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## **PARTICULAR SPECIFICATION**

### **M18: MECHANICAL CENTRIFUGAL PUMPS**

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## **PARTICULAR SPECIFICATION M18: MECHANICAL CENTRIFUGAL PUMPS**

### **CONTENTS**

<b>M18.1</b>	<b>SCOPE.....</b>	<b>- 3 -</b>
<b>M18.2</b>	<b>INTERPRETATIONS .....</b>	<b>- 3 -</b>
<b>M18.2.1</b>	<b>Abbreviations .....</b>	<b>- 3 -</b>
<b>M18.2.2</b>	<b>Standards.....</b>	<b>- 3 -</b>
<b>M18.2.3</b>	<b>General Requirements .....</b>	<b>- 4 -</b>
<b>M18.3</b>	<b>PUMPS.....</b>	<b>- 4 -</b>
<b>M18.3.1</b>	<b>Design Parameters.....</b>	<b>- 4 -</b>
<b>M18.3.2</b>	<b>Pump Casing .....</b>	<b>- 5 -</b>
<b>M18.3.3</b>	<b>Pump Impeller.....</b>	<b>- 6 -</b>
<b>M18.3.4</b>	<b>Pump Shaft .....</b>	<b>- 7 -</b>
<b>M18.3.5</b>	<b>Shaft Coupling.....</b>	<b>- 7 -</b>
<b>M18.4</b>	<b>BEARINGS .....</b>	<b>- 7 -</b>
<b>M18.4.1</b>	<b>Bearing Housing .....</b>	<b>- 7 -</b>
<b>M18.4.2</b>	<b>Lubrication .....</b>	<b>- 7 -</b>
<b>M18.5</b>	<b>GLANDS AND SEALS .....</b>	<b>- 8 -</b>
<b>M18.6</b>	<b>VENT COCKS.....</b>	<b>- 8 -</b>
<b>M18.7</b>	<b>BASE PLATE.....</b>	<b>- 8 -</b>
<b>M18.8</b>	<b>DRIVE UNIT .....</b>	<b>- 8 -</b>
<b>M18.8.1</b>	<b>Gearbox / Motor Coupling .....</b>	<b>- 8 -</b>
<b>M18.9</b>	<b>GEARBOX .....</b>	<b>- 9 -</b>
<b>M18.10</b>	<b>MONITORING DEVICES .....</b>	<b>- 9 -</b>
<b>M18.11</b>	<b>PRESSURE GAUGES .....</b>	<b>- 9 -</b>
<b>M18.12</b>	<b>TEMPERATURE DETECTORS.....</b>	<b>- 9 -</b>
<b>M18.13</b>	<b>NO-FLOW PROTECTION .....</b>	<b>- 9 -</b>
<b>M18.14</b>	<b>INDICATOR ON AUTOMATIC AIR VENT .....</b>	<b>- 9 -</b>
<b>M18.15</b>	<b>GLAND LEAKAGE .....</b>	<b>- 9 -</b>
<b>M18.16</b>	<b>PIPEWORK.....</b>	<b>- 9 -</b>
<b>M18.17</b>	<b>HOLDING DOWN BOLTS .....</b>	<b>- 10 -</b>
<b>M18.18</b>	<b>VIBRATION AND NOISE .....</b>	<b>- 10 -</b>
<b>M18.19</b>	<b>CORROSION PROTECTION .....</b>	<b>- 10 -</b>
<b>M18.20</b>	<b>DESIGNATION AND INFORMATION PLATES.....</b>	<b>- 10 -</b>
<b>M18.21</b>	<b>INTERCHANGEABILITY .....</b>	<b>- 10 -</b>
<b>M18.22</b>	<b>RECOMMENDED SPARE PARTS.....</b>	<b>- 10 -</b>
<b>M18.23</b>	<b>OPERATION AND MAINTENANCE MANUAL.....</b>	<b>- 10 -</b>
<b>M18.24</b>	<b>DRAWINGS .....</b>	<b>- 11 -</b>
<b>M18.25</b>	<b>INSTALLATION .....</b>	<b>- 11 -</b>

