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1. INTRODUCTION

This specification has been prepared to assist The Employer's personnel in the preparation of the technical information required for selection and acceptance of centrifugal pumps.

2. SUPPORTING CLAUSES

2.1 SCOPE

This specification details The Employer's requirements for the design, material selection, manufacture, inspection, testing and documentation for horizontal and vertical spindle centrifugal pumps to provide maximum efficiency and cost effectiveness in handling fluids. Slurry and submersible pumps are dealt with separately from clear medium pumps in this document.

Fire Pumps are addressed by requirements from NFPA 20 (National Fire Protection Association Standards)**.** The user to also refer to the standards here below:

- 240-134826496 Fire Pump Annual Performance Test Guideline
- 240-127420730 Fire Pump Annual Performance Test Data Collection Template

Note: The technical scope specifically excludes Critical pumps (Condensate Extraction, Condensate Polishing Booster Plant, Boiler Feedwater and Boiler Water Circulating Pumps).

Positive Displacement (PD) pumps are not addressed in this document.

2.1.1 Purpose

This specification has been prepared to assist The Employer's personnel in the preparation of the technical information required for selection and acceptance of centrifugal pumps.

2.1.2 Applicability

This document shall apply to Eskom Generation.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative)

[1] 240-101712128 Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings

[2] 240-106365693 Standard for the External Corrosion Protection of Plan, Equipment and Associated Piping with Coatings

[3] 240-50237155 New Medium Voltage Motor Procurement Standard

[4] 240-57617975 New Low Voltage Motors Procurement Standard

[5] 240-81755793 Slurry Pumping Systems Design Standard

[6] 36-1126 Specification for Corrosion Protection of Plant and Equipment with Coatings

[7] API 610 2010 Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries ISO 13709: (Identical) Centrifugal pumps for petroleum, petrochemical and

natural gas industries

[8] API 682 Pumps - Shaft Sealing Systems for Centrifugal and Rotary Pumps

[9] API 686 Design Practice Note, Recommended Practices for Machinery Installation

[10] ASME B31.1: ASME Code for Pressure Piping

[11] ASME VIII: ASME Boiler and Pressure Vessel Code (BPVC)

[12] BS EN 1092-1 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Steel flanges.

[13] BS EN 1092-2 Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Cast iron flanges

[14] BS EN 1092-3, Flanges and their joints. Circular flanges for pipes, valves, fittings and accessories, PN designated. Copper alloy flanges

[15] BS EN 60529, Degrees of protection provided by enclosures (IP) code.

[16] BS EN ISO 3274, Geometric Product Specifications (GPS). Surface texture. Profile method. Nominal characteristics of contact (stylus) instruments

[17] BS EN ISO 9906, Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1, 2 and 3.

[18] BS ISO 10816-1 to 7, Mechanical vibration. Evaluation of machine vibration by measurements on non-rotating parts.

[19] BS ISO 21940-12, Mechanical vibration. Balance quality requirements for rotors in a constant (rigid) state. Specification and verification of balance tolerances.

[20] BS ISO 3069, End-suction centrifugal pumps. Dimensions of cavities for mechanical seals and for soft packing.

[21] ISO 9001 Quality management systems – Requirements

[22] SANS 10227: Code of Practice for The Evaluation of the Technical Competence of Inspection Authorities for the Certification of Vessels under Pressure

[23] SANS 1123, Pipe flanges

[24] SANS 1465-1, Steel castings for general engineering applications Part 1: Carbon and low alloy steel castings

[25] SANS 1465-2, Steel castings for general engineering applications Part 2: Wear-resistant carbon and low alloy steel castings

[26] SANS 1465-3, Steel castings for general engineering applications Part 3: Corrosion-resistant and heat-resistant steel castings

[27] SANS 1556-1, ISO metric screw threads Part 1: Principles and basic data for general

purpose screw threads

[28] SANS 1556-2, ISO metric screw threads Part 2: Principles and basic data for general purpose screw threads

[29] SANS 3744 Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Engineering methods for an essentially free field over a reflecting plan.

[30] SANS 3746 Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane.

[31] SANS 62-1 Steel pipes Part 1: Pipes suitable for threading and of nominal size not exceeding 150 mm

[32] SANS 62-2 Steel pipes Part 2: Screwed pieces and pipe fittings of nominal size not exceeding 150 mm

[33] SANS 8501-3 Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness Part 3: Preparation grades of welds, edges and other areas with surface imperfections.

2.2.2 Informative

[34] OHS Act: Occupational Health and Safety Act, 1993

[35] PER: Pressure Equipment Regulations, 2009

[36] SANS 1431: Requirements for Structural Steel

2.3 DEFINITIONS

Definition	Description
Casing pressure	It is the composite of all major stationary pressure containing parts of the unit, including all nozzles or other parts attached thereto.
Maximum allowable casing working pressure	It is the greatest discharge pressure at the specified pumping temperature for which the pump casing is designed. The design shall conform to the requirements noted in this specification.
Maximum discharge pressure	It is the maximum possible suction pressure to be encountered, plus the maximum differential pressure the pump is able to develop when operating with a closed valve at the specified condition of speed, specific gravity, and pumping temperature, with the maximum diameter impeller that can be fitted.
Maximum suction pressure	It is the highest suction pressure to which the pump is subjected during operations.
Net Positive Suction Head available (NPSHA)	It is determined by the designer of the pumping system, and is the total suction head or inlet pressure to the pump. The NPSHA includes the suction pressure in the vessel, geodetic difference between the level in the vessel and the centre line of the pump in metres of liquid in absolute pressure (referred to the pump centreline for horizontal pumps or to the top of the foundation for vertical pumps) minus the vapour pressure of the liquid at pumping temperature in metres absolute and minus all losses in the suction line up to the pump suction flange in metres.
Net Positive Suction Head required (NPSHR)	Centrifugal pumps require enough pressure on the suction side of the pump to prevent flashing in the impeller eye. This flashing reduces the pump's

Definition	Description
	performance and can damage the impeller. The amount of pressure required for a specific pump is determined during the design of the impeller and is confirmed by testing during performance tests. “Net positive suction head” (NPSH) required or NPSHR. It is determined by the Contractor from tests performed pumping water. It is the minimum NPSH required (in metres of liquid absolute) at the rated capacity to prevent performance impairment due to cavitation.
Normal	Normal applies to the design point and best efficiency operating zone
Power consumption	It is the shaft power required by the pump (in kW) at the specified rated operating conditions.
Pump	A machine which increases the pressure of the fluid it handles. In general, pumps may be divided into two classes, the dynamic pressure type and the positive displacement type.
Rated	This applies to the specified guarantee-point operating conditions, including capacity, head, net positive suction head required, specific gravity, speed, power, viscosity and efficiency.
Rated discharge pressure	It is the discharge pressure of the pump at the guarantee point with rated capacity, speed, suction pressure, and specific gravity.
Rated suction pressure	It is the suction pressure for the operating conditions at the guarantee point.
Throat bushing	It is a close-clearance restrictive ring in the casing between the seal (or packing) and the impeller, to decrease the stuffing box pressure, isolates the box fluid from the fluid pumped, or reduces the flow of the stuffing box fluid into the sealing area.
Wear ring	Used with closed impeller pumps to restrict leakage from the high pressure side of the pump to the low pressure side around the shrouds (front and back) of the impeller. The point on the pump that will deteriorate gradually by friction or wear and tear.

