4 CENTRIFUGAL PUMPS (SPLIT CASING)

4.1 GENERAL

4.1.1 Scope

1 This Part specifies the requirements for the design, manufacture construction, installation testing and commissioning of single stage centrifugal split casing pumps, to handle treated sewage effluent, surface and ground/potable water Pumps 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

4.1.2 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)

BS 7854 ..... Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts - ; (BS 7854-2 Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts - Large land-based steam turbine generator sets in excess of 50 MW: ISO 20816-2 Mechanical vibration. Measurement and evaluation of machine vibration - Land-based gas turbines, steam turbines and generators in excess of 40 MW, with fluid-film bearings and rated speeds of 1 500 r/min, 1 800 r/min, 3 000 r/min and 3 600 r/min ; BS 7854-3 Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts - Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ ; BS 7854-4 Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts - Gas turbine driven sets excluding aircraft derivatives: ISO 20816-4 Mechanical vibration. Measurement and evaluation of machine vibration - Gas turbines in excess of 3 MW, with fluid-film bearings)

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 1563 .....Founding - Spheroidal graphite cast irons; (ISO 1083 Spheroidal graphite cast irons — Classification; ISO 17804 Founding — Ausferritic spheroidal graphite 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)

EN 22339 .....Taper pins, unhardened (ISO 2339)

ISO 281 .....Rolling bearings — Dynamic load ratings and rating life

ISO 2339 .....Taper pins, unhardened

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 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 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

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)

DIN 1.4517 .....Cast Stainless Steel (duplex stainless steel formulated for casting: EN 10213 Steel castings for pressure purposes; EN 10283 Corrosion resistant steel castings)

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)

4.1.3 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 curve (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.

4.2 PRODUCTS

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

3 The Contactor shall verify the NSPHA value prior to ordering of pumps.

4 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.

5 To ensure vibration-free operation, all rotating components of each pumping unit shall be statically and dynamically balanced to 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 4.2.2.

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

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

7 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.

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

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

10 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.

11 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.

12 The Contractor shall ensure that drive motors, variable speed drive 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.

13 If variable speed drive or soft starter 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.

4.2.2 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 plus minimum of three years of uninterrupted continuous operation or 25,000 hours operation, whichever is later. Wearing components shall have a design life of not less than 5 years or 10 years where major dismantling is required.

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 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 Horizontal shaft pumps installed on plinths at ground level are the preferred arrangement.

6 Pumps shall be suitable for use in the conditions specified in Section 1. The pumped media temperature shall be taken as 40 °C to 45ºC.

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) Duty Head
(c) power input
(d) efficiency
(e) NPSH required

11 Water velocity in pump suction and discharge nozzles shall not exceed 4 and 5 m/s respectively at maximum operating condition within pump operation specified range.

12 The optimum efficiency of the pump shall not be less than 85% at rated duty point unless specifically mentioned otherwise, and shall be designed for parallel operation of duty pumps. The minimum efficiency shall not be less than 70% at any other operating point located within specified pump operation range.

13 The minimum flow for each pump shall not exceed 40% of the best efficiency flow.

14 The maximum flow for each pump shall not be less than 110% of the rated flow at best efficiency point at rated speed.

15 The pump capacity at run-out conditions shall not be less than 130% of the duty point unless specifically mentioned otherwise.

4.2.3 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 for sewage, treated effluent and ground/potable water Pumps 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 BS 970-1 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 or EN 1563, 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 duplex stainless steel to DIN 1.4462.
(i) pump shaft sleeves shall be stainless steel Grade 316 Ti (EN 1.4571).
(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

4.2.4 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 treated sewage effluent, stormwater or ground/potable water Pumps 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.

(d) components that would come in contact with chlorine/chlorine dioxide shall, as far as resistant & tolerant to chlorine up to 0.8 ppm and chlorine dioxide upto 0.6 ppm. Material compatibility to be justified by the supplier.

(e) The casing shall be provided with vent and drain connections, screwed type, and fitted with removable cocks. The material of construction for the removable cocks shall be stainless steel 316.

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) volute casings shall be of the double volute type split axially with the suction and delivery branches, bearing housing and feet cast integrally with the same half casing, thus enabling the whole of the rotating assembly to be removed without opening pipe joints or disturbing the alignment of the pumpset.

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

(d) volute casing halves shall be cast in one piece, with smooth water passage lined with a proprietary corrosion and erosion lining to the Manufacturer's recommended specification,

(e) two lifting screws eye bolts shall be fitted to the upper casing

(f) 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

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

(h) the split casing pumps shall be constructed of two half casings fitted with tapered guide pins to EN 22339 to ensure accurate alignment on re-assembly. The casing joint shall be a metal face to face joint with a non hardening sealing compound, no jointing gasket shall be used. Metal face to face joints shall be flat and parallel with a maximum gap of 0.05mm, mating faces shall have a surface finish of 0.8 microns C.L.A or better.

(i) Pump casings shall have a minimum corrosion allowance of 3 mm unless otherwise specified on the data sheets.

3 Impellers:

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

(b) impellers shall be designed with smooth water passages and finished to smooth surfaces, they shall be balanced statically and dynamically as a whole assembly together with the shaft and secured on the shaft by a suitable locking nut arrangement..

(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

(e) impellers shall be double entry shrouded type, and shall be fully balanced and supported between bearings.