<b>M18.26</b>	<b>INSPECTION, TESTING AND COMMISSIONING.....</b>	<b>- 11 -</b>
<b>M18.26.1</b>	<b>Testing by Manufacturer .....</b>	<b>- 11 -</b>
<b>M18.26.2</b>	<b>Witnessed Testing .....</b>	<b>- 11 -</b>
<b>M18.26.3</b>	<b>Testing by an Independent Facility .....</b>	<b>- 12 -</b>
<b>M18.26.4</b>	<b>Failure to Pass Performance Test .....</b>	<b>- 12 -</b>
<b>M18.26.5</b>	<b>Commissioning .....</b>	<b>- 13 -</b>
<b>M18.26.6</b>	<b>Tests at the Site of the Works.....</b>	<b>- 13 -</b>
<b>M18.27</b>	<b>COLOUR CODES.....</b>	<b>- 13 -</b>
<b>M18.28</b>	<b>MEASUREMENT AND PAYMENT.....</b>	<b>- 14 -</b>

## **M18.1 SCOPE**

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

## **M18.2 INTERPRETATIONS**

### **M18.2.1 Abbreviations**

In this Specification the following abbreviations will apply:-

ANSI	:	American National Standards Institute
ASTM	:	American Society for Testing and Materials
BS	:	British Standards Institution
SANS	:	South African National Standards
SIS	:	Swedish Institute of Standards
DIN	:	Deutsch Industry Normen
ISO	:	International Organisation for Standardization
ASME	:	American Society of Mechanical Engineers
SAECC	:	South African Electrolytic Corrosion Committee
AGMA	:	American Gear Manufactures Association

### **M18.2.2 Standards**

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

SANS 10400	:	National Building Regulations
BS 5304	:	Code of practice for safeguarding of machinery
SANS 9096-1: 1994	:	Testing of welders, where applicable to the type of welding required
BS 292 Part 1: 1987	:	Dimensions of ball bearings, cylindrical and spherical roller bearings
SANS 10162-4	:	Structural use of Steel Part 4: The design of cold-formed stainless steel structural
SANS 1044-3	:	Welding Part 3: The fusion of steel (including stainless steel): Tests for the approval of welding procedures
SANS 10044-4	:	Welding Part 4: The fusion welding of steel (including austenitic stainless steel): Tests for the approval of welders working where weld procedure approval is not required.
SANS 10064	:	The preparation of steel surfaces for coating
SANS 10102-4	:	Selection of pipes for buried pipelines Part 1: General Provisions
SANS 10104	:	Hand railing and balustrading (safety aspects)
SANS 10111-2-1	:	Engineering Drawing Part 1: General principles Engineering Drawing Part 2: Geometric Tolerancing Section 1

SANS 10341	: Installation and maintenance of bearings – General guidelines
SANS 1700-5-9	: Fasteners Part 5: General requirements & material properties Section 8: Corrosion resistant stainless steel fasteners-Bolts, Screws & Studs
SANS 1700-5-10	: Fasteners Part 5: General requirements & material properties Section 8: Corrosion resistant stainless steel fasteners-Nuts
BS EN ISO 14847:1999	: Rotary positive displacement pumps. Technical requirements
BS EN 734:1995	: Pumps and pump units for liquids. Common safety requirements
BS EN 12162:2001	: Liquid pumps. Safety requirements. Procedure for hydrostatic testing
BS EN 60041:1995	: Field acceptance tests to determine the hydraulic performance of hydraulic turbines, storage pumps and pump-turbines.
BS EN 60994:1993	: Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps and pump-turbines)
BS EN 22858:1993	: End-suction centrifugal pumps (rating 16 bar). Designation, nominal duty point and dimensions
BS EN 23661:1993	: End-suction centrifugal pumps. Baseplate and installation dimensions
BS EN 733:1995	: End-suction centrifugal pumps, rating with 10 bar with bearing bracket. Nominal duty point, main dimensions, designation system
SANS 1123	: Pipe Flanges
ISO 281	: Rolling bearings -- Dynamic load ratings and rating life
BS 4999	: General requirements for rotating electrical machines. Specification for standard dimensions
SIS 05 59 00	: Pictorial Surface Preparation Standards for Painting Steel Surface
BS 5316 Part 2	: Pump test codes

