KINGDOM OF LESOTHO
LESOTHO HIGHLANDS WATER PROJECT
THE LESOTHO HIGHLANDS DEVELOPMENT AUTHORITY

LESOTHO HIGHLANDS WATER PROJECT

REQUEST FOR QUOTATION FOR

SUPPLY AND DELIVERY OF AN AUTOMATIC HYDRAULICALLY ACTUATED TRCM

ANNEXURE 2: PERFORMANCE SPECIFICATION

LHDA
LHDA Tower Building (Formerly Lesotho Bank Tower)
Kingsway
Maseru, Lesotho

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1. Purpose of this document

   This document specifies the performance requirements of the hydraulic articulating trash rack cleaning machine (TRCM) to be designed, manufactured, supplied, factory tested, commissioned, and delivered to South Africa by the TRCM Contractor.

2. Reference Documents

   This document forms part of the Request for Quotation (RFQ) for the supply of the hydraulic articulating TRCM.

   The design, manufacturing and installation of the TRCM shall conform to the following international standards and industry best practices.

BS 1400	Copper alloy ingots and castings
BS 1452	Flake graphite cast iron
BS 1490	Aluminium and aluminium alloy ingots and castings
BS 2789	Spheroidal Graphite or Nodular Graphite Cast Iron
BS 3100	Steel Castings for General Engineering Purposes
BS 3790 and ISO 4184	Belt drives
BS 4872	Approval testing of welders - Fusion welding of steel
BS 7854	Mechanical Vibration
DIN 536	Crane rails
DIN 15018 Part 1 and 2	Cranes steel structures, verification and analyses
DIN 15019 Part 1	Crane stability
DIN 17445	General purpose welded circular stainless steel tubes
DIN 19704 Part 1,2, 3	Hydraulic steel structures
EN 60204-1	Electrical equipment of machines
ISO 9001	Quality management

ISO 10816	Mechanical Vibration
BS EN 681	Elastomeric seals
DIN EN 1090 Part 2	Technical rules for the execution of steel structures
DIN EN 10025	Hot rolled products of structural steels
DIN EN 10204	Metallic products
DIN EN 12077 Part 2	Crane safety, limiting and indicating devices
DIN EN 12644 Part 1, 2	Cranes, information for use and testing
DIN EN 12999	Jib-type crane design
DIN EN 13001 Part 1, 2, 3	Cranes, general design
DIN EN 13135 Part 1, 2	Cranes, electrotechnical and non-electrotechnical equipment
DIN EN 13557	Crane controls and control stations
DIN EN 13586	Cranes, access
DIN EN 14985	Slewing Jib cranes
DIN EN 60204 Part 1	Electrical equipment of machines
DIN EN 61000 Part 6-3, 6-4	Electromagnetic compatibility
DIN EN 61082	Documents used in electric technology, Part 1 – Rules
DIN EN 61439 (VDE 0660, 600)	Low voltage switchgear and control gear assemblies
DIN EN ISO 1461	Hot dip galvanized coatings
DIN EN ISO 4628	Valuation of degradation of coatings
DIN EN ISO 12944	Paints and varnishes
DIN EN ISO 13849	Safety of machinery

3. Site Information

Matsoku weir forms part of the Lesotho Highlands Water Transfer Project (LWHP) and delivers water from the Matsoku river to the Katse dam through a diversion tunnel.

The weir is located near the town of Lejone, Lesotho, at the following coordinates: 29°13’54.77”S, 28°33’28.16”E.

Temperatures generally range between -15 °C and 35 °C. The site elevation is around 2100 masl and the surrounding area is subject to lightning strikes.

4. Technical Performance

4.1. Key Dimensions

Refer to drawings 1002140-1000-DRG-CC-0001 to 0003 for details pertaining to the dimensions of the reference design.

