3 CENTRIFUGAL PUMPS (VERTICAL SPINDLE & HORIZONTAL DRY WELL)

3.1 GENERAL

3.1.1 Scope

1 This Part specifies the requirements for the design, manufacture construction, installation testing and commissioning of vertical spindle, single-suction, dry-well, non-clog, centrifugal type pumps, to handle sewage, surface and groundwater as specified.

2 Related Sections and Parts are as follows:

This Section

Part 1, ... General

Section 1, General
Section 8, Drainage Works
Section 10, Instrumentation, Control and Automation
Section 21, Electrical Works

3.1.2 References

1 The following standards or revised/updated versions and documents of other organisations are referred to in this Part:

ASME V ..... Boiler and Pressure Vessel Code, Nondestructive Examination

ASME VIII Div. 1.. Boiler and Pressure Vessel Code, Design and Fabrication of Pressure Vessels

BS 4,..... Structural steel sections; (EN 10025 Hot rolled products of structural steels; EN 10056 Structural steel equal and unequal leg angles; EN 10210 Hot finished steel structural hollow sections)

BS 449,..... The use of structural steel in building (EN 1993- Eurocode 3: Design of steel structures)

BS 970 (ISO 683) Specification for wrought steels for mechanical and allied engineering purposes; (ISO 683-1 Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering; ISO 683-2 Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering; ISO 683-3 Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels; ISO 683-4 Heat-treatable steels, alloy steels and free-cutting steels — Part 4: Free-cutting steels; ISO 683-5 Heat treatable steels, alloy steels and free-cutting steels — Part 5: Nitriding steels; EN 10250-4: Open die steel forgings for general engineering purposes - Stainless steels; EN 10095 Heat resisting steels and nickel alloys; BS PD 970 Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels; EN 10089 Hot rolled steels for quenched and tempered springs. Technical delivery conditions; EN 10277 Bright steel products. Technical delivery conditions; EN 10278 Dimensions and tolerances of bright steel products; EN 10088-1 Stainless steels - List of stainless steels; EN 10088-3 Stainless steels - Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes;)

BS 1400,..... Specification for copper alloy ingots and copper alloy and high conductivity copper castings; (EN 1982 - Copper and copper alloys. Ingots and castings)

BS 3100,..... Specification for steel castings for general engineering purposes (EN 10293 - Steel castings. Steel castings for general engineering uses)

BS 3170,..... Specification for flexible couplings for power transmission

BS 3468, (ISO 2892) .Specification for austenitic cast iron; (EN 13835- Founding. Austenitic cast irons); (ISO 2892- Austenitic cast irons — Classification)

BS 4999, (IEC 60034, 60072) General requirements for rotating electrical machines; (IEC 60034 Rotating electrical machines- ; IEC 60072 Rotating electrical machines - Dimensions and output series -)

BS 5304,..... Code of practice for the safety of machinery (BSI PD 5304 -Guidance on safe use of machinery)

BS 5512, (ISO 281) Method of calculating dynamic load ratings and rating life of rolling bearings; (ISO 281- Rolling bearings — Dynamic load ratings and rating life)

BS 6105, (ISO 3506) .Specification for corrosion-resistant stainless steel fasteners; (ISO 3506- Fasteners — Mechanical properties of corrosion-resistant stainless steel fasteners)

BS 6861, (ISO 21940-11; ISO 21940-14) Mechanical vibration. Balance quality requirements of rigid rotors; (ISO 21940-11 Mechanical vibration — Rotor balancing - Part 11: Procedures and tolerances for rotors with rigid behaviour; ISO 21940-14 Mechanical vibration - Rotor balancing - Part 14: Procedures for assessing balance errors)

BS 7613,..... Specification for hot rolled quenched and tempered weldable structural steel plates; (EN 10025-1 Hot rolled products of structural steels - Part 1: General technical delivery conditions; EN 10025-6 Hot rolled products of structural steels - Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition)