2.4 ABBREVIATIONS

Abbreviation	Description
ANSI	American National Standards Institute
API	American Petroleum Industries
ASME	American Society of Mechanical Engineers
BEP	Best Efficiency Point
BOM	Bill of Materials
BS	British Standard
BSP	British Standard Piping
CoE	Centre of Excellence
Cw	The concentration by mass of the mixture/slurry
Cv	The concentration by volume of the mixture/slurry
EN	European Norm
ISO	International Standard Organisation
kg	kilogram
kPa	kilopascal

Abbreviation	Description
MAMSL	Metres above mean seal level
MPa	megapascal
NPSH	Net Positive Suction Head (R, Required and A, Available)
OEM	Original Equipment Manufacturer
pH	It is a scale of acidity from 0 to 14. It tells how acidic or alkaline a substance is.
PN	Pressure nominal (in Bar or MPa) an alphanumeric designation used for reference purposes related to a combination of mechanical and dimensional characteristics of a component of a pipework system. It comprises the letters PN followed by a dimensionless number.
ppm	parts per million
rpm	revolutions per minute
SANS	South African National Standard
SCOT	Steering Committee of Technology
TC	Technical Committee

2.4.1 Classification

Controlled Disclosure: Controlled Disclosure to External Parties (either enforced by law, or discretionary).

2.5 ROLES AND RESPONSIBILITIES

2.5.1 Employer's responsibilities

Employer shall provide the following information to the pump Contractor:

	Clear Medium Pumps	Slurry Pumps
a.	The design capacity, i.e. flow requirements of the pump;	The design capacity, i.e. flow requirements of the pump;
b.	The pump installation arrangement, - vertical or horizontal;	The pump installation arrangement, - vertical or horizontal;
c.	Metres above mean sea level (MAMSL) and atmospheric pressure of the installation;	Metres above mean sea level (MAMSL) and atmospheric pressure of the installation;
d.	A description and the chemical composition of the pumped fluids;	A description and the chemical composition of the pumped fluids;
e.	Not Applicable	The solid constituent's physical properties, of the pumped fluids e.g. of mud, sand, quartz, ash, lime, gypsum, etc. in the fluid;
f.	The pH value of the fluid;	The pH value of the fluid;
g.	Not Applicable	The density of the carrier fluid, in case of mixtures or slurries.

h.	Not Applicable	The specific gravity of the fluid;
i.	Not Applicable	The concentration by mass (Cw) of the mixture/slurry.
j.	The design temperature and temperature range of the pumped fluid;	The design temperature and temperature range of the pumped fluid;
k.	The head (discharge pressure) required by the pump;	The head (discharge pressure) required by the pump;
l.	The NPSH available (NPSHA);	The NPSH available (NPSHA);
m.	The suction pressure at the pumps suction nozzle;	The suction pressure at the pumps suction nozzle;
n.	The casing design temperature and pressure;	The casing design temperature and pressure;
o.	The suction and discharge nozzle rating;	The suction and discharge nozzle rating;
p.	What tests are required, i.e. shop and field tests requirements; and preferred sealing arrangement.	What tests are required, i.e. shop and field tests requirements; and preferred sealing arrangement.
q.	Pump mounting and pump train plinth design.	Pump mounting and pump train plinth design.
r.	Ancillary equipment such as drive couplings and stipulations of flanging arrangements.	Ancillary equipment such as drive couplings and stipulations of flanging arrangements.
s.	Available electrical supply (voltage and amperage)	Available electrical supply (voltage and amperage)
t.	Plant operating regime, including protections and redundancy or standby philosophies.	Plant operating regime, including protections and redundancy or standby philosophies.
u.	Required instrumentation.	Required instrumentation.
v.	Preferred sealing arrangement	Preferred sealing arrangement
w.	Preferred lubrication requirements	Preferred lubrication requirements

2.5.2 Contractor's responsibilities

2.5.2.1 General

The Contractor shall be responsible for the completeness and accuracy of all component design calculations and for compliance with all applicable requirements and the specified standard for the pump.

2.5.2.2 Data information

The Contractor shall be responsible for providing the following data information which is applicable to all Clear Medium Pumps

a. The completion of the data sheet as per Eskom Standard 240-102151797

b. The shaft deflection, torque and critical speed calculations to be done under varied conditions

c. Bearing life predictions

d. New pump clearances are required as well as a pump efficiency versus clearance chart; this will indicate how the efficiency of the pump will deteriorate with increase in clearances.

2.5.2.3 Mechanical information

The Contractor shall be responsible for providing the following mechanical information:

a. A specific statement, in writing, that the system and all components are in strict accordance with the Employer's specifications. (If they are not in strict accordance with the specifications, the Contractor shall include a specific list detailing and explaining every deviation. Deviations may include alternative designs or systems equivalent to and guaranteed for the specified duties);

b. An explicit statement, in writing, of any deviations from the specified guarantee and warranty.

c. Certified test performance curves and testing data, including differential head, power consumption recalculated to the proper specific gravity, and efficiency plotted against capacity. The water NPSH requirement curve shall be included, drawn from actual test data, for an impeller cast from the same pattern. The curve sheet shall include the maximum and minimum diameters of the impeller supplied, the eye area of the first-stage impeller, the identification number of the impeller, and the pump serial number. Viscosity corrections, if applicable, shall also be indicated;

d. Certified hydrostatic test data;

e. Operating and maintenance instructions for the pump, the mechanical seal or gland sealing, connecting coupling, and the driver when furnished by the Contractor;

f. Pump sealing arrangement as required by API 682 for the seal plan arrangement, coolers, temperature-indicating gauges, thermowells; pressure Indicators etc.

g. Pump bearing lubrication requirements,

h. Cross-sectional drawing of the pump with parts numbered and a separate list of the parts that matches the pump supplied. The parts list will include the part number, material supplied and pump manufacturers drawing number. A separate drawing of the mechanical seal, and drive coupling together with installation and setting dimensions shall be included. Baseplate drawing are also required.

i. Bills Of Materials (BOM), when requested, for the pump and mechanical seal, including part numbers, names of parts, the number of parts required, the metallurgy (SANS) number or equal) of the part, and a drawing number or casting number that identifies each part for purposes of interchangeability. Bills of materials need not include nuts, bolts, piping, and so forth, unless they are specialised;

j. A list of spare parts recommended for normal maintenance purposes. Price details for spare parts are not required unless specifically requested; and

k. An itemized list of the special tools is included in the offer.

2.6 PROCESS FOR MONITORING

None.

2.7 RELATED/SUPPORTING DOCUMENTS

[37] Centrifugal Pump Specification Templates 240-102151797.

3. CENTRIFUGAL PUMPS SPECIFICATION

Requirements for the pumps are contained in the enquiry/purchase order and the data sheet for the specific model pump, as per Eskom Standard 240-102151797. These templates state the Employer's specific data. The tenderer shall complete the construction data section.

3.1 CLEAR MEDIUM CENTRIFUGAL PUMPS

3.1.1 Mechanical design

3.1.1.1 General

Pumps shall be designed to facilitate replacement of all wearing parts and shall be so designed that the impeller replacement is possible without removing the motor or pipework. It must be noted that this arrangement would be preferred, but is not always practical. End-suction pumps shall have back pull-out design and construction.

Pumps shall be designed so that unintended reverse rotation does not damage components of the pump. The design of the pump shall, as far as possible, provide hydraulic balance of impeller/rotor and shaft. The bearing design shall accommodate any residual axial out of balance forces that may occur. Provision for absorbing end thrust shall be subject to the Employer's approval.

Where special tools are required to either assemble or to dismantle a pump, at least one set of the specific tools must be supplied per pump model supplied.

