

**JOHANNESBURG WATER (SOC) Ltd.  
BULK WASTEWATER**

**PARTICULAR SPECIFICATION  
M09: MECHANICAL ARCHIMEDEAN  
SCREW PUMPS EQUIPMENT**



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**PARTICULAR SPECIFICATION: M09: MECHANICAL ARCHIMEDEAN SCREW PUMPS EQUIPMENT**

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## M09.1 SCOPE

This specification covers the detailed design parameters, manufacture, supply, deliver, off-loading on-site, installation, testing and commissioning of mechanical Archimedean screw pumps and related equipment installed within a concrete trough structure at a wastewater treatment works. The Specification shall be read in conjunction with that of the Project Specification and other referenced particular specification.

## M09.2 INTERPRETATIONS

This specification shall be interpreted as follows:

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

### M09.2.1 Definitions

For the purpose of this Specification the following definitions apply:

- (a) **"Manufacture"** includes, as applicable, the purchase of materials or goods, fabrication and assembly, any specified corrosion protection measures and any off-site inspection or testing of materials or parts.
- (b) **"Supply"** includes, as applicable, the purchase of materials or goods, manufacture and fabrication, any specified corrosion protection measures and all required off-site inspection or testing.
- (c) **"Installation"** includes, as applicable, all handling and transport from storage, erection and aligning of Works.
- (d) **"Factory Acceptance Test (FAT)"** shall refer to all tests done on Plant or Plant items at the factory to ensure its functionality.
- (e) **"Screw Pump Unit"** shall refer to the pump, motor, power transmission elements, support structures (e.g. baseplates, frame, etc), shaft, impeller, throat tube and auxiliary equipment.
- (f) **"Drive Unit"** shall refer to the motor, power transmission elements (e.g. V-belts & Pulley), support structures (e.g. baseplates, frame, etc) and auxiliary equipment.
- (g) **"Fill Point"** shall refer to the average hydraulic invert level of the incoming flow at which the screw pump unit will lift the liquid from to the chute point.
- (h) **"Chute Point"** shall refer to the invert level of the of the screw pump discharge point.
- (i) **"Touch Point"** shall refer to the invert level of the lowest point of the sump from which the screw pump is lifting the from.

### M09.2.2 Abbreviations

In this Specification the following abbreviations will apply: -

°C	: Temperature in degrees Celsius
A	: Ampere
AC	: Alternating Current
AGMA	: American Gear Manufactures Association
ANSI	: American National Standards Institute

API	: American Petroleum Institute
ASCE	: American Society of Civil Engineers
ASME	: American Society of Mechanical Engineers
ASTM	: American Society for Testing and Materials
BEP	: Best Efficiency Point
BS	: British Standards Institution
BSPT	: British Standard pipe thread
CAD	: Computer Aided Drawing
CAM	: Computer Aided Manufacturing
CIP	: Cleaning in Place
COC	: Certificate of Conformance
D	: Diameter
dB(A)	: Sound pressure level, "A" weighed in decibels
DCS	: Distributed Control System
DFT	: Dry Film Thickness
DIN	: Deutsch Industry Normen
DN	: Nominal diameter
DP	: Differential Pressure
Eff.	: Filter efficiency in %
EPDM	: Ethylene Propylène Diène Monomer
ERW	: Electrical resistance weld
ETP	: Effluent Treatment Plant
FA	: Flange adaptor
FAT	: Factory Acceptance Tests
FBE	: Flanged both ends
FOE	: Flanged one end
FW	: Field weld
HDPE	: High Density Polyethylene
HoW	: Head of Works
ID	: Inside diameter
ISO	: International Organisation for Standardization
JW	: Johannesburg Water
ℓ/s	: Flow in litres per second
LV	: Low Voltage
m	: Distance in metre
m.a.s.l	: Metres above (mean) sea level
m/s	: Speed in metres per second
MCC	: Motor Control Centre
mm	: Dimension in millimetres
MPVC	: Modified Polyvinyl Chloride Pipes
MV	: Medium Voltage
N+1	: No of units in operation + 1 installed spare
Nm <sup>3</sup> /hr	: Normal cubic meters per hour
O&M	: Operation and Maintenance
OD	: Outside diameter
OEM	: Original equipment Manufacturer
OHS	: Occupational Health and Safety
Pa	: Pressure in Pascals
PBE	: Plain both ends
PE	: Plain end
PN	: Nominal pressure (Rating)