DIN 1.4462 ..... Duplex Stainless Steel; (1.4462 Stainless duplex austenitic-ferritic, chromium nickel molybdenum steel; EN 10088-3 Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes)

EN 1092..... Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated

EN 1561, (ISO 185) Founding - Grey cast irons; (ISO 185 - Grey cast irons — Classification)

EN 10113 ..... Hot-rolled products in weldable fine grain structural steels; (EN 10025-1 Hot rolled products of structural steels - Part 1: General technical delivery conditions; EN 10025-3 Hot rolled products of structural steels - Part 3: Technical delivery conditions for normalized/normalized rolled weldable fine grain structural steels; EN 10025-4 Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels)

ISO 10816-1 ..... Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 1: General guidelines; (ISO 20816-1 Mechanical vibration — Measurement and evaluation of machine vibration — Part 1: General guidelines)

ISO 10816-7 ..... Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts

ISO 9906 ..... Rotodynamic pumps — Hydraulic performance acceptance tests — Grades 1, 2 and 3: Grades 1, and 2 Acceptance tests for centrifugal mixed flow and axial flow centrifugal pumps part 1, class S test.

ISO 21940-11 ..... Mechanical vibration — Rotor balancing — Part 11: Procedures and tolerances for rotors with rigid behaviour

ISO 21940-14 ..... Mechanical vibration — Rotor balancing — Part 14: Procedures for assessing balance errors

Stainless Steel - Austenitic - 1.4571 (316Ti); (EN 10088-3 Stainless steels - Part 3: Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes)

3.1.3 Submittals

1 In addition to the requirements of Part 1 of this section the Contractor shall provide data and information as described in the following paragraphs.

2 Design Data

(a) the Contractor shall provide manufacturer's published pump curves, system curves , parallel operation curves (All pumps) and the necessary hydraulic calculations to justify the sizes of any pumps selected.

3 Shop Drawings

(a) the Contractor shall provide the following:

(i) duty impeller diameter

(ii) maximum impeller diameter

(iii) minimum impeller diameter

(iv) velocity of liquid in pump suction at duty point

(v) velocity of liquid in pump delivery at duty point

(vi) velocity of liquid in the pump casing or impeller eye at duty point

(vii) net positive suction head

(viii) the materials of construction shall be specified in detail and itemised against a sectional drawing of the pump motor, drive shafting and flywheel proposed.

(ix) characteristic curves for the full range of impeller diameters.

(b) after approval of the pump types the Contractor shall submit the test data as required under factory inspection and testing

4 Operation and Maintenance Manuals and Instructions. The Contractor shall include all the documentation provided as above and the results of all the factory and site inspection and testing in the manuals

3.2 PRODUCTS

3.2.1 General

1 Pumps and drives shall be rated for continuous duty and shall be capable of pumping the flow range specified in the Project Specification without surging, cavitation, or vibration.

2 The flow rate at the generated duty point shall be between 90% to 110 % of the Best Efficiency Point.

3 The pumps shall meet maximum allowable shut-off head and maximum allowable required net positive suction head (NPSH) specified in the Project Specification.

4 The Contractor shall verify the NSPHA value prior to ordering pumps.

5 The pumps shall not overload the motors for any point on the maximum speed pump performance characteristic curve within the limits of stable pump operation as recommended by the manufacturer to prevent surging, cavitation, and vibration, as well as throughout the entire pump operating range.

6 To ensure vibration-free operation, all rotative components of each pumping unit shall be statically and dynamically balanced to BS 6861, ISO 21940-11 and the following requirements shall be met:

(a) the mass of the unit and its distribution shall be such that resonance at normal operating speeds is avoided

(b) in any case, the amplitude of vibration as measured at any point on the pumping unit, motor or drive shafts shall not exceed the below limits 3.2.2.

(c) at any operating speed, the ratio of rotative speed to the critical speed of a unit, or components thereof, shall be less than 0.8 or more than 1.3.

7 Vibration outside the below limits shall be sufficient cause for rejection of the equipment.

8 All parts of each pump shall be designed to withstand the stresses that will be imposed upon them during their handling, shipping, erection, and operation.