3.1.1.2 Pump characteristic curves

Pumps shall have stable head-capacity curves rising continuously from closed valve to duty point to shut-off. For pumps operating in parallel, the head rise at shut-off shall not be more than 15 to 20 % of the head at the Best Efficiency Point (BEP) of the pump. The preferred operating point is between 5% forward and 10 % back from BEP on the capacity scale.

Pumps required to operate singularly or in parallel shall have their characteristics specifically selected to ensure stable operation over the full range of flow capacity from minimum to 125 % of design duty rating under all operating conditions specified.

The impeller diameter shall be such that a minimum of 5 % increase in differential head at the rated capacity can be obtained by installing a larger diameter impeller of the same pattern.

One set of spare wear rings shall be supplied with oversize outside diameter to enable them to be machined at site to the correct dimensions.

Horizontal spindle pumps with two or more stages and all horizontal single stage - double suction impeller pumps shall have impellers mounted between bearings.

3.1.1.3 Casing

The pressure limit (rated pressure) of the pump shall be clearly defined by the manufacturer.

The design pressure and hydrostatic test pressure of the pump shall be as indicated on the individual data sheets. Pressure casing thickness shall be suitable for the stated design and hydrostatic pressures and include a 3 mm minimum corrosion allowance.

The casing shall be designed with renewable wearing rings fixed to the housing.

Pumps shall be furnished with flanged suction and discharge nozzles integral to the casing. Flange design pressures shall be as indicated on the individual data sheets. Flanges shall preferably be to BS EN 1092 or SANS 1123, design pressure as stated on the data sheets.

All cast iron pump casings with flanges and other bolted mating surfaces shall have a full width gasket surface (raised faces are not allowed). Casing gaskets shall be of a design suitable for the rated operating conditions and for hydrostatic test conditions. The casing cover gaskets shall be confined on the atmospheric side to prevent blow-out.

All pumps shall be provided with automatic air release valves with separate isolating and test cocks unless the pump is made self-venting by the arrangement of nozzles.

Provision shall be made for fitting a thermometer pocket into the pumps volute or discharge branch at the lowest point.

All horizontal pumps shall be provided with a drain connection.

Pumps shall be provided with suitable means to facilitate disassembly of gasket joints, such as eye bolts, lugs, jack screws, etc.

When jackscrews are supplied as a means of separating contacting faces, the mating face shall be counter-bored to receive the jackscrews where marring may cause a leaky joint or poor fit. Hollow-head screws should be avoided if possible.

3.1.1.4 Impellers

The impeller shall be cast in one piece and be provided with wear rings to permit easy maintenance of proper running clearances, hydraulic passage fettling is permissible to ensure a smooth wetted surface.

Impellers shall be secured against circumferential and axial movement when rotating in the intended direction. Pinning of the impeller is not acceptable. The nut holding the impeller on the shaft shall have a blind bottom with no threads exposed to the fluid pumped.

Each impeller of the centrifugal pump shall be statically balanced before fitting to the shaft. After the entire rotating element has been assembled it shall be statically and dynamically balanced to BS ISO 21940-12, quality grade G 2.5 as a minimum.

Dynamic balance at not less than the rated speed is required for all pumps.

3.1.1.5 Wear rings

Renewable wear rings shall be provided on both the casing and impeller unless otherwise specified. Where required for axial balance front and back wear rings at the same level shall be provided. Pumping vanes or rudimentary vanes shall not be used to establish axial balance.

The wearing rings should have good galling properties or have a distinct hardness difference between the rotating and stationary part.

Mating wear surfaces of hardenable materials shall have a difference in a Brinell hardness number of at least 50, unless both the stationary and rotating wear surfaces have Brinell hardness numbers of at least 400.

Renewable wear rings shall be held in place by a press fit with locking pins or threaded dowels (axial or radial) or by flanged and screwed methods.

When establishing running clearances between stationary and rotating parts, consideration shall be given to operating conditions and properties of the material used (i.e. hardness and gall resistance) for these parts. Clearance shall be sized to prevent contact, and material combinations selected to minimize the risk of seizure and erosion.

3.1.1.6 Shafts and shaft sleeves

Replaceable shaft sleeves to protect the shaft are required when:

- The pump has a packed stuffing box with gland packing sealing arrangement;
- The fluid pumped is not compatible with the shaft material;
- The mechanical seal has a dynamic elastomer in contact with the shaft; or when otherwise specified.
- Shafts shall be of ample size and stiffness to:
  - Transmit the prime mover rated power/torque at the rated speed;
  - Minimise unsatisfactory packing or seal performance;
  - Minimise wear and the risk of seizure; and take due consideration of the static and dynamic radial loads,
  - The first critical speed shall not be less than 110-130% with worn clearances, and the methods of starting and inertial loading involved.

The roughness of the shaft or sleeve at the stuffing box, mechanical seal or oil seal shall not be greater than 0.8 μm unless otherwise required for the seal. Measurement of surface roughness shall be in accordance with ISO 3274.

Shaft sleeves shall be sealed at one end, and the shaft sleeve assembly (or nut) shall extend beyond the outer face of the packing gland or the seal end plate to prevent leakage between the shaft and the sleeve being mistaken with leakage through the stuffing box packing or the mechanical seal faces.

Manufacture and assembly of the shaft and sleeve, if fitted, should ensure that the run out at the radial plane through the outer face of the stuffing box is not greater than 50 μm for nominal outside diameters 50 to 100 mm, and not greater than 100 μm for nominal outside diameter greater than 100 mm.

The diameter of the portions of the shaft or shaft sleeves in contact with shaft seals shall be in accordance with ISO 3069 where practical.

Axial movement of the rotor permitted by bearings shall not adversely affect the performance of the mechanical seal. When a shaft sleeve is fitted it shall be positively secured against circumferential and axial movement. The shaft sleeve shall be sealed against the impeller hub so that the shaft is not wetted.

Snap rings or circlips in direct contact with the bearings shall not be used for transmitting the thrust from the shaft to the inner race of the thrust bearing. Locknuts and lock washers are preferred.

In order to have satisfactory gland packing or mechanical seal performance, to avoid shaft breakage, and prevent internal wear or seizure, the shaft stiffness for one and two stage horizontal and vertical in-line pumps shall limit the total shaft deflection under the most severe dynamic conditions over the complete head-capacity curve, with a maximum diameter impeller and the specified speed and fluid, to a maximum of 50 μm at the face of the stuffing box (or at the mechanical seal face for built-in seal pumps) and to less than one-half the minimum diametral clearance at all bushings and wear rings. The required degree of shaft stiffness can be achieved by a combination of shaft diameter, shaft span or overhang, and casing design. Support by conventional packing shall not be considered when determining shaft deflection.

Radial bearings shall be of the standard available design (ball, roller, sleeve) unless otherwise specified.

3.1.1.7 Bearings

All bearings shall be designed for a minimum life of 100 000 hours in the specified service with continuous operation at maximum radial and axial loads.

Thrust bearings shall be sized where the hydraulic axial force is not completely balanced, or where the rotor has to be supported during the start and stop sequence.

Pump bearings shall be arranged for oil lubrication, with a plugged oil drain hole provided.

Gasket or threaded connections shall not be used to separate cooling or heating fluids from lubricants. All openings in the bearing housing shall be designed to prevent the ingress of contaminants and the escape of lubricant under normal operating conditions.

Where the bearing housing also serves as an oil chamber, an oil level indicator or constant level oiler shall be provided. The mark for the recommended oil level or the setting of the constant level oiler shall be permanent and visible and shall state whether the level is stationary or running. These bearing are normally drained during transportation. A tag should be added to the bearings notifying personal on site that the bearings need to be lubricated. The same for thrust bearings that require grease etc.