PPE	: Personal Protective Equipment
PQP	: Project Quality Plan
PSV	: Pressure Safety Valve
QCP	: Quality Control Plan
RFA	: Restrained flange adaptor
rpm	: Rotational speed in revolutions per minute
SAECC	: South African Electrolytic Corrosion Committee
SANS	: South African National Standards
SAT	: Site Acceptance Tests
SAW	: Submerged arc weld
SCADA	: Supervisory Control and Data Acquisition
SIS	: Swedish Institute of Standards
SOC	: Slip-on coupling
SS	: Stainless Steel
STP	: Standard Temperature and Pressure (i.e. T = 20°C, P = 101, 3 kPa).
w.t.	: Wall thickness of pipes
TDS	: Total Dissolved Solids
uPVC	: Unplasticised Polyvinyl Chloride
VSD	: Variable Speed Drive
WP (B)	: Weld preparation (Butt)

#### M09.2.3 Standards

All design standards for the Archimedean screw pumps shall be subject to the latest amendments and editions of the following standard specifications:-

PD 5304:2014	: Guidance on safe use of machinery (British Standards)
SANS9606-1: 1994	: Testing of welders, where applicable to the type of welding required
BS ISO1312-1:2018	: Rolling bearings. Accessories for sleeve type linear ball bearings. Boundary dimensions, geometrical product specifications (GPS) and tolerances for series 1 and 3
SANS 10162-4	: Structural use of Steel Part 4: The design of cold-formed stainless steel structural
SANS 15614-1	: Specification and qualification of welding procedures for metallic materials - Welding procedure test Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys
BE EN 15614-1:2017	: Specification and qualification of welding procedures for metallic materials. Welding procedure test. Arc and gas welding of steels and arc welding of nickel and nickel alloys
BS EN ISO 18286:2010	: Hot-rolled stainless-steel plates. Tolerances on dimensions and shape
SANS 10064	: The preparation of steel surfaces for coating
SANS 10111-2-1	: Engineering Drawing Part 1: General principles Engineering Drawing Part 2: Geometric Tolerancing Section 1

SANS 10341	: Installation and maintenance of bearings – General guidelines
SANS 1700-5-9	: Fasteners Part 5: General requirements & material properties Section 8: Corrosion resistant stainless steel fasteners-Bolts, Screws & Studs
SANS 1700-5-10	: Fasteners Part 5: General requirements & material properties Section 8: Corrosion resistant stainless steel fasteners-Nuts

#### M09.2.4 Other Particular Specification

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

M08: Particular Specification for Gearboxes

E01: Particular Specification for Electric Motors

G01: Particular Specification for Colour Codes

G02: Particular Specification for Corrosion Protection

Volume 1: Automation and Control Design Standards SCADA

Volume 6: Automation and Control Design Standards Cabling

Volume 8: Automation and Control Design Standards Flow Measurement

Volume 9: Automation and Control Design Standards Level Measurement

### M09.3

#### **GENERAL DESIGN PARAMETERS**

Archimedean flow pumping equipment shall be designed such that the following requirements are met: -

