be flanged. All unions used shall be “navy” unions with bronze facings.

Unions and flanges shall be so arranged that any one of the pumps together with its motor can be removed with a minimum of disturbance to the rest of the cooling water pipe-work, leaving the isolating valves in place so that the second pump set can continue operating.

All bends shall be medium or long sweep bends; elbows will not be permitted. All bends shall be T-pieces to allow rodding in case of blockages.

All tees in the main circulating pipes and those branching off the main supply and return cooling water pipes to the pumps and motors shall be fabricated sweep tees using medium sweep weld bends for the fabrication thereof.

(d) Cooling Water Conditioning System

Should it be required, the Contractor shall design, supply and install a dedicated water conditioning system that will ensure suitable quality for the CWS. The source of the water conditioning system will be the raw water abstracted from the Crocodile River (stored in the Balancing Reservoir). The water conditioning system shall be 100% available and provide for suitable redundant units.

30.5.3.2 Motor Cooling Water Flow Control Valves

Each motor cooler shall be equipped with a combined flow control / flow indicator / flow switch device installed in the main discharge pipes of the cooling water pumps. The flow switch shall be set to prevent start up and to trip the complete pump set when there is no cooling water flow or the flow drops below the minimum required flow rate. A bridging timer is required to allow for the pumps to start-up.

30.5.3.3 Seal Water Flow Control Valves

Each seal shall be fitted with a combined, flow regulator / pressure regulator / flow indicator and flow switch. They shall be fitted on the inlet pipe to each seal. The flow switch shall trip the pump in the event of a low flow or no-flow condition. Hydraulic fittings and all rubber hoses shall be factory crimped. No pipe clamps will be allowed.

30.5.3.4 Protection Plant Items

(a) Pressure Gauges

Pressure gauges shall be installed where indicated on the P&ID's.

Pressure gauges shall be as specified in Clause 30.6.7.

30.5.4 Valves and Actuators

All valves and actuators shall comply fully with the requirements of the Section 35 - Valves.

30.5.4.1 Suction Isolating Valves

Each pump line in the Low- and High Lift Pumping Stations shall be equipped with a DN1200 and DN1000 suction isolating butterfly valve respectively installed on the suction side of the pumps as indicated on the Drawings.

The pressure rating of the valves shall be 1000 kPa in the Low-Lift Pumping Station and 1600 kPa in the High-Lift Pumping Station. The valves shall be of the replaceable resilient seal arrangement with double offset.

The butterfly valve shall be equipped with a suitable electrically driven actuator. The actuator shall feature a local / remote switch and pushbuttons for stop, open and close. No wireless remote control of the actuator is required.

30.5.4.2 Delivery Isolating Valves

The delivery isolating valves shall be DN1000 and DN800 butterfly valves in the Low- and High-Lift Pumping Stations respectively. The pressure rating of the valves shall be 1600 kPa on the discharge of the low-lift pumps and 4000 kPa on the discharge of the high-lift pumps. The valves shall be of the replaceable resilient seal arrangement with double offset.

The butterfly valves shall be equipped with a suitable electrically driven actuator. The actuator shall feature a local / remote switch and pushbuttons for stop, open and close. No wireless remote control of the actuator is required.

30.5.4.3 Non-return Valves

Non-return valves on DN1000 and DN800 pumplines inside the pumping stations as indicated on Drawings shall comply with the requirements of Clause 35.7 of Section 35 – Valves.

The pressure rating of the valves shall be 1600 kPa on the discharge of the low-lift pumps and 4000 kPa on the discharge of the high-lift pumps.

30.5.4.4 Small Bore Valves

All small bore valves shall be stainless steel, two piece body, ¼ turn ball valves and of minimum nominal bore 19 mm. All manually operated valves installed on the cooling water system shall be suitably rated for the pressure under which they operate.

Provision shall be made for drain valves on all suction and delivery pipe specials of both the low-lift and high-lift pumps.

Air release valve are required as indicated on Drawings with isolating valve. The LLPS suction pipework air valve's isolating valve shall be equipped with a suitable electrically driven actuator.

30.6 SUNDRIES

30.6.1 Safety Guards

Removable or hinged galvanised wire, expanded steel mesh or sheet metal cages shall protect all shafting and couplings. Guards shall be sufficiently heavy and rigid in design to avoid accidental body contact with the coupling or shaft. Guards shall be provided in accordance with the Machinery and Occupational Safety Act and to the approval of the Engineer.

30.6.2 Air and Drain Cocks

Adequately sized air valves to enable the entrapped air to be released freely shall be provided on the pumps and at any high points on the delivery mains within the limits of pump supply.

Drain cocks shall be provided on the pumps, and also on drains from the pump seals.

All water and drain cocks shall discharge visibly into funnel shaped receivers and small bore tubing (permatube or galvanised) discharging to waste.