Recommended lubricants and lubricant volumes should be indicated on the pump casing by means of a permanent tag or label.

Bearing housings shall be equipped with labyrinth type end seals and deflectors where the shaft passes through the housing; lip-type seals shall not be used. The labyrinth deflector design shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

Bearing housings shall preferably be arranged so that bearings can be replaced without disturbing pump drives or mountings.

3.1.1.8 Shaft sealing — general

The pump design shall permit the use of all the following alternatives:

- A soft gland type packing;
- A single mechanical seal; and
- A double mechanical seal

This is to allow a pump supplied with soft gland type packing to follow an engineering change process to possibly convert to a preferred mechanical seal technology and arrangement. All sealing material must be fully compatible with the medium being pumped.

All seal flushing and quenching aspects of API 610 to be complied with during the fabrication of the pumps.

Coupling halves shall be effectively secured against circumferential and axial movement relative to the shafts.

Maximum axial movement of the rotating parts must be within the limits allowed by the mechanical seal OEM.

Arrangements shall be made for containing, collecting and draining all liquid leakage from the seal area.

A deflector shall be provided on vertical pumps not equipped with auxiliary packing or closure to prevent foreign materials from entering the space between the mechanical seal and the shaft.

Mechanical seals or gland type seals shall not be used during the hydrostatic test but shall be used during all running or performance tests. Mechanical seals or gland type seals be installed in the pump before shipment and shall be clean, lubricated, and ready for initial service. On

pumps that require final adjustment in the field, the Contractor shall attach a metal tag warning of this requirement.

3.1.1.9 Mechanical seals

The mechanical seals would have a minimum life rating of 50 000 operating hours, provisions for cooling water to the mechanical seal if required. The Contractor must indicate the flow, pressure, recommended quality and supply temperature of cooling water required to adequately cool the mechanical seals. The mechanical seal's construction material, "O"-Rings and seal face material must be fully compatible with the medium being pumped.

Seal gland plates shall be of the same material as the pump casing except that carbon steel plates shall be furnished with cast iron, ductile iron or bronze casing.

Provision shall be made for centring the seal end plate in relation to the seal chamber bore. An inside or outside diameter register fit is an acceptable method of achieving this.

The seal end plate shall have sufficient rigidity to avoid distortion. The seal housing and end plate, including the corrosion resistant fixing bolts, shall be designed for the permissible operating pressure at operating temperature and the required seating load.

Gaskets between seal housing and stationary seal ring or seal end plate shall be externally confined or of equivalent design in order to prevent blow-out.

All stationary seal components, including the seal end plate, shall be protected from accidental contact with the shaft or sleeve. When a stationary sealing component contacts the shaft or sleeve, the surface in contact with the seal shall be adequately hard and corrosion resistant.

For slurry pumps all flushing plans, and flushing medium requirements shall be provided by the Contractor.

3.1.1.10 Stuffing boxes

Where soft packing has been specified, the pumps shall be delivered to site with the shaft seals prepacked, and sufficient new shaft seal packing material shall be supplied with each pump to repack the pump shaft seal once off. This spare packing shall be suitably packaged to prevent deterioration on site. The shelf life of the soft packing must be specified.

The stuffing boxes shall be fitted with renewable type non-ferrous throat bushings. Provisions must be made for flushing of the stuffing boxes if required.

The stuffing box on all packed pumps shall be provided with a lantern ring with inlet and outlet connections. The lantern ring shall be aligned with the water inlet connection. The Contractor shall state the location of the lantern ring within the packing group and how much longitudinal movement is permitted.

Stuffing boxes shall have not less than four rings of packing plus the lantern ring.

When the stuffing box of a vertical pump is subject to discharge pressure and a bleed-off to suction is used, this bleed-off should be by means of internal rather than external piping.

Stuffing box glands shall be easily removable and must permit replacement of packing without removal or disassembly of any other part of the pump. Glands shall preferably be made with completely enclosed bolt holes. Slotted holes open at one side, are acceptable only if studs are provided for securing glands.

3.1.1.11 Drive Couplings

All-metal, flexible disc drive couplings with stainless steel elements shall be furnished on all horizontal pumps. Spacer type drive couplings shall be provided on all pumps with mechanical seals or whenever required for maintenance.

Rigid coupling types shall be used on vertical pump installations to connect the motor to the pump, it shall be possible to remove the pump shaft sealing without removing the rigid coupling. The drive coupling shall be sized to transmit the maximum torque, where the design torque shall not be less than twice that of the rated motor torque or the intended driver. The speed limitation of the drive coupling shall correspond to all possible operating speeds of the intended pump driver.

The permissible operating radial, axial and angular misalignment shall not exceed the limits given by the drive coupling manufacturer. Drive couplings shall be selected so that the operating conditions, such as temperature, torque variations, number of starts, etc., and the rigidity of pump and baseplate are taken into account.

Removable sheet-metal coupling guards shall be supplied and mounted. Vertical pumps shall be provided with removable or hinged wire mesh drive coupling guards.

The drive coupling shall be dynamically balanced to ISO 21940 quality Grade 2.5(as a minimum) when the drive coupling size-speed relationship is such that balancing is recommended by the drive coupling manufacturer. If the drive coupling components are balanced together, the correct assembly position shall be shown by permanent and visible marks.

Drive couplings shall be properly keyed into place. The type of key used during balancing shall be indicated by the Contractor.

3.1.1.12 Baseplates and mounting

Horizontal pumps shall be supplied with baseplates where requested by the Employer. The baseplate shall be sized (length and width) for the pump, driver and all accessories, without overhang, except that the motor driver conduit boxes may extend beyond the baseplate.

The baseplate shall have a drain pan or rim. Connections for the drain shall be tapped in the raised lip at the pump end and shall be so located as to allow complete drainage. Connections for a drain shall be tapped at least 25 mm BSP in diameter and be located at the pump end of the baseplate. The deck plate or upper surface of the baseplate shall be sloped 1 in 120 minimum toward the drain end and shall cover the length and width of the baseplate.

The baseplate shall be fabricated from channel iron section to ensure a complete distribution of grout across the entire concrete plinth without removal of pumps, driver, or any auxiliaries. The grouts shall be arranged so that the pumped fluid will not accumulate over the open grout.

The baseplates must be made corrosion resistant to the medium being pumped. Driver support pads on baseplates shall be machined flat and jacking bolts for axial and horizontal alignment shall be furnished at each pad.

All shims shall be from stainless steel shim stock. In exceptional circumstances packers would be utilised to rectify casting errors. The baseplate flatness should be equal or less than 0.02 mm per metre length between pads and supports for motor and pump.

3.1.1.13 Installation of motors and pumps

The surface of the plinths shall be level, with a vertical tolerance not exceeding 2 mm over any grouting allowance, to minimise vertical shims.

- The maximum allowable number of shims under any equipment support foot is three (3).
- The movable machine shall have a minimum of 2 mm thick shims under each support foot, made of 300 series stainless steel.
- The maximum shim stack height shall not exceed 5 mm. Only one (1) 2 mm or thicker shim per mounting foot is allowed.

3.1.1.14 Auxiliary piping

Cooling water, gland oil, lube oil, and recirculating piping systems, including all accessories such as gauges and valves, shall be furnished by the pump Contractor, fully assembled and installed on the pump.