(f) impellers shall be supplied from the manufacturers standard range and shall not be trimmed or cropped to meet the specified duty.

(g) Impellers shall be selected from middle range for their pump casing and shall be sized such that a larger impeller (with 10% increase in diameter) capable of supplying an additional 25% flow can be fitted in the pump casing with no modifications.

4 Bearings:

(a) Pumps bearing shall be Ball or Roller bearing of antifriction maintenance free standard type. The bearing shall be easy to replace and protected against ingress of dust and moisture by effective seals. Bearing supports shall not be bolted type and shall be part of pump casing lower half only. Where bearings are pressure lubricated, they shall be supplied complete with the associated lubricating oil system.

5 Mechanical Seal:

(a) The shaft seal shall be of the mechanical type and designed to suited for both intermittent and continuous running under all operating conditions. Lubricating and cooling water for the seals shall be drawn from external source/connections. The sealing construction and design should enable the inspection and removal the seals without disturbing the pumps.

(b) An inline filter shall be provided in the flush line to prevent any foreign material entering the seal chamber.

6 Suction elbows:

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

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

7 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. The 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 or water connections 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.

8 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, centred, 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.

9 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.

(f) Motors of horizontal pumps shall be mounted on an extension of the pump base plate and shall drive the pump directly through a flexible coupling.

(g) Motors of close coupled vertical pumps shall be mounted on an extension of the pump support frame and shall drive the pump directly through a flexible coupling.

(h) Remotely driven vertical pumps shall have a plummer block bearing mounted on an extension of the pump support frame and shall drive the pump directly through a flexible coupling between the plummer block and pump shaft, the drive shaft between the plummer block and motor shall have flexible couplings at each end.

10 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 where exposed to the process fluid and through the stuffing box

(d) shafts shall be key-seated for securing the impeller and coupling. Detail of the fixing arrangement 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 (316 Ti) and sealed internally to prevent leakage along the shaft by means of mechanical seal.

11 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 concrete beam, or 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.

12 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.

13 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.

14 Motors:

(a) shall be in accordance with 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 de-rated for variable speed operation

(e) motor shall be sized to be able to drive the larger impeller (as per 4.2.4.- 3g) with no modification.

(f) An over-rating of 15% higher than the maximum power required at point of 110 % of the duty point. Of Q-H curve.

(g)

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

16 Coatings:

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

17 Couplings:

(a) 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.

4.2.5 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 25 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 drain channel as below, a 25mm tee with isolation valve and piping to the drain channel, shall be provided 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 (axial and radial) and temperature sensors shall be fixed on large pumps and motors' upper and lower bearings (i.e. above 75 KW) for condition monitoring. Similarly vibration sensors (axial and radial) shall be provided for the plumber block bearings of the drive shaft, the data from all sensors should be made available in the SCADA panel.

4.2.6 Factory Inspection and Testing

1 The Contractor shall secure from the pump manufacturer certification that the following inspections Vibration and Noise 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 (c) above has been performed again after the performance test (2) below.

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

3 Each Pump shall be factory tested for performance with job motor according to ISO 9906 Grade 1E for large pumps & motors 75 KW & above

4 However smaller pumps shall be tested as per ISO 9906 Grade 2B/3B as per client's requirements:

(a) flow

(b) inlet pressure

(c) outlet pressure

(d) motor power

(e) efficiency

(f) NPSH required

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

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

7 The Contractor shall secure from the pump manufacturer the following 3.1 type 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 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, 7 and/or 8.

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

(f) Citified Visual Inspection to be provided.

(g) Certificate of Origin to be provided.

4.2.7 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 complete set 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.

4.3 INSTALLATION AND COMMISSIONING

4.3.1 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.

4.3.2 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 Confirmation/Non Objection Letter from Manufacturer's representative that installation & piping-works are done as per their recommendation and that testing and commissioning can be started. Following the completion of the installation and satisfactory startup of the equipment's, site acceptance tests for all pumps, shall be conducted over the entire speed range and pumps shall be free of cavitation or excessive vibration or noise. Performance of each pump shall be within acceptable tolerance of ISO 9906, Grade-1. In case of non-compliance to this required performance, the manufacturer/contractor shall take corrective actions as necessary to improve the performance of pumps.

3 Considering this stringent performance criteria, manufacturer must review the water quality, the piping & installation layout of pump station with locations of key equipment's such as pressure & flow transmitters and all other components that may affect the pump performance test at site

4 The commissioning tests shall be performance and reliability trials, mainly for the purpose of satisfying the Engineer that the pump sets 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.

5 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) 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

(g) 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.

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

7 Vibration shall be checked and recorded. The full speed vibration of all pumps shall be within acceptable limits as 4.2.2.14

8 Excessive vibration shall constitute sufficient cause for rejection of the equipment.

9 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.

10 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.

11 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.

4.3.3 Retention of pump efficiency for sustainable performance

1 Pumps shall offer sustainable performance over a longer period. Manufacturer shall specify efficiency after defect liability period (2 years), with tolerance limit at the time of the bidding & give warrantee for the retention of efficiency after defect liability period (2 years). After completion of defect liability period but before issuing final taking over certificate, Site tests shall be performed as explained above, to ascertain the performance with agreed tolerance. In case of non-compliance to this required performance, the manufacturer/contractor shall take corrective actions as necessary to improve the performance of pumps at his cost. Otherwise Client may carry out such rectifications from others at the risk & cost of contractor

END OF PART