9 The completed units, when assembled and operating, shall be free of cavitation, vibration, noise, and oil or water leaks over the range of operation.

10 All units shall be so constructed that dismantling and repairing can be accomplished without difficulty.

11 The pump supplier shall be responsible for proper operation of the complete pumping system, which includes the pump, motor, variable speed drive unit (if designated), and associated controls furnished with the pump.

12 For the performance curve of the selected pump impeller, head shall continuously rise as flow decreases throughout the entire curve from runout to shutoff head.

13 The Contractor shall ensure that drive motors, variable speed drive or softer starter systems (if designated) and pumps are furnished and tested together by the pump manufacturer, who shall supply full certification for the proper function of the entire pumping system, within the limits of the designated design conditions.

14 If variable speed drive systems are specified, motor and drive system shall be fully compatible, and shall be of sufficient power and torque, and be capable of sufficient heat transfer for starting, accelerating and continuously operating over the entire range of head/capacity conditions, from minimum to maximum pump operating speed, as designated.

3.2.2 Design Conditions

1 Pumps shall be designed and constructed to satisfactorily operate and perform within the designated design conditions and the requirements specified herein. They shall be designed for a life of 20 years with service intervals at 20,000 hours.

2 Castings, fabrications, machined parts and drives shall conform to the industry standards for strength and durability and shall be rated for continuous duty over the entire operating range.

3 Bearings shall be of the anti-friction type designed for an L10 life of at least 100,000 hours in accordance with BS 5512 ; ISO 281.

4 Pump and motor maximum operating speed shall not exceed 1500 rpm, unless a lower speed is specified in the Project Specification.

5 Pumps shall be of non-clog design, capable of passing spheres of a minimum 100 mm diameter unless other diameters are designated.

6 Pumps shall be suitable for use in the conditions specified in Section 1. The pumped media temperature shall be taken as 40 °C.

7 Renewable impeller wear rings shall be fitted, to the impeller and volute case, except where not available on a standard production unit.

8 Vibration levels of pump shall not exceed the levels given in ISO 10816 Part 1 and Part 7 quality bands A and B. for the measurement and classification of mechanical vibration.

9 The pump, motor and associated electrical equipment shall be rated for a minimum of 10 starts per hour, unless otherwise designated.

10 The Contractor shall ensure that the pump manufacturer provides certification which guarantees the following:-

(a) flow rate
(b) total head
(c) power input
(d) efficiency
(e) NPSH required

3.2.3 Materials

1 Pumps shall be manufactured of the following materials as a minimum:

(a) volute casings shall be Ni-resist cast iron, EN 1561, Grade 250
(b) impellers shall be duplex stainless steel DIN 1.4517;
(c) impeller wear rings shall be of duplex stainless steel DIN 1.4462;
(d) casing wear rings shall be of non ferrous or stainless steel BS970-1 Grade 316 S31 with good anti- seizure propertied against the rotating element. There shall be a difference of at least 50 points Brinell hardness of the opposed wear surfaces;

(e) suction elbows shall be cast or ductile iron, EN 1561, Grade 250

(f) stuffing box covers shall be cast iron, EN 1561, Grade 250

(g) bearing frames shall be cast iron, EN 1561, Grade 250

(h) pump shafts shall be of Duplex stainless steel conform to DIN 1.4462 or a suitable duplex ferritic – austenitic stainless steel;

(i) pump shaft sleeves shall be stainless steel Grade 316 S31;

(j) fasteners shall be stainless steel to BS 970-1 Grade 316 S31.

(k) fly wheels if fitted shall be steel, BS 3100.

2 Supporting steelwork for bearings, drive shafts, platforms, ladders and stairways shall comply with BS 4, BS 449, BS 7613 and EN 10113 as applicable.

3 Additional or other requirements for materials of construction may be specified in the Project Specification

3.2.4 Fabrication

1 General: The pump shall be fabricated in accordance with the following requirements, and as described in the following paragraphs.