The piping shall be designed and arranged for easy disassembly to permit maintenance and cleaning, and shall be properly supported to prevent vibration and damage. The temperature and pressure rating of the auxiliary piping, handling pumped fluid shall be not less than the pump case maximum discharge pressure and temperature.

a. 18Cr-8Ni stainless steel shall be used for the piping or tubing of flushing fluids to mechanical seals;

b. Minimum wall thickness of tubes shall be 1.65 mm for 16 mm tubes and 2.4 mm for 19 mm tubes.

c. Tubing connections shall be Crawford, Swagelok or the Employer approved equivalent. Tube fittings and ferrules shall be 18Cr-8Ni stainless steel.

Copper tubing and brass fittings are unacceptable.

Tapped openings and piping threads shall conform to SANS 1556 ISO metric screw threads.

Carbon steel piping shall be pickled. Stainless steel tubing and piping shall be cleaned with a suitable solvent. The above cleaning shall be performed prior to assembly of the pumping unit.

Auxiliary piping connections shall be plugged. Carbon steel plugs shall be used with cast iron casings; otherwise, the plugs shall be of the same metal as the casing material. Plugs shall have a square shank to permit the use of a wrench.

The piping inlet and outlet connections shall be located at the edge of the baseplate opposite the driver end. All water cooled parts shall be piped in parallel and all parts on a single base plate shall be piped from a common supply and return header. The Employer will specify the inlet cooling water pressure and temperature on the individual pump data sheet. The Contractor shall supply orifices or valves to balance the cooling water flow through each branch. Valves and headers shall be oversized to allow for final field balancing.

Closed sight flow indicators with inlet and outlet shutoff valves are required for all cooling water systems.

3.1.1.15 Cooling water

The piping shall be arranged for flow through the jacket, coolers and glands. The piping inlet and outlet connections shall be located as specified in 3.1.1.13.

The pump Contractor shall state on the individual pump data sheet the capacity of cooling water, pressure and temperature required by each pump.

Cooling water jackets or housing shall be designed for not less than 520 kPa working pressure.

Water cooled gland packing stuffing box glands shall be of the split cowl type, with bushings, and supplied with a demountable flexible hose equipped with a needle type control valve for connecting to the cooling system.

3.1.1.16 Drain pipework

The contractor shall supply and install all drain pipework, including fittings, fixings and supports from the pump baseplate connection to the nearest drain.

Water pipework shall be galvanized with screwed fittings that conform to SANS 62.

3.1.2 Materials

The materials selection in the construction of the equipment and accessories shall be suitable for the severity of the service intended.

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

Prior approval by the Employer is required before any major repair is done to the pressure casing. Mechanical seals which are compatible with the pumped fluid shall be provided if so requested.

All materials selected for pump components shall be compatible with the medium pumped.

The pump shall be constructed of materials specifically chosen to resist deterioration by pitting and corrosion.

All parts subject to wear shall be fitted with renewable liners and all bearings shall be lubricated automatically.

Minimum flow protection systems shall be designed in accordance to the relative standards and best practices. Other components such as strainers, valves, piping, safety guards etc., instrumentation and control and the interchangeability shall also be accounted for in the designs.

3.2 SLURRY PUMPS

3.2.1 Mechanical design

3.2.1.1 General

Pumps shall be designed to facilitate replacement of all wearing parts and shall be so designed that the impeller replacement is possible without removing the motor or pipework. It must be noted that this arrangement would be preferred, but is not always practical. End-suction pumps shall have back pull-out design and construction.

Pumps shall be designed so that unintended reverse rotation does not damage components of the pump. The design of the pump shall, as far as possible, provide hydraulic balance of impeller/rotor and shaft. The bearing design shall accommodate any residual axial out of balance forces that may occur. Provision for absorbing end thrust shall be subject to the Employer’s approval.

Where special tools are required to either assemble or to dismantle a pump, at least one set of the specific tools must be supplied per pump model supplied.

3.2.1.2 Pump characteristic curves

Pumps shall have stable head-capacity curves rising continuously from closed valve to duty point to shut-off. For pumps operating in parallel, the head rise at shut-off shall not be more than 15 to 20 % of the head at the Best Efficiency Point (BEP) of the pump.

Pumps required to operate singularly or in parallel shall have their characteristics specifically selected to ensure stable operation over the full range of flow capacity from minimum to 125 % of design duty rating under all operating conditions specified.

The impeller diameter shall be such that a minimum of 5 % increase in differential head at the rated capacity can be obtained by installing a larger diameter impeller of the same pattern.

One set of spare wear rings shall be supplied with oversize outside diameter to enable them to be machined at site to the correct dimensions.

Horizontal spindle pumps with two or more stages and all horizontal single stage - double suction impeller pumps shall have impellers mounted between bearings.

3.2.1.3 Casing

The pressure limit (rated pressure) of the pump shall be clearly defined by the manufacturer.

The design pressure and hydrostatic test pressure of the pump shall be as indicated on the individual data sheets. Pressure casing thickness shall be suitable for the stated design and hydrostatic pressures and include a 3 mm minimum corrosion allowance.

The casing shall be designed with renewable wearing rings fixed to the housing.

Pumps shall be furnished with flanged suction and discharge nozzles integral to the casing. Flange design pressures shall be as indicated on the individual data sheets. Flanges shall preferably be to BS EN 1092 or SANS 1123, design pressure as stated on the data sheets.

All cast iron pump casings with flanges and other bolted mating surfaces shall have a full width gasket surface (raised faces are not allowed). Casing gaskets shall be of a design suitable for the rated operating conditions and for hydrostatic test conditions. The casing cover gaskets shall be confined on the atmospheric side to prevent blow-out.

All pumps shall be provided with automatic air release valves with separate isolating and test cocks unless the pump is made self-venting by the arrangement of nozzles.

Provision shall be made for fitting a thermometer pocket into the pumps volute or discharge branch at the lowest point.

All horizontal pumps shall be provided with a drain connection.

Pumps shall be provided with suitable means to facilitate disassembly of gasket joints, such as eye bolts, lugs, jack screws, etc.

When jackscrews are supplied as a means of separating contacting faces, the mating face shall be counter-bored to receive the jackscrews where marring may cause a leaky joint or poor fit. Hollow-head screws should be avoided if possible.

3.2.1.4 Impellers

The impeller shall be cast in one piece and be provided with wear rings to permit easy maintenance of proper running clearances, hydraulic passage fettling is permissible to ensure a smooth wetted surface.

Impellers shall be secured against circumferential and axial movement when rotating in the intended direction. Pinning of the impeller is not acceptable. The nut holding the impeller on the shaft shall have a blind bottom with no threads exposed to the fluid pumped.

Each impeller of the centrifugal pump shall be statically balanced before fitting to the shaft. After the entire rotating element has been assembled it shall be statically and dynamically balanced to BS ISO 21940-12, quality grade G 2.5(as a minimum).

Dynamic balance at not less than the rated speed is required for all pumps.

3.2.1.5 Wear rings

Renewable wear rings shall be provided on both the casing and impeller unless otherwise specified. Where required for axial balance front and back wear rings at the same level shall be provided. Pumping vanes or rudimentary vanes shall not be used to establish axial balance.

The wearing rings should have good galling properties or have a distinct hardness difference between the rotating and stationary part.

Mating wear surfaces of hardenable materials shall have a difference in a Brinell hardness number of at least 50, unless both the stationary and rotating wear surfaces have Brinell hardness numbers of at least 400.

Renewable wear rings shall be held in place by a press fit with locking pins or threaded dowels (axial or radial) or by flanged and screwed methods.

When establishing running clearances between stationary and rotating parts, consideration shall be given to operating conditions and properties of the material used (i.e. hardness and gall resistance) for these parts. Clearance shall be sized to prevent contact, and material combinations selected to minimize the risk of seizure and erosion.