- To ensure reasonable standards of engineering in design, materials selection and construction processes;
- To facilitate manufacture, inspection, installation, maintenance, cleaning and repairs;
- To ensure safe and satisfactory operation for an acceptable life expectation of 15 years under the ambient conditions prevailing at the Site;
- The offered equipment shall be support in forms of spares by the original equipment manufacturer for at least 15 years in alignment with the specified life expectation of 15 years from project installation;
- The minimum availability of the equipment shall be 99 %;
- To prevent undue stresses being produced by expansion due to temperature changes;
- To keep maintenance costs to a minimum that represent the value for money in both the initial purchase and subsequent running costs;
- To facilitate inter-changeability of units and/or sub-parts throughout the operational life of the new equipment against the existing equipment and/or sub-parts currently being used on the existing JW Wastewater Treatment Works;
- To operate without undue vibration and excessive noise. Maximum of 75dBA measured at 1 metre from operating equipment;
- To comply with the legal requirements such as the Occupational Health &

Safety Act, 1993 and Regulation's requirements in respect of safety as well as the prevention of water and air pollution;

- To satisfy any specific requirement contained in the latest editions of the published statutory codes and legislation, and
- To be suitable for operation 365 days per year, 24 hours per day under specified design conditions.

#### **M09.4**

#### **SPECIFIC DESIGN PARAMETERS**

The screw pump design shall be robust design and operate continuously, impact free at an optimised low speed to minimised wear with capability to handle contaminated feasible flow specific to the site installation. The pump capacity shall be design with a factor of 1.2 times the average design flow specified for process requirements. This shall then be the specified pump capacity requirement.

The screw pump's diameter and the number of flights shall be based on the specific capacity of the pump. The required screw pump configuration,, capacity and lift shall be as specified in the Project Specification. The screw pump shall be designed such that the screw inclination for the lift head specified is between 30° and 40° from the horizontal, the selected level position shall be based on optimum performance and best efficiency point . The performance shall then be achieved with a screw diameter and the rotational speed optimally selected. The design of the screw pump shall take into consideration maximum operational rotational speed which cannot be exceeded to avoid the liquid being pumped by the screw pump from being thrown out of the trough

The screw pump size i.e. diameter, pitch length and number of flights shall be selected and designed to allow the pump to optimally operate between 30% to 110% of the specified flow capacity i.e. the first top flight from the lower end of the screw pump shall align horizontally with the fill point as specified in the project specification.

The selection of the pump shall ensure optimal and higher efficiency operation between 50% to 100% of the required capacity. Furthermore, the BEP of the pump should at least be between 80% and 100% of the required capacity. Preference shall be given to pumps with the efficiency of 65% and more with the pump operating at the fill point.

Detailed performance curves for the pump type shall be provided at the time of tendering. The curve(s) shall indicate the following:

- Head (metres) vs. flow (litres/second) - The curve shall extend from 0% to 120% of the selected BEP based on the duty flow
- Power absorbed in kW - The curve shall extend from 0% to 120% of the selected BEP based on the duty flow
- Pump efficiency – The curve shall extend from 0% to 120% of the selected BEP based on the duty flow range.
- The efficiency curve shall be flat over a wide range in order to provide efficient working at various pump operating conditions.
- On the same performance curve, there shall be indication of the corresponding level showing at least 3no. of points including and between the touch and fill point of the suction sump.

The screw pump equipment to be installed shall include but not limited to helical screw shaft, motor, mechanical overload release couplings, gearbox, anti-reverse rotation devices, flexible final couplings, top and bottom bearings with housing, bed-plates, splash plates, lubrication equipment and all fasteners and anchor bolts.

The rotating screw assembly shall consist of a centre tube seam welded by the tube-manufacturer with cold formed helices fillet-welded all around thereto and stub shaft housings on both ends of the tube. All parts shall be of ample dimensions and strength to minimize any resultant deflection and properly machined and assembled to ensure perfectly free running. The span length of the flights shall be to specific fill point and the chute point of the screw trough, but the torque tube shall extend over these point in order to optimise the length of the stub shafts to the lower and upper bearing supports.

The screw pumps shall be designed taking into account the specified fill point in the sump. The design of the screw pump shall ensure that the tendency for the rotating assembly of the pump to float be taken into consideration when selecting bearing, other components and the overall design of the screw pump assembly.