Figure 1. Fixed parameters

Parameter	Dimensional Constraint
Mass	The machine’s mass shall be less than 40 tonnes.
Vertical Reach	As a minimum requirement, the machine shall be capable of reaching the bottom of the screens at 2083.3 masl from a platform at 2093.2 masl.
Screen Width	The maximum clear opening width of the screens is 1200 mm between the concrete columns into which the screen guide channels is casted
Rail Length	The intake spans over a distance of 20.8 m across the thirteen screen bays
Rail Gauge	Maximum of 3 m depending on the load distribution of the machine onto the existing structure.
Maximum lifting load	2 Tonnes
Trash rack inclination	Vertical

Type of debris	Grass, leaves, logs, trash

Figure 2. TRCM Parameters

Parameter	Description
Model number	Model number
Travel speed [m/min]	Travel speed on the rails
Lifting and lowering speed [m/min]	Lifting and lowering speed
Maximum slewing range [°]	Maximum angle of horizontal rotation
Rotating speed [°/min]	Horizontal rotating speed
Cleaning capacity [N]	Safe working load
Rake width [mm]	Width of the rake
Self-weight of the machine [kg]	Unloaded weight of machine
Power requirement [kW]	Power required

4.2. Debris Removal

The TRCM shall be designed to safely remove debris weighing up to 2 tons, and the machine shall be capable of grabbing and lifting tree trunks of 700 mm in diameter and 6 m in length. It shall be able to lay down large debris on the concrete slab adjacent to the skip area where it can be cut to size.

The TRCM shall be capable of cleaning the screens during floods when the river water level rises up to 2093 masl. The TRCM shall only shut down when the river level exceeds 2093.2 masl to prevent damage to the equipment and supporting systems upon very high river levels.

The TRCM shall also provide for manual manoeuvring of oversized debris (i.e. logs longer and heavier than 6 m and 2 tons) away from the screens (using alternative claws or hooks or otherwise) and towards the weir crest without having to lift it and to enable discharge over the spillway.

Debris disposal shall be through a skip that will be positioned at the end of the rails, and which will be removed from site by truck.

4.3. Cleaning Sequence

It is expected that the machine will be running a cleaning cycle once every week, but the machine should be capable of executing a full cleaning cycle at least once every day in automatic mode.

In addition, the machine shall be designed to operate for up to 9 hours per day for up to 5 days safely in manual operation mode within the design limits of the machine. This is required during high river flow periods when debris is expected to increase significantly, and manual operation intervention is required to remove large logs and severely compacted debris.

The automated cleaning sequence shall be pre-programmed by the TRCM Contractor. The following minimum programming/setup by the Employer shall be allowed for in the TRCM control system:

a. Frequency of cleaning cycles

b. Lifting load limit

c. Traverse end stops

d. Screens to clean and screens not to clean

4.4. Traversal

The TRCM shall be equipped with an undercarriage designed to operate on railway tracks allowing the machine to move automatically across the entire screened intake, thereby allowing perfect positioning above each of the thirteen screens. The wheel blocks shall be driven by electric motors.

The supplier shall provide comprehensive technical details of how the rail assembly is to be installed onto the existing structure and the wheel loads for all operational scenarios.

The railway gauge shall be adequately spaced, and wheels flanged appropriately to ensure secured operation at maximum vertical reach and maximum load.

4.5. Boom and Claw

The gripper rake or claw shall be hydraulicly actuated and secured to a hydraulic articulating boom.

Consideration shall be given to:

- The screens sections being vertical and held in place only by their weight and their guides

- The existing intake and screen design
- The interface between the TRCM's claw and the screens
- Sedimentation cleaning
- Surface cleaning of floating debris

The arms of the boom shall be actuated by double acting cylinders. The cylinders shall not encounter the water level during operation.

4.6. Hydraulics

The system shall consist of a power-controlled hydraulic pump. All hydraulic components shall be controlled through proportional valves. The flow rates shall be controlled based on the load-sensing principle. Return filters shall be in place to protect the system against pollution. The TRCM shall be provisioned with a thermostatically controlled oil cooler.

4.7. Manual and Automatic Control

The TRCM shall provide for manual operation by an LHDA operator as standard. Hard-wired protections shall ensure safety of personnel and to avoid damage to the TRCM itself, the structure or the screens. The machine shall provide for manual operation from an operator/driver seat or by means of a handheld remote (pendant) control.

Automatic operation shall be offered separately by the TRCM Contractor. In automatic mode the route, schedule, and operation shall be pre-programmed.

The machine's degrees of freedom shall provide for each of the thirteen screens to be cleaned individually and shall avoid any damage to the existing intake structure, the screens or the TRCM. Lights and alarms shall be provided as visual and audio cues to indicate the status of the machine and to help ensure the safety of operators.

Semi-automatic operation shall be offered separately by the TRCM Contractor. Semi-automatic operation shall allow the machine to complete a full cleaning cycle at the push of a button and shall allow the operator to select specific screen bays to be cleaned.