#### M18.2.3 General Requirements

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

M08: Particular Specification for Gearboxes

M21: Particular Specification for Pressure Pipework

E01: Particular Specification for Electric Motors

G01: Particular Specification for Colour Codes

G02: Particular Specification for Corrosion Protection

Automation and Control Design Standards Volume 8: Flow Measurement

Automation and Control Design Standards Volume 11: Temperature Measurement

### **M18.3 PUMPS**

#### M18.3.1 Design Parameters

Centrifugal pumps shall have stable non-overloading characteristics and the shaft speed shall not exceed 1500 rpm.

The pumps shall be of the highest quality and shall be suitable for continuous operation over long periods with a minimum amount of maintenance at high-sustained efficiency.

In all applications, with exception of clear water pumps, non-clogging impellers must be used. Pumps shall be designed as to remove the impeller cover without moving the pump, pipe work or motor. Each pump shall have a drip tray with a 20 mm diameter galvanised drain pipe to the nearest drainage point.

The pump design shall make adequate provision for the balancing of residual axial thrust. Pumps shall be supplied complete with suction and delivery pressure gauges complete with air-bleed and isolating cocks, shaft couplings and guards, gland leakage piping, base plates, foundation bolts and other necessary equipment.

Detailed performance curves for the pump type shall be provided at the time of tendering.

The curves shall indicate the following:

- Head (metres) vs. flow (litres/second) - 0% to 120% duty flow
- Power absorbed in kW - 50% to 120% of duty flow
- Pump efficiency – 0% to 120% duty flow
- Net positive suction head curves required by the pumps at the specified flow rate.

The efficiency curve shall be flat over a wide range in order to provide efficient working at various pump operating conditions.

Pumps shall be able to operate without cavitation over a full range as specified without throttling. Pumps are required to operate continuously at an ambient temperature of 40°C.

The following quantities shall be guaranteed by the Contractor:

- Minimum flow rate of the pump at the specified total head.
- Maximum power demand at the specified total head.
- Minimum efficiency at the specified total head.
- Maximum net positive suction head required by the pump at the specified flow rate.

#### *Multiple Units*

Unless specified arrangements incorporating multiple units coupled in series in order to achieve the duty specified for each complete pump set shall only be offered as an alternative.

The mechanical equipment to be supplied under this Contract shall be installed, tested and commissioned on concrete structures, constructed by others, to the dimensions indicated on the construction detail drawings.

### M18.3.2

#### Pump Casing

The pump casings shall be manufactured from cast iron or cast steel depending on the stresses corresponding to the required test pressures. Unless otherwise stated the dimensions and drilling of the suction and discharge flanges shall be SANS 1123 to the design pressures as specified but with a minimum of 10 Bar.

The pressure rating of the flanges shall at least be equal to the maximum static pressure plus the pump shut-off pressure.

Casings shall be designed for not less than the following working pressures or 1.5 times the actual working total discharge pressure, whichever is the greater.

Horizontal Split casing	:	1000 kPa
End Suction type	:	1000 kPa
Vertical Split Casing	:	600 kPa
Multistage	:	1.5 times working pressure.

#### *End suction pumps*

End suction pumps are arranged with a central suction connection and a tangential discharge connection. Both these connections shall be suitably flanged.

The casings shall be split at right angles to the shaft to enable the easy withdrawal of the impeller assembly. The volute casing shall be preferably a separate casing from the pump bearing and base assembly, but bolted and spigoted thereto.

For end suction pumps of more than 5.5l/s and not more than 70 l/s capacity, the casing shall be arranged to have a removable casing cover on the motor side so that the pump may be dismantled without disturbing the suction or delivery piping.

#### *Horizontally split casings*

These shall be double entry type casings, which are split on the axial centreline. The suction and delivery branches must be cast integral with the part of the pump incorporating the pump base.