3.2.1.6 Shafts and shaft sleeves

Replaceable shaft sleeves to protect the shaft are required when:

- The pump has a packed stuffing box with gland packing sealing arrangement;
- The fluid pumped is not compatible with the shaft material;
- The mechanical seal has a dynamic elastomer in contact with the shaft; or when otherwise specified.

Shafts shall be of ample size and stiffness to:

- Transmit the prime mover rated power/torque at the rated speed;
- Minimise unsatisfactory packing or seal performance;
- Minimise wear and the risk of seizure; and take due consideration of the static and dynamic radial loads,
- The first critical speed shall not be less than 110-130% with worn clearances, and the methods of starting and inertial loading involved.

The roughness of the shaft or sleeve at the stuffing box, mechanical seal or oil seal shall not be greater than 0.8 μm unless otherwise required for the seal. Measurement of surface roughness shall be in accordance with ISO 3274.

Shaft sleeves shall be sealed at one end, and the shaft sleeve assembly (or nut) shall extend beyond the outer face of the packing gland or the seal end plate to prevent leakage between the shaft and the sleeve being mistaken with leakage through the stuffing box packing or the mechanical seal faces.

Manufacture and assembly of the shaft and sleeve, if fitted, should ensure that the run out at the radial plane through the outer face of the stuffing box is not greater than 50 μm for nominal outside diameters 50 to 100 mm, and not greater than 100 μm for nominal outside diameter greater than 100 mm.

The diameter of the portions of the shaft or shaft sleeves in contact with shaft seals shall be in accordance with ISO 3069 where practical.

Axial movement of the rotor permitted by bearings shall not adversely affect the performance of the mechanical seal. When a shaft sleeve is fitted it shall be positively secured against circumferential and axial movement. The shaft sleeve shall be sealed against the impeller hub so that the shaft is not wetted.

Snap rings or circlips in direct contact with the bearings shall not be used for transmitting the thrust from the shaft to the inner race of the thrust bearing. Locknuts and lock washers are preferred.

In order to have satisfactory gland packing or mechanical seal performance, to avoid shaft breakage, and prevent internal wear or seizure, the shaft stiffness for one and two stage horizontal and vertical in-line pumps shall limit the total shaft deflection under the most severe dynamic conditions over the complete head-capacity curve, with a maximum diameter impeller and the specified speed and fluid, to a maximum of 50 μm at the face of the stuffing box (or at the mechanical seal face for built-in seal pumps) and to less than one-half the minimum diametral clearance at all bushings and wear rings. The required degree of shaft stiffness can be achieved by a combination of shaft diameter, shaft span or overhang, and casing design. Support by conventional packing shall not be considered when determining shaft deflection.

Radial bearings shall be of the standard available design (ball, roller, and sleeve) unless otherwise specified.

3.2.1.7 Bearings

All bearings shall be designed for a minimum life of 100 000 hours in the specified service with continuous operation at maximum radial and axial loads.

Thrust bearings shall be sized where the hydraulic axial force is not completely balanced, or where the rotor has to be supported during the start and stop sequence.

Pump bearings shall be arranged for oil lubrication, with a plugged oil drain hole provided.

Gasket or threaded connections shall not be used to separate cooling or heating fluids from lubricants. All openings in the bearing housing shall be designed to prevent the ingress of contaminants and the escape of lubricant under normal operating conditions.

Where the bearing housing also serves as an oil chamber, an oil level indicator or constant level oiler shall be provided. The mark for the recommended oil level or the setting of the constant level oiler shall be permanent and visible and shall state whether the level is stationary or running. These bearing are normally drained during transportation. A tag should be added to the bearings notifying personal on site that the bearings need to be lubricated. The same for thrust bearings that require grease etc.

Recommended lubricants and lubricant volumes should be indicated on the pump casing by means of a permanent tag or label.

Bearing housings shall be equipped with labyrinth type end seals and deflectors where the shaft passes through the housing; lip-type seals shall not be used. The labyrinth deflector design shall effectively retain oil in the housing and prevent entry of foreign material into the housing.

Bearing housings shall preferably be arranged so that bearings can be replaced without disturbing pump drives or mountings.

3.2.1.8 Shaft sealing — general

The pump design shall permit the use of all the following alternatives:

- A soft gland type packing;
- A single mechanical seal; and
- A double mechanical seal

This is to allow a pump supplied with soft gland type packing to follow an engineering change process to possibly convert to a preferred mechanical seal technology and arrangement. All sealing material must be fully compatible with the medium being pumped. The shelf life of the gland packing must be stated.

All seal flushing and quenching aspects of API 610 to be complied with during the fabrication of the pumps.

Coupling halves shall be effectively secured against circumferential and axial movement relative to the shafts.

Maximum axial movement of the rotating parts must be within the limits allowed by the mechanical seal OEM.

Arrangements shall be made for containing, collecting and draining all liquid leakage from the seal area.

A deflector shall be provided on vertical pumps not equipped with auxiliary packing or closure to prevent foreign materials from entering the space between the mechanical seal and the shaft.

Mechanical seals or gland type seals shall not be used during the hydrostatic test but shall be used during all running or performance tests. Mechanical seals or gland type seals be installed in the pump before shipment and shall be clean, lubricated, and ready for initial service. On pumps that require final adjustment in the field, the Contractor shall attach a metal tag warning of this requirement.

3.2.1.9 Mechanical seals

The mechanical seals would have a minimum life rating of 50 000 operating hours, provisions for cooling water to the mechanical seal if required. The Contractor must indicate the flow, pressure, recommended quality and supply temperature of cooling water required to adequately cool the mechanical seals. The mechanical seal's construction material, "O"-Rings and seal face material must be fully compatible with the medium being pumped.

Seal gland plates shall be of the same material as the pump casing except that carbon steel plates shall be furnished with cast iron, ductile iron or bronze casing.

Provision shall be made for centring the seal end plate in relation to the seal chamber bore. An inside or outside diameter register fit is an acceptable method of achieving this.

The seal end plate shall have sufficient rigidity to avoid distortion. The seal housing and end plate, including the corrosion resistant fixing bolts, shall be designed for the permissible operating pressure at operating temperature and the required seating load.

Gaskets between seal housing and stationary seal ring or seal end plate shall be externally confined or of equivalent design in order to prevent blow-out.

All stationary seal components, including the seal end plate, shall be protected from accidental contact with the shaft or sleeve. When a stationary sealing component contacts the shaft or sleeve, the surface in contact with the seal shall be adequately hard and corrosion resistant.

For slurry pumps all flushing plans, and flushing medium requirements shall be provided by the Contractor.

3.2.1.10 Stuffing boxes

Where soft packing has been specified, the pumps shall be delivered to site with the shaft seals prepacked, and sufficient new shaft seal packing material shall be supplied with each pump to repack the pump shaft seal once off. This spare packing shall be suitably packaged to prevent deterioration on site.

The stuffing boxes shall be fitted with renewable type non-ferrous throat bushings. Provisions must be made for flushing of the stuffing boxes if required.

The stuffing box on all packed pumps shall be provided with a lantern ring with inlet and outlet connections. The lantern ring shall be aligned with the water inlet connection. The Contractor

shall state the location of the lantern ring within the packing group and how much longitudinal movement is permitted.

Stuffing boxes shall have not less than four rings of packing plus the lantern ring.

When the stuffing box of a vertical pump is subject to discharge pressure and a bleed-off to suction is used, this bleed-off should be by means of internal rather than external piping.