Lifting provision shall be subject to the approval of the Employer's Agent / Employer's Representative

#### M09.4.1 Torque Tubes

The upper and lower ends of the torque tubes shall be equipped with internal watertight bulkheads, inboard of standard flanges. The torque tube shall be air pressure tested to a minimum test pressure of 400 kPa to assure there are no leaks. The maximum design stress shall not exceed 20 MPa and the allowable stress for the material grade offered and a minimum factor of safety of 3 shall be used against all structural and dynamic failure loads. All welds between the torque tube segments and at the torque tube end flanges shall be full penetration welds with the minimum weld size calculated based on the thickness of the thicker material. The end plates shall be provided with tapped boltholes and indexes to fit the standard dimension flange of the shaft extensions. The shaft extensions shall consist of a standard dimension flange with index to fit the tube end plate and matching bolts.

A solid upper drive shaft and a lower stub shaft shall be fastened to the upper and lower end of the spiral screw with high strength bolts respectively. The material of the centre tube and helices shall be structural steel to BSEN ISO 18286.

#### M09.4.2 Flights

Flights shall be helical shaped and continuously welded to the torque tube on both sides of the flight. The screw shall be statically balanced and shall be manufactured in a lathe machine in which the flights shall be machined to a true radius. Preferable flights shall be of composite material with 100mm of the flight tip constructed from high corrosive resistance material. The number of the flights shall be optimally with reference to the functional dimensions of the trough and screw for the correct selection of the pump capacity and rotation speed.

Helices shall be evenly spaced and accurately shaped to a cylindrical shape. The helices at the leading ends of the screw shall be reinforced. The spiral screw shall be

designed for minimum deflection. The deflection shall not exceed  $L$  (span length, mm)/2500 of the bearing centre distance when calculated as a simple horizontal beam uniformly loaded with a dead load of the screw and 100% of the liquid capacity along the span of the screw pump. The clearance between the outer radius of the flights and the trough shall be bigger than the maximum allowable deflection in order to prevent damage of the flights during operation while keeping the backflow to a minimum.

#### M09.4.3 Screw Assembly

Primary and secondary stresses in the screw assembly shall be calculated in accordance with BS 153: Part 3B and the design and fabrication shall be in accordance with BS 153: Part 4.

The design life of the screw assembly shall be assessed in accordance with Code of Practice for Fatigue – BS 5400: Part 10.

Stress calculations shall not include any allowance that might be claimed by the attachment of the helices to the centre tube or to buoyancy when the screw is lifting fluid.

#### M09.4.4 Welds

The submerged arc welding process (SAW) shall be used with the exception of the attachment of the helices, with approval testing of welding procedures in compliance with BS EN ISO 15614-1 or SANS 15614-1.

Longitudinal and circumferential welds only shall be made to the centre tube except for the attachment of helices, which shall be by a continuous fillet weld interrupted where it intersects centre tube welds.

Circumferential welds shall not occur at a greater distance than 20% from the extremities of the finished tube and preferably at the lower end only when joining tubes.

All longitudinal and circumferential welds shall be non-destructive tested (NDT) with the method appropriate for the size and environmental conditions subject to the approval of the Employer's Agent / Employer's Representative. The method of NDT selected shall guarantee the weld integrity based on the weld test used in the WPS & PQR approved for the specified weld and material. This shall as a minimum guarantee that the following defects are easily detected; lack of fusion, porosity, undercut and mechanical damage.

#### M09.4.5 Stub shafts

The stub shafts at both ends of the centre tube shall affect a gradual reduction in diameter. The stub shafts shall be steel forgings to BS 970: Part 1 and the fastenings to the housings shall not under any circumstances be subject to cyclical stressing.

The stub shaft shall be readily removable from the housing prior to transport and readily replaceable at Site. The fixing arrangements i.e. flanges to the torque tube for stub shafts shall be air and watertight.

#### M09.4.6 Bearings

##### M09.4.6.1 Bottom Bearing

The bottom bearing design shall be of continuous immersion in wastewater with provision for self-alignment and allowance for axial movement of the shafts. The bearing shall be designed for a life of at least 200 000 hours at an (L10) rating. Bearings for the lower stub shaft shall be designed to withstand bending, down pull, thermal expansion and radial loads imposed by the screw pump under 100% loading.