30.6.3 Baseplates

Pumps and motors shall be mounted on baseplates of rigid design, manufactured in either cast iron or fabricated steel, equipped with anchor bolt holes, anchor bolts and drain connections. Grout holes in concrete bases shall be unobstructed.

CI base plates shall be fully machined to receive the pump or motor. Fabricated steel baseplates shall be substantially ribbed and stress relieved before any machining is undertaken. Baseplates shall be machined at the points of contact with the pump and motor supports so that the set may be mounted on the baseplate in correct alignment without the use of shims. In addition, at least four levelling pads (all machined to the same height relative to the other machined surfaces) shall be provided so that the baseplate can be accurately levelled up on Site. Refer to Section 28 – Mechanical General, regarding shims and alignment. Machining is not required for units of 15 kW and under. Permanent dowelling pins shall be fitted after each item of Plant has been in normal operation for at least 72 hours and after the final alignment has been approved by the Engineer in writing.

Baseplates and pump supports shall be so constructed and the pump so mounted as to minimise misalignment caused by deflections arising from normal piping strains, internal differential thermal expansion, hydraulic piping thrust and similar causes.

At least two holes of 50 mm diameter shall be cut into baseplates for grouting purposes without having to remove the pump or motor. Levelling bolts with set screws and nuts shall be fitted to the base plates of all units 100 kW and above. Corrosion protection of baseplates shall comply with the requirements of Section 37 – Painting and Corrosion Protection.

30.6.4 Anchor Bolts

Anchor bolts shall not be less than M20 and shall be of high tensile steel bolts / studs. Anchor bolts of an approved design shall be used as anchors.

Unless otherwise specified, one of the following methods to fix the anchor bolts shall be used:

a) The Contractor shall drill holes of an appropriate diameter and depth into the concrete plinth, and grout the anchor bolts in, using an approved pre-packed two-part epoxy mortar; or

b) Pockets at least 100 mm square and at least 12 bolt diameters in depth shall be left in the concrete plinths.

The pump supplier shall be responsible for providing the Contractor with an accurately constructed rigid template to fit on top of the plinth formwork and into which the anchor bolts will be bolted. The details of the template shall be such that it does not obstruct the concreting of the plinth.

30.6.5 Auxiliary Pipe Systems

Recirculation piping systems for gland oil, lubrication oil, bearings, seals and accessories such as gauges and valves, shall be furnished by the Contractor such as to facilitate easy maintenance. Material used for all auxiliary piping and valves shall be stainless steel 316 and shall be suitable for the designed duty of the pumps. All items shall be properly cleaned before assembly. Auxiliary piping shall be installed in a manner which prevents damage to the instruments and gauges due to the vibration of the pump.

30.6.6 Auxiliary Piping to Mechanical Seals

18 Cr-8 Ni stainless steel piping or tubing shall be used for the flushing fluids to mechanical seals. Minimum tubing wall thickness for sizes up to 20 mm OD sizes shall be 1.65 mm.

Tubing connections shall be “Crawford Swagelok” or similar approved. Tubing fittings and ferrules shall be 18 Cr-8 Ni Stainless Steel. Copper tubing and brass fittings are unacceptable.

Auxiliary piping connections shall be plugged with solid plugs. Carbon steel plugs shall be used with cast iron casings; otherwise the plugs shall be of the same metals as the casing material. Plugs shall have a shank to facilitate the use of a pipe wrench.

30.6.7 Pressure Gauges

Pressure gauges shall in general conform to SANS 1062:2010. The pressure gauges shall have 100 mm diameter dials with stainless steel casing, glycerine filled complete with separate stainless steel isolating ball cocks. The gauges shall be capable of displaying the maximum and static pressure but their maximum pressure reading range shall not be higher than 150% of the operating pressure.

Pressure gauges together with stainless steel ball cocks shall be fitted on the suction and delivery sides of all pumps.

The pressure gauges shall be calibrated to a common datum corresponding to the pump centre line level. The datum level and the difference in level between the datum level and the mounting height of the pressure gauges shall be indelibly marked on the dials of the respective pressure gauges.

One suction pressure transducer, and one delivery pressure transducer, per pumpset shall be supplied and installed together with the gauge, suitable for an input range corresponding to that of the respective pressure gauges. The transducers shall have an output of 4 - 20 mA over the scale range specified for the associated gauge. A suitable DC power supply for each pumpset shall be supplied to power the transducer.

After erection, and before completion, each pressure gauge, each pressure transducer and each pressure switch shall be set at the correct set point on Site. Each pressure switch shall be set by the Contractor to operate at the minimum suction pressure of the pump, and the setting shall be marked by means of an approved engraved label to be mounted at the pressure switch. Calibration certificates shall be submitted to the Engineer for each gauge, transducer and pressure switch after the Site set point has been set.