The other half of the casing must be easily removable for an internal examination of the pump without the necessity of disturbing either the suction or delivery pipe work or rotating assembly.

The casing shall be fitted with suitable renewable corrosion resisting wearing rings and bushes in all positions where fine clearances require to be maintained. Wearing rings shall be made of high quality bronze or stainless steel.

All casings must be fitted with ceramic or stainless steel neck rings where fine clearances must be maintained between stationary and moving parts, to suit the fluid pumped.

#### *Semi-concentric back pull-out design casings*

The pump casing shall be semi-concentric back pull-out design, with the first half of the circumference after the pump outlet being cylindrical. The remaining circumference shall spiral outwards towards the flanged centreline discharge. The casing shall be manufactured from cast iron.

All casings shall be provided with the following tapping's as a minimum requirement:-

- One suction pressure gauge tapping
- One discharge pressure gauge tapping
- One bleeder cock tapping
- One filling point tapping
- Suitable tapping or, where possible, internal drilling to provide water for the glands.

All casings shall be heavily ribbed and strengthened as necessary to resist hydraulic forces, and internal passages shall be smoothly finished to minimize hydraulic forces.

### M18.3.3

#### Pump Impeller

Each impeller after machining and dressing shall be independently statically balanced and the

complete rotating assembly with coupling shall be dynamically balanced.

All impellers shall be of a non over loading design.

Impellers shall be securely keyed and fixed to the shaft by means of suitable shaft nuts and locking sleeves.

All bolting devices must be securely locked so that they cannot accidentally come loose. Bolting devices shall be made of corrosion resistant materials.

#### M18.3.4 Pump Shaft

The pump shafts shall be of sufficient dimension in order to avoid excessive torsional or bending stresses and deflection.

The pump shaft shall be designed so that the critical speed of the rotating assembly is well above the maximum pump operating speed.

The impeller shall be secured to the shaft in such a way that it can be readily removed without any damage to the impeller and the shaft.

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

#### M18.3.5 Shaft Coupling

The pump and motor shall be connected by a flexible coupling in such a way as to prevent them from uncoupling regardless of which way the impeller may be rotating.

The coupling shall accommodate small axial, lateral and angular misalignments without imposing undue stresses on the shaft and bearings. The coupling shall be enclosed in a stationery solid-plate guard to the Engineers satisfaction.

### M18.4 **BEARINGS**

All bearings shall be suitable for shaft rotation in both directions. All bearings shall be designed for a life of at least 100 000 hours at an (L10) rating. Bearings for the output shaft shall be designed to withstand bending, up thrust, down pull, thermal expansion and radial loads imposed by the impeller.

The rotating assembly shall be positively located in the axial direction and thrust bearings will therefore be required.

For ease of lubrication all bearing grease pipes must be piped to grease nipples on the outer cover of the pump support frame.

#### M18.4.1 Bearing Housing

The bearing housing shall be manufactured from cast iron and shall be oil bath lubricated. Oil level sight glasses shall be provided with level markers for running and filling minimum and maximum positions respectively. These shall be arranged for easy viewing and shall take into account the angle of mounting.

The bearing housing and motor stool design shall provide accurate, self-aligning mounting for the flanged electric motor.

#### M18.4.2 Lubrication

In the case where oil lubrication is required, adequate provision shall be made for the cooling of

the oil. The bearings shall be required to operate at temperatures no higher than 60°C.

Oil reservoirs of sufficient capacity shall be fitted with easily accessible oil level indicators, which are to be clearly marked in order to indicate the oil standing and running levels.

#### **M18.5 GLANDS AND SEALS**

Low pressure glands of the stuffing box pattern shall allow repacking without having to dismantle the pump.

If mechanical seals are offered they shall be manufactured from 316 SS to prevent the pump from leaking and shall be cartridge-type seals with O-rings and silicon carbide or tungsten carbide faces.

The cartridge seal shall be pre-assembled and pre-tested, requiring no adjustments and settings from the installer. Any springs required to push the seal faces together shall be shielded from the fluid that is to be pumped. The cartridge shall include a heat treated sleeve and an iron seal gland.