Bottom bearing can be provided as seal for life bearing or continuous lubricated bearing. Continuous lubricated bottom bearing shall be preferable grease lubricated. Selection and design of screw pump bottom bearing shall be subject to the approval of the Employer's Agent / Employer's Representative.

Rotating parts shall be suitable for connection to a system that enables continuous remote monitoring of the bearing.

**NB: A complete bottom bearing shall be provided as a spare for each size and type of screw pump installation unless otherwise specified in the project specification.**

##### M09.4.6.2 Bottom Bearing Housing

The bottom bearing housing and mounting support shall be designed to withstand radial forces only including upward forces due to buoyancy during static sump level conditions. The bottom bearing shall be completely protected by a stationary shroud to prevent material such as rags, ropes, cables and other debris contained in the wastewater being pumped from becoming wrapped around its rotating parts. The bearing shall be split on its horizontal centre line together with the renewable bush feather keyed bearing shell to facilitate inspection without disturbance of the stub shaft or the need to support the screw.

The lower bearing housing shall be designed for water resistance and shall not contain less than two lip seals. The lip seals shall be protected from abrasive materials by a seal cover.

Seals shall be split and readily changed without the disturbance of the stub shafts or the need to support the screw.

The bottom of the bearing housing shall be fitted with an inspection cover or shrouds and the shroud shall be constructed from two halves to facilitate easy removal from the bearing assembly without disassembling the lower stub shaft. Each half shroud part may not exceed 25 kg in weight. late

Each half of the bottom bearing shells shall be spirally grooved such that rotation of the journal assists the passage of lubricant through the bearing surfaces.

The design of the bearing housing and shells shall provide for repositioning the bottom shell to the top position and vice versa when wear has taken place.

The bottom bearing housing shall preferably be pivoted, and foot mounted so as to facilitate self-alignment in all axes to the deflection of the screw pump under any

pumping condition or when the screw pump is running dry. Provision shall be made to take into account the resultant force on the screw pump due to the higher water level mentioned above.

#### M09.4.6.3 Lubrication

The continuous lubrication of bottom bearings shall be through an external automatic lubrication system by means of a light grease or oil system pressurised by an electric motor driven plunger pump or oil hydraulic reservoir in the form of a power pack. If the former is chosen, the grease shall return to a suitable removable receptacle located on a bracket fixed to the external sump wall or, if the latter, a return pipe shall be provided to return oil to the reservoir via a suitable inclined 'in-line' filter.

The lubricant shall be piped to the bottom bearing via a high-pressure tube housed in a pipe duct down the side of the trough behind the splash plate or cast into the concrete structure.

Hard wiring provision shall be made for priming the system (30 second for oil or 60 seconds for light grease) prior to start-up of the screw pump as part of operational philosophy of the system. An adjustable pressure relief valve shall be provided for either system together with a pressure gauge and pressure switch.

An external stationary shroud shall be provided to prevent detritus affecting the bearing or lubrication pipes during operation.

#### M09.4.6.4 Top Bearing

The top bearing shall be designed to accommodate the entire thrust including upward forces due to buoyancy of the rotating parts of the screw together with a proportion of the radial forces. The thrust shall be transferred from the shaft to the bearing by means of a suitable thrust ring or lock nuts designed not to fail under the thrust load imposed of the dead load of the screw assembly and the live load from the liquid being pumped. A "circlip" arrangement will not be acceptable. The bearing shall be grease lubricated with a Stauffer "tell-tale" (or equivalent) lubricator accessible from the machinery room and shall have seals on both ends. It shall be possible to easily dismantle and replace this bearing without removing the stub shaft.

The top bearing shall be foot mounted on a rigid support frame which allows ease of installation and alignment of the screw pump unit, which shall also seal the opening in the motor room wall.