(a) pumps shall be capable of handling raw, unscreened sewage, effluent, storm or groundwater as required

(b) all castings shall be produced in accordance with the pump manufacturer's specifications under the manufacturer's direct supervision

(c) components shall conform with the requirements listed in the following paragraphs.

2 Volute casings:

(a) volute casings shall be large enough at all points to pass any size solid which can pass through the impeller

(b) wall thickness shall be sufficient to withstand all stresses in service at full operating pressure

(c) volute casings and integral discharge nozzle shall be cast in one piece, with smooth water passage lined with a proprietary corrosion and erosion liner to the manufacturer's recommended specification,

(d) a hand hole (minimum size 75 mm by 125 mm) shall be provided near discharge flanges for inspection and cleaning. The inner contour of hand hole covers shall conform to that of volute casings

(e) a minimum 12 mm brass or stainless steel tap shall be provided on the top and bottom of discharge nozzles, next to discharge flanges, for venting and draining

(f) volute casings shall be so arranged that impellers may be removed without disturbing either suction or discharge piping.

3 Impellers:

(a) impellers shall be cast or machined in one piece

(b) impellers shall be designed with smooth water passages to prevent clogging by string or fibrous materials

(c) impellers shall be fitted with a renewable wear ring and the casing shall be fitted with a matching wear ring

(d) entire rotating assemblies shall be designed so that they may be withdrawn from pump assemblies without disturbing the suction or discharge piping connections

4 Suction elbows:

(a) suction elbow shall be supplied by the pump manufacturer as DI flanged long radius reduced elbow with integral lining to resist cavitation.

(b) (b) a minimum 25 mm brass or stainless steel pipe tap shall be provided near the suction flanges for a pressure gauge connection.

5 Stuffing boxes:

(a) stuffing box covers shall be accurately machined to fit onto the volute casing and shall be of sufficient thickness to withstand the pressure imposed upon it under operating conditions. Stuffing box cover and back vanes of the impeller shall allow water cooling to the gland packing.

(b) stuffing boxes shall be cast integrally with the stuffing box cover and shall be of sufficient depth to hold at least 5 rings of packing

(c) soft-packed glands shall be designed for grease or water lubrication and shall be provided with large size grease lubricators with indicators

(d) glands and lantern rings shall be split to facilitate easy repacking and shall have tapped easy withdrawal holes on the upper face.

6 Bearing frames, bearing housings, and bearings:

(a) bearing frames shall be cast in one piece

(b) frames shall carry both radial and thrust bearings

(c) outboard bearings shall be the thrust bearing and the housing shall be designed to provide an axial clearance adjustment downward between the impeller and suction cover by use of shims or other suitable means

(d) bearing housings shall be fitted with suitable grease seals to prevent loss of grease and to prevent entrance of contaminants

(e) frames shall be provided with a tapped hole with a minimum diameter of 25 mm, located as low as practicable to drain the leakage from packing glands

(f) bearing frames shall be accurately machined, centered, and securely bolted to volutes and stuffing box cover assemblies

(g) construction shall be such that entire rotating assemblies may be removed without disturbing the suction or discharge piping

(h) large openings shall be provided adjacent to stuffing boxes to facilitate adjustment and repacking

(i) upper bearings shall be the thrust type and shall carry the entire pump thrust load

(j) bearings shall be grease lubricated with a provision for forcing out the old grease and limiting back pressure.

7 Supporting bases:

(a) pumps shall be furnished with a suitable supporting base either cast integrally with the volute or otherwise attached to the pump casing

(b) bases shall provide openings large enough to permit access to suction elbows and cleanout hand holes

(c) bases shall be designed to support the assembled weight of the pump and shall safely withstand all stresses imposed thereon by vibration, shock, and all possible direct and eccentric loads

(d) pump bases shall be of an adequate horizontal dimension to provide sufficient footing contact area and anchorage facilities

(e) the height of pump bases shall be such that the suction flange will clear the floor, footing surfaces or ducts, with sufficient space allowed for dismantling bolts.