Pump pressure gauges shall be connected as follows:

a) Pressure tapping sockets / nipples arranged to connect to the suction and delivery branches at a horizontal position on the pipe circumference;

b) Suitable bosses, tapped and faced, shall be provided on the suction and delivery piping of each pumpset to accommodate the pressure gauge and transducer. Pressure gauges shall be fitted in such a manner that vibrations from the pump and/or pipework cannot be transmitted to the pressure gauges;

c) Suitable approved brackets shall be supplied and installed to support the pressure gauges, transducers and switches. Each gauge and transducer shall be provided with an isolating cock and an additional high quality test cock shall be provided at each pressure measuring point, for the connection of test instruments. It shall be possible to check and isolate the pressure instruments without disturbing piping or connections;

d) The Contractor shall supply and connect all piping and fittings to the instruments; and

e) The DC power supplies shall be supplied as loose items and shall be installed and wired by the Contractor.

30.6.8 Nameplates

A corrosion-resistant nameplate shall be permanently attached to the pump and contain the following information:

a) Manufacturer's name;

b) Year of manufacture;

c) Serial number of pump;

d) Size and type of pump;

e) Rated capacity in cubic metres per hour (m^3/h), litres per second (ℓ/s) or cubic metres per second (m^3/s);

f) Pump head at rated duty in metres (m);

g) Pump speed (rpm);

h) Maximum allowable casing working pressure in kilopascals (kPa);

i) Mass of complete rotating element in kg; and

j) Mass of completely assembled pumps in kg.

30.6.9 Flow switches

Flow switches are required at each pump's suction side of the Low-Lift and High-Lift Pumping Stations.

Standard paddle type flow switches sense liquid flow in either direction to monitor flow / no-flow conditions. The paddle is trimmed during installation to permit switch actuation at the minimum flow rate. As flow increases in a pipe, the paddle of the switch pivots to move out of the liquid path, producing less than 20 kPa of pressure drop regardless of pipe size.

Standard material is stainless steel with 1" BSP male end. The instrument shall be PN40 rated with an IP 65 enclosure and electrical requirement of 250 V. Preferable installed in a vertical, top of pipe position.

30.6.10 Number Plates

Each pumpset shall be provided with an approved number designation plate (baked enamel coated steel plate or similar) indicating the applicable Tag number as indicated on P&ID Drawings, etc. The letters shall be at least 100 mm in height and the plate shall be mounted close to the pumpset in a position which is readily visible from inside the control room.

30.6.11 Cabling

Cabling shall be as specified in Section 39 – Electrical - Plant and Installation and as shown on the Drawings.

30.7 PAINTING AND CORROSION PROTECTION

Corrosion protection shall be as specified in Section 37 – Painting and Corrosion Protection.

30.8 INSTALLATION EQUIPMENT

30.8.1 General

The Contractor shall provide all equipment that is necessary to install, test and commission all items covered in this Section.

30.8.2 Handling and Rigging

This Section should also be read in conjunction with Clause 28.11 under Section 28 – Mechanical General.

The Contractor shall provide temporary end covers that adequately, in the opinion of the Engineer, protect flanges and threads, and prevent damage to internal lining during transportation and during handling on Site.

The Plant and rigging equipment used by the Contractor for the handling and placing of pumps, motors, valves and pipes shall be such that no installed Plant is over-stressed during any operation. The pumps shall be so transported, stored, and handled that they are not overstressed at any time and are not damaged in any way. Special attention shall be given to the prevention of bearing and seal damages during transport. Pumps damaged or cracked in any way shall be removed from the Site, and repaired to a standard approved by the Engineer.

All heavy components designed to be dismantled and handled shall be provided with the following:

a) Rings, lugs, collars for lifting;

b) Slings, chains and special tools for handling; and

c) Special lifting screws, fitted at selected points and in sufficient numbers, for components designed to be uncoupled.

The facilities described above are part of the Contractor's supply. All custom made lifting equipment and cradles for the lifting of components and/or pumpsets necessary for installation or maintenance shall be provided by the Contractor and handed over to the Engineer on completion of the Contract.

30.8.3 Setting Out

The Contractor shall use any conventionally acceptable device to control the installation and alignment of the pumpsets, etc.

30.9 INSTALLATION AND OPERATING REQUIREMENTS

30.9.1 Placing on Concrete Plinths

The Contractor shall install the pumps, motors, valves and pipework on the completed concrete plinths, with holding down bolt pockets, constructed for the pumps, motors, valves and pipework.

Before positioning the pumps on their foundations the Contractor shall roughen the concrete surface, and ensure that all surfaces are free of all foreign materials, grease, oil, etc. The pumps shall be aligned as specified in Clause 30.9.2 before grouting commences.