Remote monitoring from the Employer's national control room shall be provided. Remote monitoring shall be provided by means of radio telemetry. Access to the remote monitoring platform/interface shall be password protected and shall not require an annual software license.

The TRCM shall allow operators to manually remove and insert the screens when required. The claw may be replaced with a hook or other fitting suitable for the purpose of removing and inserting the screens.

4.8. Protections

The machine shall be designed with fail-safe protections in place for automatic, semi-automatic and manual operation to prevent damage to the machine, the screens, or the existing structure. The machine shall allow the operator to intervention at any stage. Sensors shall be adequately calibrated to prevent the machine operating beyond the designed operational range, forces and torques.

The TRCM shall have the following protections in place as a minimum:

- Overload protection
- Lightning protection connected to the earthing system installed at the weir
- Sensors to prevent damage to the structure and the TRCM
- Audible (sirens and alarms), and visual (lights) warnings
- Emergency stop function

4.9. Energy Supply

A 1.5 km mink power line supplies the site with electricity from a 50kVA transformer. The energy source for the TRCM shall be electrical:

- 3-phase 400 V/ 50 Hz
- Maximum power input: Supplier to specify

Care shall be taken in the cable management system to avoid any damage to the power supply or TRCM power distribution system from operation of the TRCM.

4.10. Control Cabinet and PLC

The control cabinet shall be lockable and of weatherproof construction. It shall have adequate temperature control and ventilation for the operation environment.

4.11. Environmental Health and Safety

The TRCM shall not cause oil pollution of the river and surrounding areas.

The TRCM shall not endanger the LHDA operators with unsafe operational practises. Consideration shall be taken for:

- Exposed joints or mobile parts that may pose a danger. These shall be secured by protection covers.
- The TRCM shall safely come to a stop in the event of power failure.
- Appropriate illumination shall be fixed to the machine for nighttime operation.
- Temperature and oil level control for the hydraulics.
- Wind loads.
- Water level
- Emergency stops.
- Overload security
- Line break safety at hydraulic units
- Obstruction detection on the carriage
- Remote monitoring shall be provisioned for

5. Maintenance Requirements

The TRCM shall be robust and fit-for-purpose for the Matsoku weir site with a minimum operational life of 20 years. No major replacement of structural and/or electrical and control systems should be required for a period of 20 years. Replacement of consumable spares will be acceptable, but the consumable spares shall be identified in the offer of the Contractor.

The LHDA's operations and maintenance team shall be able to independently perform general maintenance and replacement of key parts based on training provided by the TRCM Contractor. A list of critical and long lead item spares that are not available in Lesotho or South Africa shall be provided by the TRCM Contractor

The TRCM Contractor shall specify the requirements for routine maintenance, preventative maintenance and safe operating procedures for attending to breakdowns and replacing key parts. The service intervals shall be specified by the supplier.

5.1. Routine Maintenance

The routine maintenance requirements shall be basic enough that it may be performed by the operator. It can be defined as the checks required before the machine is brought into operation.

Routine maintenance shall include (as appropriate), but not be limited to checking fluid levels, replacing oil and filters, greasing bearings, gears, and joints, calibrating sensors, filters, guides, switches, the tightness on bolts and fittings, and the power cable.

5.2. Preventative Maintenance

Preventative maintenance can be defined as the periodic planned maintenance. In some instances, preventative maintenance may need to be done on a routine basis. Preventative maintenance shall not require significant dismantling and downtime may not extend beyond a maximum of one week.

Preventative maintenance includes planned maintenance of major components before the end of their working life to prevent unplanned downtime.

5.3. Breakdowns

No reliance shall be given on breakdown maintenance as a means for equipment preservation as it would indicate that the underlying maintenance philosophy has failed. However, we may recognise that all equipment is susceptible to random faults, even when rigorously maintained. For this reason, it is adamant that the operating personnel be equipped with a breakdown maintenance plan for such occasions.

6. Spares

Spares which are specified as part of the Works shall be packed individually in wooden boxes with the lids unattached. Each box shall be labelled with the Contract number, manufacturer, contents, relevant part/model numbers and the supplier's address. The boxes shall be brought to Site and the lids shall be secured to the boxes immediately after the Engineer has accepted the spares and the packaging.

7. Signage

All signs as specified below shall be installed prior to commissioning.