Full details of the seals and glands indicating the materials, finishes, clearances etc. shall be submitted with the Tender.

A spare mechanical seal for each size and type shall be supplied.

#### **M18.6 VENT COCKS**

Vent cocks shall be fitted at all high points to the pump casing. These cocks shall be adequately sized in order to allow the trapped air to be released freely.

An automatic air vent shall be fitted to each pump casing if specified. This device shall be suitable for the remote operation of an indicator to show the open and closed positions of the air vent.

#### **M18.7 BASE PLATE**

The base plate of the pump and motor shall be rigid. The pump and motor shall be situated on the upper face of each base plate, which shall be machined flat and smooth to ensure that the pump and motor are bedded properly without the use of spacers.

The pump/motor base plate shall be completely aligned prior to grouting and provision shall be made to grout within the base plate itself to facilitate vibration-free operation.

Base plates which have a mass greater than 200 kg shall have two jacking bolts at right angles with a lock nut at every corner of the unit.

#### **M18.8 DRIVE UNIT**

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

##### **M18.8.1 Gearbox / Motor Coupling**

The coupling shall be fully rated to transmit the motor full load power and tested to prove the above features together with static and dynamic balance. The motor shall be coupled to the gearbox input shaft with either a V-belt or a flexible coupling. V-belts and couplings are to be provided with protective cover guards.

**M18.9 GEARBOX**

Refer to M08: Volume M08: Mechanical Specification for Gearboxes.

**M18.10 MONITORING DEVICES**

Full detail of all monitoring devices offered must be submitted with the Tender.

**M18.11 PRESSURE GAUGES**

Pressure gauges shall be fitted with an isolating cock, shall be vibration and shock resistant and shall be calibrated to read with an accuracy of  $\pm 1\%$  of the indicated pressure. Three 20mm minimum diameter ball valves shall be employed to zero the gauge, to isolate it and to vent to atmosphere. A chemical seal shall be used to insulate the gauge from the media being measured.

The faceplate diameters of the pressure gauges shall be at least 100 mm. The gauges shall indicate the water pressure in kilopascal and shall have a range of a maximum of 50% higher than the normal maximum working pressure. All gauge glass must conform to internationally recognized standards. These standards include DIN 7081, BS 3463 and JIS B 8211.

A calibration certificate is to be provided with each pressure gauge.

**M18.12 TEMPERATURE DETECTORS**

If required oil lubricated bearings and glands offered shall be fitted with temperature detectors. The temperature detectors shall be PT100 – RTD's

If grease lubricated bearings are offered, the Tenderer will indicate in his Tender if temperature detectors can in fact be used. If temperature detectors are not feasible, an alternative means of monitoring bearings must be offered.

**M18.13 NO-FLOW PROTECTION**

- (a) Each pump shall be protected against no flow by a flow meter installed in the discharge line from the pump.

**M18.14 INDICATOR ON AUTOMATIC AIR VENT**

If an automatic air vent is required for the pump casing, it shall be fitted with an indicator to indicate the open and closed positions of the air vent. The air vent shall be suitable for remote operation and air vent control shall be mounted on the control panel inside the pump station.

**M18.15 GLAND LEAKAGE**

If a gland leakage device is required in order to monitor the gland leakage it shall be supplied and fitted with adjustable alarm contacts designed to close when gland leakage rises to a pre-set value.

**M18.16 PIPEWORK**

All suction and delivery pipes shall be connected to the pump casing by means of flexible connections. All flexible connections shall be installed as close to the pump's casings as possible, and in any event, shall be between the suction valve and the pump casing and delivery non-return valve and the pump casing. In all cases the flexible connection shall be in the section of piping of smallest diameter.

Double Victaulic joint are generally preferred for flexible connections, but approved re-enforced rubber bellow units are acceptable for low-pressure services.

All valves and pipework external to the pump casing and separated there from by means of flexible connections shall be securely anchored to prevent movement.

Refer to Particular Specification M21: Volume M21 Pressure Pipework for a detailed specification on pipework.