The pumps shall be placed such that grouting clearances are maintained between the machine base, plinths and formwork.

30.9.2 Alignment

The Contractor shall align and level accurately the pump unit, using metal blocks and shims under the baseplate at the anchor studs and, in the case of heavy Plant, midway between studs. The anchor nuts shall then be drawn tight against the plinth. The pump and motor shall then be checked for alignment.

If alignment needs improvement, metal shims or wedges shall be added at the appropriate places under the baseplate. The Contractor shall align the units using laser beam alignment, and shall ensure that no measured deviation exceeds the smallest values recommended by the manufacturers of the motors, pumps and flexible couplings respectively. The readings shall be recorded and made available to the Engineer upon request.

The Contractor shall be responsible for filling the voids inside and between the baseplate and plinth with an approved non-shrink grout.

The Contractor shall satisfy himself that the baseplate is fully supported over its whole length and that no voids have been left on the underside of any parts of the baseplate.

After the pumps have been in operation about one week, the foundation bolts shall be finally tested for tightness, the alignment checked (using clock gauges) and dowel pins fitted in the pump and motor feet in the approved manner.

When the grout has thoroughly dried (about 14 days after grouting), the exposed edges shall be painted by the Contractor using an approved oil paint of the same colour as the pump baseplate.

30.9.3 Defects

Each pumpset and each piece of ancillary Plant shall be thoroughly cleaned and carefully examined for damage and defects immediately before installation. Should any damaged or defective pumpset or ancillary piece of Plant be installed, it shall be removed and replaced at the Contractor's expense and to the satisfaction of the Engineer.

30.9.4 Keeping Pump Sets Clean

Every reasonable precaution shall be taken during installation to prevent the entry of foreign matter and water into the pump(s).

30.9.5 Mounting

In addition to supplying and installing the pumpsets, the Contractor shall supply and install all appurtenant pipework and valves and he shall connect the pumpsets to the pipework. Pipework exerting unnecessary strain on pumps due to force fit will not be allowed.

30.9.6 Electrical Inspection

The Contractor shall check all items of electrical Plant for direction of rotation, correct phasing, motor and terminal voltage, and insulation resistance. The motor heaters shall be switched on for at least 5 hours immediately prior to running for the first time.

Before energising any of the motors for the purpose of commissioning, the Contractor shall measure the insulation resistance of each motor between phases and to the casing.

30.9.7 Glands / Mechanical Seals

Gland bolts shall be left completely loose and the final gland packing and tightening of gland bolts shall only be undertaken after the motors have been tested for direction of rotation and once the Plant is ready for commissioning.

Where mechanical seals are fitted and the pump design allows it, the motor couplings shall be disconnected during the initial dry run tests of the motors to ensure that the seals are not damaged.

30.9.8 Finishing and Painting

Finishing and painting and cleaning up the Site are regarded as inherent parts of the installation. On completion of erection, all pipework, control gear and indicating gear within the pump house shall be thoroughly cleaned.

Mechanical damages to paintwork caused by handling and during installation shall be repaired in accordance with Section 37 – Painting and Corrosion Protection. Final cosmetic application of polyurethane coatings shall be in accordance with the colour code as prescribed in Section 37.

The whole of the work shall be left in a clean and properly finished condition. All paints, and materials used in their preparation, shall be of the best quality of their respective kinds. All paint work shall be executed by tradesmen skilled in this class of work, and strictly in accordance with the paint manufacturer's product data sheets.

30.10 TOLERANCES

30.10.1 General

The standards laid down in this Section shall be adhered to in all cases unless the standards used by the Contractor are more stringent. In all cases where the Contractor deviates from the subjoined standards, the Engineer shall be informed in writing and only after acceptance by the Engineer can the alternative standards be used.

30.10.2 Shafts

The surface of the shaft (or sleeve) through the stuffing box shall not exceed a roughness of 32 rms (root mean square) and the pump shaft (or sleeve) shall be straight and any runout, as measured by a dial indicator, shall not exceed 0.0254 mm total indicator reading.

Dynamic shaft deflection measured under the worst conditions of load shall not exceed 0.050 mm maximum at the face of the stuffing box.

The balancing of all rotating Plant shall comply with the requirements of ISO 1940/1:2003 (Balance Quality Requirements of Rigid Bodies) using balance grade G1 or Balance Tolerance grade API. Complete test certificates shall be submitted for evaluation before assembly of the units.

The alignment of shafts shall comply with the requirements of BS 3170:1972. The shafts should be aligned in such a manner that both parallel and angular misalignment is eliminated. The acceptable alignment tolerance for parallel misalignment is 0.07 mm and for angular misalignment 0.07 mm / 100 mm.

30.10.3 Performance

Permissible variations from the required performance are as for Class B test in BS EN ISO 5198: 1999.