Bearings shall be designed for a L10 life in excess of 200 000 hours. The Contractor shall submit proof of the required bearing rating.

The opening through which the shaft pass through the bearing housing shall be sealed off from the outside. This shall be achieved as minimum by using a combination of double lip seal between the rotating shaft and housing, an enclosure disc screwed onto the housing and finally a v-ring clipped on the exposed rotating shaft.

#### M09.4.7 Gearboxes

Each screw pump shall be directly coupled to a suitable gearbox through a flexible coupling with the gearbox in line and driven by a motor through a mechanical overload release coupling or V-Belts. It shall be noted that the gearbox will be mounted at an angle as the same plane of the screw torque tube or upper bearing and must be designed accordingly. The gearbox shall be provided with an anti-reverse rotation clutch or backstop device to prevent reverse rotation.

Refer to Particular Specification M08: Mechanical Gearboxes for a detailed specification for gearboxes.

##### M09.4.7.1 Gearbox/Motor Coupling

The coupling between motor and gearbox shall be of the mechanical overload release type with manual resetting facility or preferably a flexible correctly tensioned V-belt pulley arrangement type coupling. The incorporation of a shear pin will not be acceptable. The coupling shall instantaneously protect the motor and gearbox should the screw suddenly become arrested in rotation. The coupling shall be fully rated to transmit the motor full load power and tested to prove the above features together with static and dynamic balance.

##### M09.4.7.2 Gearbox and Motor Mounting

The gearbox shall be mounted directly to a purpose designed concrete plinth. The motor shall be provided with slide rails, which shall be mounted to the above plinth or in a compact unit frame mounted on the top side of the gearbox.

#### M09.4.8 Electric Motors

The screw pump shall be driven by a high efficiency fixed speed electric motor. Refer to Particular Specification E01: Electric Motors for a detailed specification for Electric motors.

Starting characteristics of motors shall be suitable for the equipment offered. These shall also include the motor phase protection, overloading, etc as specified in the project specification.

Bearings shall be adequate to withstand continuous operation when supporting the rotor shaft inclined at the angle specified in the Project Specific Specification or in-line with the installation assembly of the screw pump. Bearings shall be sealed or self-lubricated, provided with a readily accessible filter and clearly visible oil level indicator.

#### M09.4.9 Screw Troughs (if not installed on a screed concrete trough)

A steel trough liner or a concrete casting mould shall be designed and constructed in line with the selected Screw Pump required, the trough design shall be subject to the approval of the Employer's Agent / Employer's Representative. The Contractor shall be responsible for the final alignment of the trough to provide the correct clearances, and for the supervision of the formation of the trough.

The trough shall extend between the pump inlet sump and the discharge channel without distortion.

The trough shall be so shaped as to avoid 'wedges' between screws and sidewalls and to provide for the return of any excess liquid or solids without interference with screw pump rotation. Unless otherwise specified, the trough width between the side walls shall be at least the diameter of the screw pump plus 400mm.

The trough shall preferably have its profile shaped by means of the screw itself, after installation, in order to ensure minimise clearance and maximize efficiency for the specific screw pump.

M09.4.10 Side Profiles

In order to contain the pumped liquid on the high-water level side of the screw axis, caused by the rotation of the pump, special side profiles shall be fitted. The profiles shall be fixed to the concrete trough and the channel sidewall using high strength stainless steel fixing bolts, to maintain a small clearance around approximately 230° of the screw circumference.

M09.4.11 Screw Pump Covers

Where specified in the project specification, the sump screw shall be supplied with clear, UV resistant and removable covers. Along with this, access stars shall be incorporated in the civil design to allow access on both sides of the screw pump.

M09.4.12 Lifting

if not specified in the project specification, there screw pump unit assembly shall be supplied under the same contract with a lifting crawl beam installed over the center of the pumps and on the bottom bearing section. The minimum safe working load shall be 1000 kg or as per the heaviest equipment assembly whichever is greater. The lifting equipment shall be design and manufactured from corrosion protect structural steel. The details of such lifting equipment shall be referred to in the particular specification for lifting equipment or as specified in the project specification.