8 Pump shafts:

(a) pump shafts shall be of such diameter that they will not deflect more than 0.05 mm at the face of the stuffing box while operating at the maximum design speed, as determined by calculations from the manufacturer

(b) the entire length of shafts shall be turned, ground, and polished

(c) a renewable shaft sleeve shall be provided over shafts through the stuffing box

(d) shafts shall be key-seated for securing the impeller and coupling Details of the fixing arrangements shall be indicated in the proposal.

(e) sleeves shall be secured either by key or suitable locking screw to the Engineer's approval.

(f) Shaft sleeves shall be stainless steel EN 1.4571 (316Ti) and sealed internally to prevent leakage along the shaft.

9 Drive shafts:

(a) vertical shafting shall be connected to drive motors with a direct, close coupled connection or of the flexible type, consisting of sections with flanged universal joints and intermediate bearings and Plummer blocks as designated or required

(b) splined connections shall be provided adjacent to the pump

(c) mating steel flanges for connection to driver and driven units shall be furnished

(d) shafts shall be designed for continuous duty to transmit the maximum output torque and power of the units

(e) components shall be adequately sized and designed for the service intended, including transient due to power failure

(f) all shaft sections shall be statically and dynamically balanced individually. Shaft sections shall not exceed 3 m and shall run below their first critical speed

(g) intermediate shaft support bearings shall be of the anti-friction type, grease lubricated, mounted in Plummer blocks dowelled to the supporting steel work

(h) slip splines in drive shafts shall permit removal of the pump rotating assemblies without removal of any section of intermediate shafting, bearings, or discharge piping

(i) intermediate bearings shall be supported by steel channel sections either fixed in position on the dry well walls, or mounted on a substantial frame with support from the dry well walls. There shall be no transmission of vibration from each bearing.

10 Ring bases and base plates:

(a) pump drive units shall be mounted on a suitable cast iron or fabricated steel ring base with adequate clearance and openings to provide ready access to the upper shaft coupling

(b) ring bases shall be a minimum of 250 mm high and shall be rugged enough to support the full weight of the motor

(c) base plates shall be square and shall be of sufficient thickness to support the drive assemblies

(d) base plates shall be drilled to accommodate the size and number of anchor bolts required

(e) where designated, bases shall be mounted on a suitable bolted, removable framing to cover access openings.

11 Fly wheels:

(a) fly wheels shall be fitted where required for surge protection and to achieve smooth start and smooth stop to avoid NRV slamming

(b) fly wheels shall be mounted in a housing directly beneath the drive motor and above the motor room floor, if the motors are mounted in a motor room

(c) the top bearing housing and drive shaft shall carry the flywheel. Unless agreed by the Engineer, the fly wheel shall not be mounted on the motor shaft

(d) fly wheels shall be statically and dynamically balanced to BS 6861 and shall be positively keyed to the drive shaft

(e) flywheels shall be designed such that there is an even tangential stress distribution throughout the flywheel

(f) flywheel speeds shall not exceed $30ms^{-1}$ for cast iron and $50ms^{-1}$ for cast steel.

12 Motors:

(a) motors shall be in accordance Section 21

(b) motors shall be 3 phase 50 Hz, voltage as specified in the Project Specification

(c) motors shall be squirrel cage, induction air cooled to IP 54, as a minimum, unless specified otherwise in the Project Specification

(d) motors shall be derated for variable speed operation

(e) Motors above 75 KW shall be provided with bearing vibration monitoring on 2 axes

(f) Motors above 75 KW shall be provided with winding temperature monitoring PT100 or similar subject of Engineers/Client approval.

13 Pump Control Systems: Pump control systems shall be furnished and installed in accordance with Section 10 and the Project Specification.

14 Coatings:

(a) all parts of the pump shall be fusion bonded epoxy coated to a minimum thickness of 300 microns. External parts and the motor shall be coated as the paint specification in Section 8

(b) Coupling, pump shaft and impeller shall be balanced together to ISO 1940 quality level G 6.3 prior to final assembly.