30.10.4 Vibration

30.10.4.1 Pumps

Vibration shall be measured at ± 10% of best efficiency flow in the radial and axial direction for vibration levels as specified in Table 30/1.

TABLE 30/1
ACCEPTANCE CRITERIA FOR HORIZONTAL PUMPS

FREQUENCY RANGE		AMPLITUDE Radial Direction (mm/sec, peak)	AMPLITUDE Axial Direction (mm/sec, peak)
Frequency	Related to RPM		
Overall vibration	Overall	3.5	1.8
Sub-harmonic	< 1 x RPM	0.6	0.6
Harmonic	1 x RPM	2.5	1.6

FREQUENCY RANGE		AMPLITUDE Radial Direction (mm/sec, peak)	AMPLITUDE Axial Direction (mm/sec, peak)
Frequency	Related to RPM		
Lower frequencies	2 x RPM	1.5	0.9
Impeller-induced	(No of vanes) x RPM	1.5	0.7
Higher frequencies	(10 to 50) x RPM	0.95	0.95

30.10.4.2 Electrical Motors

Test data taken on electrical motors running solo:

a) Motor to have a ½ key installed;

b) Motor to be placed on rubber mat at least 6 mm thick or free-hanging;

c) Where possible motor to be tested at full service speed;

d) Measurement must be taken in the horizontal, vertical and axial direction on each bearing (HVA);

e) Maximum amplitude of any peak in each frequency range to be recorded;

f) Maximum line amplitude is the amplitude value of the highest discrete frequency component within the stated frequency range in any direction (HVA); and

g) Factory test certificates from the motor manufacturer must be included with delivery.

TABLE 30/2
ACCEPTANCE CRITERIA FOR MOTORS > 370 KW

FREQUENCY RANGE		AMPLITUDE In Any Direction (mm/sec, peak)
Frequency	Related to RPM	
Overall vibration	Overall	2.5
Sub-harmonic	< 1 x RPM	0.6
Harmonic	1 x RPM	2.4
Lower multiples	(2 to 9) x RPM	0.9
Higher frequencies	(10 to 50) x RPM	0.3
Overall Acceleration	0 to 20 kHz	0.5 g at peak

30.11 FACTORY ACCEPTANCE TEST (FAT) AND PRE-COMMISSIONING

30.11.1 General Requirements

Inspection and Factory Acceptance Test (FAT) of pumps at the Factory shall comply with the general requirements as stipulated in Section 28 – Mechanical General.

a) Where witnessed FAT or Site tests are required, the Contractor shall conduct trial test runs, and satisfy himself that the test results are in accordance with the requirements specified, before notifying the Engineer. The Contractor shall be liable for the cost incurred by the Employer in the event of an abortive test requiring a retest.

b) Any pump that requires segmental hydro test shall have the method of hydro testing fully described in the proposal.

c) If hydrostatic tests are performed with the shaft in position, the mechanical seals shall be removed and tests conducted with other types of seals or sealing methods.

d) In carrying out the tests, the quantity of water pumped shall be measured volumetrically if facilities are available, but, if not, by a meter made in strict accordance with Class B, BS EN ISO 5198. The readings of discharge given by the meter shall be taken to be correct and accepted as such by the Contractor. Apparatus shall be provided to calibrate the testing equipment before and after the tests and to measure accurately the electrical power consumed.

e) The fact that the Employer will be running the pumping units between the Preliminary Acceptance Tests and Final Acceptance Test will in no way relieve the Contractor of his responsibility for the proper performance of the Plant, unless any improper performance is due to negligence on the part of the Employer.

f) Except as provided for in i) and ii) below, all labour, materials, fuel, stores, apparatus and instruments for the tests shall be supplied at no extra cost by the Contractor.

   i) The cost of such tests and/or analyses required by the Engineer to be effected by independent authorities will be refunded to the Contractor by the Employer if the results of such tests and/or analyses prove satisfactory.

   ii) The Employer will provide free of charge, as and when available, the electrical load or supply and the necessary water required to run the Plant for the Contractor's preliminary runs and for the final acceptance tests.

g) Three copies of the Contractor's records of all tests shall be furnished to the Engineer, as specified in Clause 30.11.4 d). The vibration testing shall be undertaken by an approved agency when requested by the Engineer. Payment will be as specified in f) i) above.

h) The Contractor shall carry out the tests specified below and such additional tests in the Manufacturer's works, on the Site or elsewhere as in the opinion of the Engineer are necessary to determine that the Plant complies with this Section. Where mechanical seals are specified or form an integral part of the pumps installed under this Contract, all performance tests shall be conducted with the seals installed.

i) If the Engineer so requires, all instruments forming part of or used in the Plant shall be calibrated at the expense of the Contractor by an approved independent authority.

j) The Contractor shall carry out the tests on Site so as not to interfere with the operation of the Works or the execution of other contracts.

k) In the event of the pump plus pipework's failure to meet the specified values, the Contractor shall be responsible for the cost of the tests, rectification and subsequent re-testing until the Specification is met.

l) The Plant provided by the Contractor for hydrostatic pressure testing at both the manufacturer’s works and Site Works shall include the pump, pressure gauges, meters and all necessary tools and fittings required for the performance of the tests.