Stuffing box glands shall be easily removable and must permit replacement of packing without removal or disassembly of any other part of the pump. Glands shall preferably be made with completely enclosed bolt holes. Slotted holes open at one side, are acceptable only if studs are provided for securing glands.

3.2.1.11 Drive Couplings

All-metal, flexible disc drive couplings with stainless steel elements shall be furnished on all horizontal pumps. Spacer type drive couplings shall be provided on all pumps with mechanical seals or whenever required for maintenance.

Rigid coupling types shall be used on vertical pump installations to connect the motor to the pump, it shall be a possible to remove the pump shaft sealing without removing the rigid coupling. The drive coupling shall be sized to transmit the maximum torque, where the design torque shall not be less than twice that of the rated motor torque or the intended driver. The speed limitation of the drive coupling shall correspond to all possible operating speeds of the intended pump driver.

The permissible operating radial, axial and angular misalignment shall not exceed the limits given by the drive coupling manufacturer. Drive couplings shall be selected so that the operating conditions, such as temperature, torque variations, number of starts, etc., and the rigidity of pump and baseplate are taken into account.

Removable sheet-metal coupling guards shall be supplied and mounted. Vertical pumps shall be provided with removable or hinged wire mesh drive coupling guards.

The drive coupling shall be dynamically balanced to ISO 21940 quality Grade 2.5(as a minimum) when the drive coupling size-speed relationship is such that balancing is recommended by the drive coupling manufacturer. If drive coupling components are balanced together, the correct assembly position shall be shown by permanent and visible marks.

Drive couplings shall be properly keyed into place. The type of key used during balancing shall be indicated by the Contractor.

3.2.1.12 Baseplates and mounting

Horizontal pumps shall be supplied with baseplates where requested by the Employer. The baseplate shall be sized (length and width) for the pump, driver and all accessories, without overhang, except that the motor driver conduit boxes may extend beyond the baseplate.

The baseplate shall have a drain pan or rim. Connections for the drain shall be tapped in the raised lip at the pump end and shall be so located as to allow complete drainage. Connections for a drain shall be tapped at least 25 mm BSP in diameter and be located at the pump end of the baseplate. The deck plate or upper surface of the baseplate shall be sloped 1 in 120 minimum toward the drain end and shall cover the length and width of the baseplate.

The baseplate shall be fabricated from channel iron section to ensure a complete distribution of grout across the entire concrete plinth without removal of pumps, driver, or any auxiliaries. The grouts shall be arranged so that the pumped fluid will not accumulate over the open grout.

The baseplates must be made corrosion resistant to the medium being pumped. Driver support pads on baseplates shall be machined flat and jacking bolts for axial and horizontal alignment shall be furnished at each pad.

All shims shall be from stainless steel shim stock. In exceptional circumstances packers would be utilised to rectify casting errors. The baseplate flatness' should be equal or less than 0.02 mm per metre length between pads and supports for motor and pump.

3.2.1.13 Installation of motors and pumps

The surface of the plinths shall be level, with a vertical tolerance not exceeding 2 mm over any grouting allowance, to minimise vertical shims.

- The maximum allowable number of shims under any equipment support foot is three (3).
- The movable machine shall have a minimum of 2 mm thick shims under each support foot, made of 300 series stainless steel.
- The maximum shim stack height shall not exceed 5 mm. Only one (1) 2 mm or thicker shim per mounting foot is allowed.

3.2.1.14 Auxiliary piping

Cooling water, gland oil, lube oil, and recirculating piping systems, including all accessories such as gauges and valves, shall be furnished by the pump Contractor, fully assembled and installed on the pump.

The piping shall be designed and arranged for easy disassembly to permit maintenance and cleaning, and shall be properly supported to prevent vibration and damage. The temperature and pressure rating of the auxiliary piping handling pumped fluid shall be not less than the pump case maximum discharge pressure at the maximum pumping temperature.

a. 18Cr-8Ni stainless steel shall be used for the piping or tubing of flushing fluids to mechanical seals;

b. Minimum wall thickness of tubes shall be 1.65 mm for 16 mm tubes and 2.4 mm for 19 mm tubes.

c. Tubing connections shall be Crawford Swagelok or the Employer approved equivalent. Tube fittings and ferrules shall be 18Cr-8Ni stainless steel.

Copper tubing and brass fittings are unacceptable.

Tapped openings and piping threads shall conform to SANS 1556 ISO metric screw threads.

Carbon steel piping shall be pickled. Stainless steel tubing and piping shall be cleaned with a suitable solvent. The above cleaning shall be performed prior to assembly of the pumping unit.

Auxiliary piping connections shall be plugged. Carbon steel plugs shall be used with cast iron casings; otherwise, the plugs shall be of the same metal as the casing material. Plugs shall have a square shank to permit the use of a wrench.

The piping inlet and outlet connections shall be located at the edge of the baseplate opposite the driver end. All water cooled parts shall be piped in parallel and all parts on a single base plate shall be piped from a common supply and return header. The Employer will specify the inlet cooling water pressure and temperature on the individual pump data sheet. The Contractor shall supply orifices or valves to balance the cooling water flow through each branch. Valves and headers shall be oversized to allow for final field balancing.

Closed sight flow indicators with inlet and outlet shutoff valves are required for all cooling water systems.

3.2.1.15 Cooling water

The piping shall be arranged for flow through the jacket, coolers and glands. The piping inlet and outlet connections shall be located as specified in 3.1.1.13.

The pump Contractor shall state on the individual pump data sheet the capacity of cooling water, pressure and temperature required by each pump.

Cooling water jackets or housing shall be designed for not less than 520 kPa working pressure.

Water cooled gland packing box glands shall be of the split cowl type, with bushings, and supplied with a demountable flexible hose equipped with a needle type control valve for connecting to the cooling system.

3.2.1.16 Drain pipework

The contractor shall supply and install all drain pipework, including fittings, fixings and supports from the pump baseplate connection to the nearest drain.

Water pipework shall be galvanized with screwed fittings that conform to SANS 62.

3.2.2 Materials

The materials selection in the construction of the equipment and accessories shall be suitable for the severity of the service intended.

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

Prior approval by the Employer is required before any major repair is done to the pressure casing. Mechanical seals which are compatible with the pumped fluid shall be provided is so requested.

All materials selected for pump components shall be compatible with the medium pumped.

The pump shall be constructed of materials specifically chosen to resist deterioration by pitting and corrosion.

All parts subject to wear shall be fitted with renewable liners and all bearings shall be lubricated automatically.

Minimum flow protection systems shall be designed in accordance to the relative standards and best practices. Other components such as strainers, valves, piping, safety guards etc., instrumentation and control and the interchangeability shall also be accounted for in the designs.

3.2.3 Electric motors

3.2.3.1 General

All Medium voltage motors (>1 kV) supplied shall be in accordance to the Employer specification 240-50237155. All Low Voltage motors (<1 kV) supplied shall be in accordance with the Employer specification 240-57617975.

Effective provision shall be made to take up any thrust along the drive axis that might arise due to thermal effects transferred from the driven machinery.

All motors shall be arranged so that they can be removed and maintained without disturbing the driven machine, piping or electrical items.

3.2.3.2 Motor alignment

Horizontally mounted motors of frame size 160 and above shall have:

- A vertical alignment facility on the motor itself (drilled and tapped holes in the feet); and
- A horizontal alignment facility on the motor supporting structure (plinth).