All equipment greater than 25kg shall have lifting eyes integrally incorporated in their housing to allow safe and accessible lifting of the equipment installed.

**M09.5 FASTENERS**

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

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

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

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

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

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

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

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

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

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

#### **M09.6 METAL PREPARATION AND PROTECTION**

Refer to Particular Specification G02: Corrosion Protection.

#### **M09.7 COLOUR CODING**

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

**M09.8**

**MATERIAL OF CONSTRUCTION**

The pump unit components shall be constructed of the material specified in the Table below:

**Material Specifications:**

COMPONENT	MATERIAL TYPE
Torque tube(s)	Mild steel epoxy coated NB. Use as a minimum a composition coating with a Zincrich primer for application with high sand content.
Helices or Flights	Mild steel epoxy coated NB. Use as a minimum a composition coating with a Zincrich primer for application with high sand content.
Helices or Flights Tips (100mm)	304L Stainless Steel
Connecting flanges to torque tube	Mild steel epoxy coated
Stub shaft	Mild steel to BS 970 grade and epoxy coated
Bearing housing	Epoxy coated Cast iron
Support frames for both upper and lower bearing	304L stainless steel
Bearing bushes	Phosphor bronze
Bearing lubricant tubes	304 L Stainless Steel
Gearbox and Motor support frame	Hot Dipped Galvanised Mild steel
Support frame covers for shaft coupling and V-belt pulley elements	Mild steel epoxy coated
Screw trough	304L stainless steel
Belt drive pulleys	Cast Iron
Hold down bolts and fasteners	316 stainless steel
Side profile and support (Splash Plate)	304L stainless steel
Screw Pump Covers	Clear UV resistant Plastic.
Access platforms	GRP with stainless steel clips.
All other accessories shall be of the manufacturer's standard, industry approved, and corrosion protected.	

#### **M09.9 RECOMMENDED SPARES AND SPECIAL TOOLS**

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

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

#### **M09.10 VIBRATION AND NOISE**

The screw pump as well as the motors will comply with the requirements of BS EN60034 part 9 and 14. The Contractor shall carry out vibration tests as requested by the Employer's Agent or Employer's Representative in compliant with the specified vibration standard. The noise level shall not exceed 75 dBA measured at 1m from the pump.

The vibration velocity measurements for fixed speed pumps shall be taken within the 0-100% of the operating envelope. The Root Mean Square (RMS) vibration velocity levels generated by the pump unit during testing shall not exceed 4.2 mm/s or the maximum recommend level by the OEM, but the standard value shall be whichever is less.

The Contractor will also be requested by the Employer's Agent or Representative to measure and confirm the vibration velocity once the screw pump unit is installed more specifically at the lower and upper bearings.

#### **M09.11 GUARANTEE OF PERFORMANCE**

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

#### **M09.12 QUALITY MANAGEMENT (QM) AND QUALITY ASSURANCE**

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

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

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

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

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

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

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

M09.12.1 Material Tests

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

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

M09.12.2 Type Tests

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

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

M09.12.3 Substandard Quality Control

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

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

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

M09.12.4 Access for Surveillance

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

M09.12.5 Manufacture

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

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

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

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

**M09.12.6**      Installation

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

**M09.13**            **PERFORMANCE TESTING**

**M09.13.1**        Works testing

Each item of equipment shall be subject to inspection and testing prior to despatch from the works. All test (including static and dynamic balancing) results shall be made available to the Employer's Agent or Representative for verification or when the QCP's require intervention or hold points for inspection.

**M09.13.2**        Before commissioning

- Check that all bearings are lubricated properly.
- Ensure that the belts are correctly tensioned.
- Ensure all HD bolts are torqued down correctly.
- The alignment and levelling of each assembly shall be checked, witnessed by and the results shall be available for inspection by the Employer's Agent or Representative.
- Check that the correct clearance tolerance within the throat tube prevails.
- The electrical functions and control shall be checked by a responsible inspector prior to attempting to start any motor on this Project.