(i) drive motor / flywheel coupling.

(ii) flywheel / drive shaft coupling.

(iii) drive shaft / pump coupling.

3.2.5 Accessories

1 The following accessories shall be provided for pumps:

(a) guards. Substantial galvanised perforated guards shall be provided at all exposed couplings, drives and shafts, in accordance with Part 1. The guards shall extend the whole length of the shaft and include hinged access doors at lubrication/inspection points for all points requiring maintenance

(b) pressure gauges. The suction and discharge nozzle of each pump shall be provided with a 19 mm diameter tapped opening, stainless steel or brass isolating valves and diaphragm gauges as Part 1

(c) volute bleed-off. Each pump shall be installed with a volute automatic air bleed-off brass valve from high point of the volute, venting via pipe to the wet well as below. 25mm tee with isolation valve and piping to drain channel, shall be given below the air bleed-off valve for manual venting of the air in the casing.

(d) access ladders, stair ways and platforms shall be provided to all points requiring maintenance, including couplings, bearings and sliding joints, as Sections 8, 16 and 17.

2 Arrangements shall be made for draining away to the drainage channel or sump any water which leaks from pump glands or any other source using 50 mm minimum diameter stainless steel pipe.

3 Vibration sensors (in both axial and traverse direction) and temperature sensors shall be fixed on large pumps and motors (i.e. above 75 KW) for condition monitoring. Similarly vibration sensors (in both axial and traverse direction) shall be provided for the plumber block bearings of the drive shaft and the data should be made available in the SCADA panel.

3.2.6 Factory Inspection and Testing

1 The Contractor shall secure from the pump manufacturer certification that the following inspections and tests have been conducted on each pump at the factory, and submit to the Engineer prior to shipment:

(a) the pump casing has been tested hydrostatically to 1.5 times the maximum closed valve pressure

(b) impeller, motor rating and electrical connections checked for compliance with the Specifications

(c) motor insulation tested for moisture content or insulation defects

(d) the insulation test (b) above has been performed again after the performance test (2) below.

(e) Net Positive Suction Head (NPSH) require.

2 The Contractor/Manufacturer shall submit detailed and complete shop testing procedure for the pump at early stage of factory internal performance test.

(a)

3 Each pump has been factory tested with job motor for performance according to ISO 9906 Grades 1, and 2, including:

(a) flow

(b) inlet pressure

(c) outlet pressure

(d) motor power

(e) torque

(f) efficiency

(g) Net positive suction head (NPSH) required.

4 Factory internal performance test reports for all the pumps shall be submitted for review and approval.

5 The pump curves shall be plotted at minimum five heads/flow rates together with efficiencies, NPSH and power etc.

6 Tolerance for flow and heads shall be in accordance with ISO 9906 – Grade 1 and 2. However for efficiency, no negative tolerance is acceptable.

(a)

7 The Contractor shall secure from the pump manufacturer the following 301 ytpe certification and submit to the Engineer prior to shipment.

(a) certified copies of the pump characteristic curves and reports generated by the tests described above and as required by ISO 9906 Grades 1,and 2

(b) foundry Composition Certificates for all major castings (pump case, impeller, motor housing) showing exact material composition and tests conducted to ensure compliance with the pump manufacturer material specifications

(c) Material certificate for the pump shaft and wear rings.

(d) non-destructive test certificates for major parts as "pump shaft" and "impeller" to be issued under ASME V requirements

(i) Ultrasound test (UT) method for pump shaft shall satisfy the required criteria of ASME VIII Div.1 Appendix 12.

(ii) Magnetic particle inspection (MPI) and/or dye penetration inspection (DPI) methods for impeller shall satisfy the required criteria of ASME VIII Div. 1 Appendices 6, 8 and/or 7.

(e) driving shaft balancing certificate as ISO 1940 requirements with balancing quality level G16.