30.11.2 Factory Acceptance Tests (FAT)

30.11.2.1 Hydrostatic Pressure Tests

All pump casings shall be hydrostatically tested at the factory to at least 1.5 times the maximum possible working pressure of the pumps before any corrosion protection is applied without exhibiting signs of sweating, undue deformation and stressing, or defect of any kind. Hydro test shall be for a

minimum period of 30 minutes. Through bolting, for the purpose of blanking the casing at the gland housing for pressure test purposes, will not be permitted.

Pumps manufactured in cast steel shall have their casting and test bars inspected and tested at the factory (the Contractor's Works) in accordance with BS EN 10293: 2015 when the power absorbed by the pumps exceeds 250 kW and/or where the working pressure exceeds 1.6 MPa.

30.11.2.2 Performance tests

The Plant provided by the Contractor to verify the guaranteed pump performance as specified in Clause 30.11.4, shall consist of the complete pump test rig including instrumentation to test the pumps in accordance with BS EN ISO 5198: 1999 Part 2 Class B. Should the Contractor lack the necessary work facilities, the pumps shall be tested on the SABS pump test rig in Pretoria at no additional cost to the Employer.

Performance tests shall be conducted on all Duty Points specified. Performance tests shall include NPSH tests at the Duty Point with the highest flow rate.

All test bed testing shall be carried out under the supervision of competent and experienced staff, fully conversant with the test bed. Test measurements shall generally be carried out in accordance with BS EN ISO 5198: 1999 Part 1 Class B.

A test manual, fully describing the test procedure as well as details of the calibration procedures and calibration interval of all instruments, shall be available at all times while the pumps are under test. The test manual shall include simplified explanations of all key points necessary on measurements, datum corrections, calculations and all points to be considered in assessing mechanical integrity. The manual shall be sufficiently comprehensive to make it the only document required by test personnel.

Performance and vibration testing shall be carried out by the pump / motor manufacturer at an approved test facility and witnessed by the Engineer or his representative. Certified test results, whether from the manufacturer's works or elsewhere, shall be provided to the Engineer before delivery.

30.11.3 Inspection and Pre-commissioning Tests – Site

30.11.3.1 Hydrostatic Pressure Tests

Pumps and pipework shall be hydrostatically pressure tested in situ by the Contractor to 1.5 times the working pressure for the pumps at their "duty point(s)", or 1.3 times the pump shut-off pressure, whichever is the greater, by means of test equipment supplied by the Contractor.

Each test shall be carried out and certified by the manufacturer in the presence of the Engineer or his representative. The Contractor shall be responsible for all expenses incurred in carrying out all tests.

When carrying out the hydraulic test the Contractor shall ensure that all valves, tees and bends are properly secured and shored to prevent movement of pipes and fittings. Should any movement occur, the Contractor shall, at his own expense, reposition and, if necessary, repair the pipes and fittings and the securing means.

The specified test pressure for medium pressure pipework, valves, etc., (refer Section 32 – Pipes and Pipe Specials) shall be applied by means of a test pump. During the test, all pipes, specials,

joints and fittings shall be carefully inspected for leaks. All visible leaks shall be made good and any pipe, special or fitting found to be defective shall be removed and replaced at the expense of the Contractor. Such replacement material shall, after installation, be tested at the expense of the Contractor.

Until the pumps, pipework, valves, specials and joints have shown zero leakage when subjected to the pressure test, the Plant will not be accepted. The test shall be repeated until the Engineer is satisfied that there is no leakage.

The above tests shall be complete and the test results submitted to the Engineer in writing before any running tests are undertaken on Site.

30.11.3.2 Performance Tests

The equipment provided by the Contractor on Site to test the performance of the Plant shall include all the instrumentation not included in the permanent installation, (e.g. Watt meter, suitable pressure gauges, water meter of sufficient accuracy to ensure testing to BS EN ISO 5198: 1999 Part 1 Class C, and all tools and suitably trained staff. These tests shall include the Pre-Commissioning Tests and Plant Performance Tests as required in Section 48.

Two separate series of tests called the Preliminary Acceptance Test and Final Acceptance Test shall be carried out by the Contractor on all pumping units after installation. Test measurements shall generally be carried out in accordance with EN ISO 5198: 1999 Part 1 Class C and Section 48 - Tests on Completion.