**M18.17      HOLDING DOWN BOLTS**

The contractor shall be responsible for the supply of all necessary holding down bolts for the machines supplied by him/her. The holding down bolts shall be manufactured from 316 SS.

All bolts necessary for assembling all equipment shall be supplied by the contractor.

**M18.18      VIBRATION AND NOISE**

The pumps as well as the motors will comply with the requirements of BS 4999. The Contractor may be requested by the Engineer to carry out vibration tests. The noise level shall not exceed 85 dBA at 1m.

**M18.19      CORROSION PROTECTION**

Refer to Particular Specification G02: Corrosion Protection

**M18.20      DESIGNATION AND INFORMATION PLATES**

Each pump shall be supplied with an information plate secured to the pump casing in a visible position indelibly marked with the following details:-

- Maker's name, pump type and serial number
- Year of manufacture
- Rated duty of pump in litres per second
- Head in metres at rated duty
- Pump speed in r/min
- Mass of completely assembled pump in kilogram

**M18.21      INTERCHANGEABILITY**

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

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

**M18.22      RECOMMENDED SPARE PARTS**

The Tenderer must submit details of spare parts recommended to be kept in store by the Employer with his Tender.

The detail will include a full description of the parts, part identification, number required, guaranteed delivery time and total price delivered to Site.

**M18.23      OPERATION AND MAINTENANCE MANUAL**

The Contractor shall hand over to the Engineer four sets of the Operation and Maintenance

Manual compiled for each installation not later than at the time of commissioning of the installation. These manuals are a prerequisite for final take-over of the plant.

The Operation and Maintenance Manual will contain the following:

- (a) Brief description of the plant and installation.
- (b) Concise operating instructions.
- (c) Routine maintenance instruction.
- (d) Precautionary measures, elementary trouble location, rectifying measures and emergency actions.
- (e) Detailed information on equipment.
- (f) Lists of spare parts including names and addresses of suppliers.

#### **M18.24 DRAWINGS**

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

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

#### **M18.25 INSTALLATION**

The pump and motor shall be aligned to within  $\pm 0.025$  mm full indicator movement on dial gauge, regardless of the coupling type. After the pump and motor feet are tightened down, ad pipework erected and tightened, both angular and parallel alignment shall be checked and recorded at each quarter revolution. These readings shall be submitted to the Engineer and is a prerequisite for handover.

Upon completion, dowel pins shall be fitted to facilitate relocation at any future time.

#### **M18.26 INSPECTION, TESTING AND COMMISSIONING**

##### **M18.26.1 Testing by Manufacturer**

The Manufacturer will carry out all tests on materials, quality control tests, dimensional checking and routine tests on parts to ensure that the pumps and materials conform to the requirements of the relevant SANS or BS specifications and to this Specification. The Engineer will not necessarily attend these tests but records must be kept and all test results will be made available to the Engineer.

##### **M18.26.2 Witnessed Testing**

In addition to the above, a number of performance tests will also be carried out in the testing facility of the supplier before equipment is transported to Site. These tests can be carried out in the workshop of the manufacturer/supplier if it is suitably equipped or another approved test facility.

The Engineer may witness these tests and the Contractor will notify the Engineer two weeks in advance of the date and place at which the equipment may be inspected and tested. When tests and inspections have met the satisfaction of the Engineer a certificate of workshop

acceptance will be issued. These certificates are a prerequisite before payment for "Materials on Site" can be passed. The Engineer's acceptance will in no way relieve the Manufacturer of any of his obligations to design, manufacture and supply pumps strictly in accordance with the Specification.

Performance tests shall include:-

- (a) Hydraulic tests on the pump casing. The test pressure will be equal to 1½ times the maximum working pressure at the delivery end of the pump. The testing will be done with blank flanges bolted onto the flanges. The pressure will be maintained for at least 15 minutes. No sign of sweating, leaking, undue deformation and stressing or defect of any kind will be evident during the test period.
- (b) Tests to prove that the rotating parts are dynamically balanced.
- (c) Performance tests on pump and driving unit.
- (d) NPSH requirements if called for in the Project Specifications.