3.2.7 Spare Parts and Tools

1 The Contractor shall provide from the pump manufacturer all the spare parts and tools required during the commissioning and maintenance periods as specified in Part 1, including those below:

(a) one set of complete bearings

(b) three sets of stuffing box packing

(c) one complete coupling

(d) one set of wear rings

(e) two sets of rubber coupling buffers

(f) one set of shaft sleeves

(g) three lantern rings for packing box.

2 The Contractor shall supply, furnished by the pump manufacturer, a complete set of all special tools required for maintenance of the pumping equipment, in a lockable tool box, complete with the list of spares.

3.3 INSTALLATION AND COMMISSIONING

3.3.1 Installation and Commissioning

1 The equipment delivered to the Site shall be examined by the Engineer to determine that it is in good condition and in conformance with the approved working drawings and certification. All equipment shall be installed in strict conformance with Part 1 of this Section and the manufacturer's instructions.

3.3.2 Site Inspection and Testing

1 The Contractor shall provide the services of the pump manufacturer's representative to supervise the installation and commissioning of the pumping equipment.

2 The commissioning tests shall be performance and reliability trials, mainly for the purpose of satisfying the Engineer that the pumpsets have been correctly assembled and installed and that their performance matches that obtained during the manufacturer's works tests. In the event of an unwarranted change in the pump performance characteristics or power consumption, all necessary steps shall be taken as soon as possible to establish the cause and remedy or rectify the fault. Similar action shall be taken for an undue increase in bearing or gland temperature, increased gland leakage rates, unsatisfactory vibration levels or any other fault or defect in the operation of the pumpset.

3 The site reliability trials shall include the following:

(a) a record of bearing and coupling clearance and alignments shall be tabulated to show the "as-built" condition of each pump

(b) a record of all overload, timing relay and oil pressure relays shall be tabulated to show the "as-built" condition of each motor starter

(c) all cables shall be "megger" tested to confirm the integrity of the insulation. A tabulated record of results shall be made

(d) the control panel shall be statically tested with motors disconnected to confirm the correct sequence of operation

(e) each pump shall be operated individually over the range from closed valve to maximum emergency top water level on a recirculation basis using fresh water and for a minimum of four hours continuously. During this test the following parameters will be recorded:-

(i) motor phase currents and voltages

(ii) pump output

(iii) ambient and test water temperatures

(iv) motor/pump casing temperature

(v) power consumed

(vi) power factor

(vii) vibration

(viii) signs of cavitation noise

(f)

(g) the commissioning trials shall extend until each pump unit has run 'continuously' for at least 3 days under all operating conditions. The term 'continuously' shall include running at various speeds or on a start/stop basis as determined by the control system

(h) the Contractor's supervisory staff, and the pump manufacturer's staff if required by the Project Specification, shall be present during the period of the tests and trials. The Contractor shall be responsible for any failure of the whole equipment or any part thereof, whether such failure shall be determined by the methods detailed herein or otherwise. If the pump test or trial is interrupted by the Contractor, or through negligence on the part of the Contractor's staff, it shall be completely repeated for the pumpset concerned.

4 The operation, over the entire specified range, shall be free of cavitation, excessive vibration or noise.

5 Vibration shall be checked and recorded. The full speed vibration of all pumps shall be within acceptable limits as 3.2.2. Excessive vibration shall constitute sufficient cause for rejection of the equipment.

6 Each pump performance shall be documented by obtaining concurrent reading showing motor voltage and amperage, pump suction head and pump discharge head as follows:

(a) readings shall be documented for a least four pumping conditions to ascertain the actual pumping curve

(b) one test shall be at shutoff head

(c) each power lead to the motor shall be checked for proper current balance.

7 Bearing temperatures shall be determined by a contact type thermometer. A running time of at least two hours shall be maintained at the maximum specified operating head.

8 In the event any of the pumping equipment fails to meet the above test requirements, it shall be modified and retested in accordance with the requirements of this Section until it meets the specified requirements, and approval of the Engineer.

END OF PART