**M09.13.3**        During Commissioning

- Ensure all lubrication pumps and flow or pressure switches are functional
- Check for correct operation of rotation, speed, vibration and noise.
- Note amperage drawn by each assembly.
- Measure the flow delivered by each pump

**M09.14**            **BEFORE EXPIRY OF THE DEFECTS LIABILITY PERIOD**

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

#### **M09.15 EQUIPMENT TRAINING PROCEDURE**

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

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

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

#### **M09.16 OPERATION AND MAINTENANCE MANUAL SUMMARY**

The Contractor shall hand over to the Employer' Agent or Employer's Representative four sets (x2 hard copies and x2 electronic copies on non-locked USB) of the Operation and Maintenance Manual compiled for each installation not later than at the time of commissioning of the installation. These manuals are a prerequisite for final takeover of the plant. A copy of the Operating and Maintenance Manual for each equipment type shall be bound in with the Operating and Maintenance Manual for the project. The manual shall be A4 size and properly bound. Drawings larger than A3 size shall be contained in separate plastic pockets.

The Operation and Maintenance Manual will contain the following:

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

#### **M09.17 DRAWINGS**

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

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

**M09.18 INTERCHANGEABILITY**

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

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

**M09.19 MEASUREMENT AND PAYMENT**

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

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

**M09.19.1 General**

The following items shall be included in the rates:

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

Payment under scheduled items shall be made per complete installation as specified, electrical connections, etc and grouting, etc. Measurement and payment will distinguish between supply / delivery; installation and testing; and commissioning and trial operation of the equipment. A further training requirement shall be allowed for as specified in the scheduled items.

**M09.19.2 Supply and delivery to site with documentation**

**Item**

**Unit**

Supply and delivery to site with documentation.....No

The tendered rates shall include for full compensation of all costs incurred in design, drawings, manufacture, supply, testing at the manufacturers works, inspections, quality control, quality assurance, factory acceptance testing, corrosion protection, packing, delivery to site including transportation costs and offloading on site including any craneage requirements. No claims whatsoever for extras will be allowed on the grounds that a necessary piece of equipment or a part thereof is not specifically mentioned.

M09.19.3 Installation, Testing and Commissioning of the Equipment

<u>Item</u>	<u>Unit</u>
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Installation, Testing and Commissioning of the Equipment.....	No
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The tendered rates shall include for full compensation of all costs incurred in installation, site testing, setting into operation, the supply of O & M manuals, commissioning and maintenance during the warranty period of all equipment specified on Site including the provision of all labour, supervision, instruments, equipment, transport, on-site quality assurance and quality control, inspection and testing (including attendance at tests witnessed by the Employer's Agent / Employer' Representative), materials and Temporary Works necessary to completely install, test and commission and render fully operational surface aeration equipment.

The rate shall also include the cost of the installation of all auxiliary equipment not specifically mentioned but obviously required, (e.g. all ancillaries, including all bolts, fastenings and brackets, safety guards and any work or material required for the proper installation of such equipment) to enable the equipment to be installed and/or function safely and correctly as specified until taken over by the Employer; the putting into service of the complete installation; remedial work and any other work as specified and necessary.

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

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

M09.19.4 Trial Operations

<u>Item</u>	<u>Unit</u>
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Trial Operations .....	No
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This specification allows for a number of calendar days within which the system Trial Operation can be completed after completion of commissioning process. The Contractor shall programme and price for providing full technical and operational support during trial operation.

M09.19.5 Employer's Operator Training

<u>Item</u>	<u>Unit</u>
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Training .....	No
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Payment for Training of the Employer's Operational Staff will be made under this Section as set out in project specification or agreed with the Employer's Agent / Employer' Representative. The lump sum shall be inclusive of all costs associated with the training programme and on-site training of personnel.

M09.19.6

Spares and Tools

**Item**

**Unit**

Spares and Tools.....No

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

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

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