3.2.4 Guarantee and warranty

3.2.4.1 Mechanical

Unless exception is recorded by the Contractor in his proposal, it shall be understood that the Contractor agrees to the guarantees and warranties specified in items a) and b):

a. All equipment and component parts shall be guaranteed by the Contractor against defective materials, design, and workmanship for one (1) year after being placed in service (but not more than 18 months after date of shipment); and

b. If any non-performance or defects occur during the guarantee and warranty period, the Contractor shall make all necessary alterations, repairs, and replacements free of charge. Field labour charges, if any, shall be subject to negotiation between the Contractor and the Employer.

3.2.4.2 Performance

Pump performance tests shall be carried out at the pump Contractor's facility or by a suitably accredited third party workshop to demonstrate the design and manufacturing integrity and compliance with the specified hydraulic and mechanical performance requirements.

The equipment shall be guaranteed for satisfactory performance under all operating conditions specified on the data sheet and system operating philosophies.

Field checks on performance, when made by the Employer, shall be made within 60 days of initial operation.

Pump characteristics to be guaranteed include outlet pump flow rate, total head of pump, efficiency, power consumption and NPSHR (if NPSHR test specified).

The hydraulic characteristic of the pump shall be determined by performance tests which shall be carried out to ISO 9906 Grade 1 B and guided by Table 9 of 9906 - Default acceptance grades.

3.2.4.3 Special tools

Where special tools are required to either assemble or to dismantle a pump, at least one set of the specific tools must be supplied per pump model supplied.

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These tools shall be handed over to the Employer at the time of delivery.

Special tools are defined as those tools which cannot generally be purchased from a general tool Contractor.

3.2.4.4 Lubrication

The Contractor shall provide the first charge of grease or other type of lubricant as required. A lubrication schedule shall be provided indicating frequency and normal quantity of top up or replacement lubricant.

3.2.4.5 Nameplates

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

- Purchase order number
- Tag item number
- Manufacturer's name
- Serial number of pump
- Size and type of pump
- Rated discharge flow in m^3/h
- Pumping head in metres
- Specific gravity
- Operating speed in rpm
- NPSHR
- Maximum allowable casing working pressure in kPa.
- Impeller diameter in mm
- Lubrication specifications and volume
- Mass of pump in kg
- Required/installed motor power in kW

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

3.2.4.6 Equipment data sheets

Each item of equipment shall be supplied with a data sheet completed by the Contractor with all relevant design, operating and maintenance information.

3.3 TESTS

3.3.1 Material tests

Chemical composition test certifications shall be provided for the pump casing, and impellers and shafts for those pumps where material test requirements are indicated on the data sheet.

3.3.2 Pump test and inspection

3.3.2.1.1 NPSH Test

NPSHR tests are only required if the NPSHA ≤ 1.5 NPSHR as indicated on the pump data sheet NPSHR data shall be taken at the following four points: minimum continuous stable flow, midway between minimum and rated flows, rated flow, and 125 % rated flow. As per Table 10 of ISO 9906.

3.3.2.2 Hydrostatic Test

A hydrostatic test shall be performed for pressure containing parts, (casings, covers and seal plates including their fasteners) at a test pressure of 1.5 times the design pressure given in the data sheets or 1.5 times the closed valve head of the pump. The test should be carried out

using clean cold water (15 ºC minimum when testing carbon steel) and the pressure maintained for at least 10 minutes without visible leakage or pressure drop.

3.3.2.1 Hydraulic Performance Test

Hydraulic performance tests shall be in accordance with ISO 9906 Grade 1, alternatively as per Table 9 in ISO 9906, and shall be included the test report. Also included shall be certified test curves drawn from the test data for the purchased pump and shall include head, efficiency, power consumption (kW), and where applicable NPSHR re-calculated to the proper specific gravity plotted against capacity.

Unless otherwise mutually agreed upon, the speed to be used in connection with tests of all pumps shall be the normal operating speed for the pump selected, upon which the pump performance ratings and guarantees are based (rated rpm).

Each pump shall be checked for acceptable vibration limits during testing.

Shut-off and pressure pulsation testing may also be requested.

The number of witnessed and non-witnessed hydrostatic, test run, NPSHR, balancing, shop inspection and alignment tests required for each set of identical pumps shall be as given in the data sheets. For stainless steel casings, water shall not contain more than 35 ppm of chloride.

3.3.3 Vibration

The equipment shall be assessed for vibration criteria against ISO 10816-7:2009(E). The equipment furnished by the Contractor shall conform to the requirements of ISO 3744 and ISO 3746 or to the maximum allowable sound level specified by the Employer.

3.4 TRANSPORTATION AND STORAGE

Pumps with three or more stages shall be disassembled after the shop running test and inspected, and all internal parts shall be coated with suitable, environmentally friendly rust preventives prior to reassembling. Single and two-stage pumps need not be disassembled after the shop running test, provided that the pump, including the stuffing box, is completely drained and dried and all internal parts are coated with suitable rust preventatives. All pumps shall be transported completely assembled, except where size or configuration makes this impractical; in such instances a Field Service Engineer shall be available to supervise the field assembly at no cost to the Employer.

All internal steel areas of bearing housings and carbon steel oil systems auxiliary equipment such as reservoirs, vessels, and piping shall be coated with suitable oil-soluble rust preventatives.

All exterior surfaces subject to atmospheric corrosion, with the exception of machined surfaces, shall be given a primary paint coat to the manufacturer's specifications, secondary coats to SANS 10140: Identification Colour Marking: The identification of contents of pipelines and vessels.

All exterior machined surfaces shall be coated with suitable rust preventatives.

All threaded openings shall be provided with steel caps or solid-shank plugs of a material with a composition comparable to that of the casing. In no case shall non-metallic plugs (such as plastic) be used.

Exposed shafts and shaft drive couplings shall be wrapped with waterproof, mouldable waxed cloth or vapour phase inhibitor paper. The seams shall be sealed with adhesive tape.

The equipment shall be protected against any damages during transportation.

Each flanged nozzle shall be protected with a wooden blank for protection during transportation and storage.

The packaging of the equipment for transport to the PowerStation shall be subject to the approval of the Employer.

The equipment shall be stored indoors or under ventilated covers. A storage and preservation procedure shall be provided. The storage area shall be clean, dry and dust free.

Suitable pump preservation, based on the anticipated storage duration shall be provided if required.

One copy of the manufacturer's standard installation instructions shall be packed and shipped with the pump. Data books for each pump with relevant material certificates, run-out certificates, balancing certificates, pressure test certificates, welding documents must be supplied to the Employer etc. The databook must be one hardcopy and one Electronic copy.

4. AUTHORISATION

This document has been seen and accepted by:

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Anasen Pillay	Senior Engineer: Low Pressure Services COE
Daniel van Tonder	Senior Engineer: Turbine Plant COE
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Henk Fourie	Chief Engineer: Bulk Materials Handling COE
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5. REVISIONS

Date	Rev.	Compiler	Remarks
November 2012	0	K. Rupnarain	Draft Document for review created from GGSS 0327
May 2013	1	K. Rupnarain	Final Document for Publication
October 2015	1.1	K. Rupnarain	240-5603058 Revised for TSC Approval. Recommendations from working group incorporated. Changed from Standard to Specification. Final Draft for Comments Review Process. Updated Final Draft after Comments Review Process
November 2015	2	K. Rupnarain	Final Rev 2 Document for authorisation and publication
October 2019	2.1	K. Rupnarain	Separating Clear Medium Centrifugal Pump and Slurry Pumps. Final Pump Care Group Acceptance.
October 2019	3	K. Rupnarain	Final Rev 3 Document for authorisation and publication

6. DEVELOPMENT TEAM

Centrifugal Pumps Specification Working Group Members

7. ACKNOWLEDGEMENTS

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