A NPSH Test shall be conducted when the NPSH available does not exceed the NPSH required by the pump by at least 2.0 m.

30.11.4 Guarantees of Performance

a) The Contractor shall guarantee the output and efficiency of all machines, which guarantees shall be binding under the Contract.

b) The fulfilment of these guarantees shall be demonstrated at the Contractor's factory premises or a suitable off-site test facility approved by the Engineer in accordance with BS EN ISO 5198: 1999 Part 2 Class B and shall be verified on Site in accordance with BS EN ISO 5198: 1999 Part 1 Class C.

c) All measuring instruments used in the tests shall have previously been certified by an independent testing authority, not more than one month prior to the test and to the Engineer's satisfaction.

d) Where guaranteed performance is specified, certified test curves shall be drawn from the test data obtained from the purchased pumps and shall include; head (m), quantity pumped (m^3/h or ℓ/s), efficiency (%), NPSH (m), power consumption (kW), rotational speed (rpm) and speed / torque (rpm/kNm). The probable performance with maximum and minimum impellers shall also be indicated, as well as tested (or probable) NPSH available.

e) Each pump shall be checked for acceptable vibration limits and noise limits if required during testing (see Clauses 30.4.4 and 30.4.5 respectively).

30.11.5 Liquidated Damages for Failure to Achieve Guarantees

a) The Contractor shall ensure that the pumps deliver the “Required minimum discharge” at each duty point, by fitting new impellers or taking whatever action is necessary should there be any shortfall in the quantity of water measured when the pumps are delivering at the total head associated with the “duty point” in fulfilment of the Guaranteed Performance criteria.

b) Payment by the Contractor in lieu of rectifying any under-performance of the pumpsets relative to the Guaranteed Performance as per Clause 30.11.4 will not be acceptable.

c) Should the Contractor be unable to rectify the under-performance liquidated damages will be payable and calculated based on the additional kW required to achieve the required pumping rate as follows: Additional kW required to achieve Duty Point N1 x kWh tariff x 24 x 365 x 10.

30.12 STANDARDS

The following Standards and Codes of Practice are referred to in this Section:

American National Standards Institute

ANSI B4.1 : Preferred limits and fits for cylindrical parts

American Petroleum Institute

API 5L : Specification for line pipe

API 1104 : Standard for welding pipelines and related facilities

American Society for Testing of Materials

ASTM A 312 : Standard Specification for Seamless and Welded Austenitic Stainless Steel Pipes

American Society of Mechanical Engineers

ASME Section VIII : Boiler and Pressure Vessel Code, Division 1 for Unfired Pressure Vessels

British Standards Institution

BS EN ISO 80000-1:2013 : Quantities and units. General

BS 4360: 1990 : Specification for weldable structural steels

BS 2633: 1987 : Welding of specials rated to 2,5 MPa and higher (Class I)

BS 2971: 1991 : Welding of specials rated to less than 2,5 MPA (Class II)

BS 3601: 1987 : Steel tubing rated higher than 1,72 MPa

BS 916: 1953 : Black bolts, screws and nuts

BS 970: 1996 : Wrought steels in the form of blooms, billets, bars and forgings

BS EN 1561: 2011 : Specification for grey iron castings

BS EN 1563: 2011 : Specification for spheroidal graphite or nodular graphite cast iron

BS EN 10293: 2015 : Specification for steel castings for general engineering purposes

BS EN 13835: 2012 : Austenitic cast iron

BS 4080: 1966	:	Methods for non-destructive testing of steel castings
BS EN 1092-1:2018	:	Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges
BS EN ISO 5198: 1999	:	Specification for acceptance tests for centrifugal, mixed flow and axial pumps

South African Bureau of Standards

SANS 1109-1:2005	:	ISO pipe threads for pipes and fittings where pressure-tight joints are made on the threads
SANS 1091:2012	:	National Colour Standard
SANS 1123:2000	:	Pipe Flanges
SANS 1700	:	ISO metric precision hexagon-head bolts, screws and nuts (coarse thread medium fit series)
SANS 121	:	Hot-dip galvanised coatings on fabricated iron and steel articles

International Standards Organisation

ISO 9001	:	Quality assurance
ISO 9002	:	Quality systems. Model for quality assurance in production, installation and service

30.13 SPARE PARTS REQUIREMENTS

The Contractor shall list and price the spare parts considered to be necessary as required for the continued operation of all mechanical, electrical and electronic Plant based not only on a reliability analysis of the Plant, but also on the reliability and availability of local suppliers of spare parts. The lists shall also include all long lead maintenance items and special maintenance tools that will be required during the maintenance of the Plant by the Contractor. The lists of additional critical spare parts must be submitted to the Engineer prior to achieving RFTO.

The total amount for spares derived from for each part of the Works shall be carried forward to the Bill of Quantities. A provisional sum will be allocated in the Bill of Quantity for the complete list of spare parts as listed by the Contractor.