A performance test shall be carried out in accordance with BS 5316 Part 2 - Class B tests if specified. Unless otherwise stated, the Contractor will be required to conduct the performance test on the combined pump/motor unit.

If a performance test of the pump and its driving unit is not possible at the manufacturer's works, this shall be stated in the Tender with reasons to allow the Engineer opportunity to make alternative proposals.

M18.26.3 Testing by an Independent Facility

The Employer may require that an independent testing facility or institution such as the South African Bureau of Standards carry out performance tests. A separate item for performance testing will be provided in the Schedule of Quantities to allow for this.

M18.26.4 Failure to Pass Performance Test

Should the pump unit fail the performance test, whether performed at the manufacturer's works or at an independent institution, the Engineer shall authorise any amendments to the plant which may be considered necessary to meet the guaranteed quantities within the permissible tolerances laid down in BS 5316 Part 2 - Class B tests and prove with further test that the equipment conform to the Specification.

All costs involved in the re-testing of pump units will be borne by the Contractor.

Should the pump unit fail to pass the test with more than 5% variation on the actual guaranteed figures; the engineer will reject the pump unit and request the Contractor to replace the unit so rejected.

Should the pump unit still fail to pass the test, but the actual figures do not vary by more than 5% from the actual guaranteed figures, the Engineer may :-

- (a) Request the Contractor to carry out amendments to ensure the compliance of the unit with the Specification; or
- (b) Accept the equipment but impose a penalty for non-compliance on the Contractor. A sum will be calculated based on the additional energy used over the life expectancy of the equipment and this will be deducted from the Contract price for each pump set for every kilowatt by which the gross demand exceeds the guaranteed figure with permissible tolerances.

**M18.26.5**      **Commissioning**

On completion of the installation the Contractor will check all items for satisfactory functioning. He will then inform the Engineer of his intention to commission the plant. The Engineer may request control measurements on pump alignment at this stage.

A detailed programme of his proposed commissioning procedures will be submitted not later than two weeks prior to the commissioning date.

After a successful running period of 4 hours (to be witnessed by the Engineer) the Contractor will hand over the installation to the Employer as well as the Operation and Maintenance Manuals. The Completion Certificate will only be issued after the units have been in successful operation for 14 consecutive days and the acceptance tests successfully completed.

During the first 14 days of operation, the Contractor will rectify any problems with the units on Site within 24 hours of being telephonically notified. During the remainder of the maintenance period, the Contractor will, within 14 days of being notified, commence rectifying any possible problems that the Employer may encounter with the equipment supplied under this Contract.

Should the Contractor fail to meet the above requirements, the Employer may appoint others to undertake the necessary repair work at the Contractor's cost.

**M18.26.6**      **Tests at the Site of the Works**

The Engineer may require that site tests are performed to verify performance figures guaranteed by the Contractor. Flow rate, total head and power input to the pump/motor units shall be determined, as accurate as Site conditions permit, for one or more points on the pump curves close to the specified duty point. The Contractor shall provide suitable instruments with recent calibration certificates.

Should these measured and calculated quantities differ from those guaranteed by more than the tolerances allowed by BS 5316 Part 1 - re-testing of the unit at any testing facility, or the recalibration of the measuring instruments.

Should the subsequent test results still fall outside the allowable tolerances, Clause M18.28.4 shall apply, and call costs shall be borne by the Contractor. In the event of the subsequent test being successful, costs shall be borne by the Employer.

**M18.27**      **COLOUR CODES**

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

**M18.28**

**MEASUREMENT AND PAYMENT**

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

The tendered rates or sums shall cover the cost of design, drawings, manufacture, supply, testing at the manufacturers works, delivery to site, off loading, installation, site testing, setting into operation, the supply of O & M manuals, commissioning and maintenance during the warranty period of all equipment specified and also for anything not specifically mentioned but obviously required, (e.g. all ancillaries, including all bolts, fastenings and brackets, safety guards and any work or material required for the proper installation of such equipment) to enable the equipment to be installed and/or function safely and correctly as specified. No claims whatsoever for extras will be allowed on the grounds that a necessary piece of equipment or a part thereof is not specifically mentioned.