30.14 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.

Unless scheduled separately, the tendered rates or sum shall cover the cost of Drawings and instructions as required in terms of Section 28 – Mechanical General.

The tendered rates or sums shall cover the cost of anything not specially mentioned, but which an experienced contractor can reasonably foresee as being required to enable the apparatus and Plant to be installed and/or function safely and correctly as specified. No claims whatsoever for extras will be allowed on the grounds that a necessary piece of Plant or part thereof is not specifically mentioned in the Bill of Quantities.

Tender rates or sums shall include for secure packaging to ensure that the pump-sets are not damaged prior to installation and cover costs of delivery, storage, etc.
Items are provided for the Contractor to price for:

- Supply of all design and pre-manufacture documentation and wiring diagrams for approval;
- Procurement / manufacture of pumpsets, delivery to Site and off-loading;
- Supply and delivery of pipe specials and ancillary Plant to Site and offloading;
- Supervision of installation of pumpsets, pipe specials and ancillary Plant and testing;
- Installation, testing and pre-commissioning of pumpsets and ancillary Plant; and
- Tools and spares.

Measurement and Payment for the preparation and submission of O&M Manuals shall be covered under Clause 48.9 of Section 48 – Tests on Completion and paid elsewhere.

30.001 Design and documentation **Unit: lump sum (Sum)**

Items are provided in the Bill of Quantities for the design of the pumpsets to Specification.

The rates tendered shall include for full compensation of all costs incurred in the design of the complete installation including full design calculations, detail working Drawings for all items, specifications, schematic diagrams, electrical Drawings and wiring diagrams, layout Drawings, material schedules, operation and maintenance manuals, programmes of work (manufacture and on-site) and any other work required to complete the design as specified. Payment will only be effected after the design and associated documentation has been approved by the Engineer.

30.002 Manufacture, Supply and deliver to Site **Unit: number (No.)**

The rates tendered shall include for full compensation of all costs incurred in the procurement, manufacture, inspections, quality assurance and quality control, corrosion protection, packaging, supply and delivery into storage on Site of the pumps, jointing material and fasteners, and associated operating or control Plant items.

The tendered rate or sum shall cover the cost of the requirements of the Occupational Health and Safety Act No. 85 of 1993 during testing, provision of Certificates which certify compliance with all goods with SABS, ISO, BS and other Standards specified in this Section and corrosion protection.

Payment for delivery shall include off loading. Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

30.003 Installation of Plant **Unit: number (No.)**
or sum (Sum)

The rates tendered shall include for full compensation of all costs incurred for installation, inspections, on-site quality assurance and quality control, testing and pre-commissioning of the pumping system, as well as the supply and installation of all wiring, cabling (other than the cabling measured under Section 39 – Electrical - Plant and Installation), and incidental parts required for the connecting up to the power supply and to ensure the proper functioning of the Plant.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

The tendered rate or sum shall cover the cost of all necessary Site oriented activities such as handling, transport to Site, supply of consumables (electricity, fuel, oil and lubricants etc.), accommodation of personnel and their gear.

30.004 Pre-Commissioning of Plant **Unit: number (No.) or sum (Sum)**

The rates tendered shall include for full compensation of all costs incurred for pre-commissioning of the pumping system. The rates tendered shall allow for the Contractor's cost associated with all aspects related to the pre-commissioning inclusive of the necessary Factory Acceptance Tests (FATs).

Provision shall be made in the rates for subsistence and travel for three persons from the Employer / Engineer to witness FATs.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

30.005 Design, procurement / manufacture, delivery to Site of complete Cooling Water System (CWS) for pumps and motors **Unit: lump sum (Sum)**

The rates tendered shall include full compensation for the design of the complete installation and all costs incurred in the manufacture and procurement of the Cooling Water System (CWS) for the pumps and motors and shall cover the cost of the supply and delivery to Site, inspections, quality assurance and quality control, as well as installation instructions and where applicable, wiring diagrams of the CWS.

30.006 Installation, commissioning and testing of complete Cooling Water System (CWS) for pumps and motors **Unit: lump sum (Sum)**

The rate shall also include for full compensation of all costs incurred for installation, pressure testing of the complete CWS, inspections, on-site quality assurance and quality control, 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.

30.007 Tools and spares **Unit: Provisional Sum (PS)**

The cost of special tools and keys shall be covered by the price for the supply of the relevant Plant.

The cost of spares, considered to be necessary by the Contractor other than spares required by the Employer, delivered to Site and handed over will be paid as a lump sum.

A Spare Part Schedule by the Employer is available in Section 48 – Tests on Completion, Table 48/3. The spares identified by the Contractor are to adhere to Clause 30.13 Spare Parts Requirements.

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

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