7.1. Operating Instructions

Operating instructions shall be framed and shall be attached to the wall in the control room using brass screws. The frame shall be of wood or aluminium with a glass front and hardboard backing. They shall include the following:

a. Start up, Shut down and Operating instructions shall be comprehensive and shall indicate actions to be taken in the case of all alarm conditions. These shall be written from the point of view of the plant operator.

b. A layout drawing of the equipment installation

c. A process and instruction diagram (P&ID)

7.2. Safety

Safety signs shall be suitably framed or encapsulated. Symbolic signs shall comply with SANS 1186 or similar approved by the Employer. The wording of the signs shall be accepted by the Engineer prior to final printing. They shall be provided by the Contractor in appropriate places on the walls of the plant room and shall include the following:

a. All statutory and special safety warning instructions.

b. Course of action during/after electrical shock.

c. Any operating restrictions for equipment.

d. Operating instructions in cases of plant trip and electrical supply failure.

e. Spares list.

8. General Specifications

The TRCM Contractor shall be responsible for all manufacturing and shall ensure that the manufacturing is performed in accordance with good industry practices and that it conforms to reputable international standards. The following manufacturing requirements shall be adhered to as a minimum.

8.1. Materials

8.1.1. General

All materials used in the manufacture and construction of plant and equipment shall be new and unused. The Contractor shall ensure that the materials are selected in accordance with the best engineering practice to suit the working conditions and corrosive environment.

8.1.2. Steel

Structural steel shall comply with the requirements of SANS 50025 (or similar approved) for grade S 355 JR or for grade S 355 JO.

8.1.3. Stainless Steel

8.1.3.1. General

The grade of stainless steel to be used shall be as specified. Rolled material shall be supplied with a matt, annealed and pickled or otherwise de-scaled surface finish.

Where grades EN Grade 1.4401 (316) and EN Grade 1.4301 (304) are specified, these shall be taken synonymously with the low carbon grades for welding.

If stainless steel is to be coated, it shall be suitably abrasive blasted to ensure adherence of the prime coat.

8.1.3.2. Certification

The Contractor shall provide spectroscopic analyses of stainless-steel materials.

Stainless steel supplied shall be clearly and permanently marked with the grade of stainless steel and cross referenced to the applicable test certificate.

8.1.4. 3CR12

This is the titanium stabilised, 12 % chrome steel. It shall be supplied with an annealed and pickled finish.

If 3CR12 is to be coated, it shall be suitably abrasive blasted to ensure adherence of the prime coat.

8.1.5. Plastics

Thermoplastics and fibre reinforced polymers shall be UV resistant, have adequate tensile strength and high impact strength and generally suit the application.

PVC is regarded as too brittle and shall not be used unless called for in this Specification or accepted in writing by the Engineer before supply.

8.1.6. Elastomers

The Contractor shall select elastomeric materials to be used for common duties as follows:

- Nitrile (NBR) shall be used if oil is present. PTFE or silicone shall be used if the working temperature is above 80 degrees Centigrade.
- EPDM may be used if oil is not present. PTFE or silicone shall be used if the working temperature is above 110 degrees Centigrade.

8.2. Castings

Castings shall comply with the relevant South African or international standard for the material used, including the following:

Grey Cast Iron	SANS 1034; BS 1452
S. G. Iron	SANS 936/7; BS 2789
Steel (General Purpose)	SANS 1465; BS 3100
Aluminium	SANS 989/992; BS 1490
Stainless Steel	DIN 17 445
Copper and Copper Alloy	SANS 200; BS 1400

Castings shall be clean and sound and shall be neatly fettled and dressed. Surfaces shall be smooth and irregularities caused by mould washaways, and the presence of porosity, inclusions and sharp edges will not be tolerated. Areas under bolt heads, nuts and washers, shall be machined or spot faced to ensure a flat and smooth pressure bearing area, and sufficient space shall be provided for the use of ring or socket spanners.

All pressure retaining castings shall be hydrostatically tested to not less than 1,5 times the maximum working pressure after machining and shall be pressure tight.

No repairs shall be undertaken to castings without the written permission of the Engineer. Cast iron castings shall not be welded.

Castings shall be heat treated to provide optimum corrosion resistance and toughness combined with reasonable machinability. In particular stainless steel castings shall be heat treated so as to ensure that all carbides are in solution, to ensure optimum grain size, and to provide maximum corrosion resistance.

The Contractor shall provide a test certificate for each casting or batch of castings, except for those made of grey cast iron, giving details of the material analysis, the heat treatment and any mechanical tests carried out.

8.3. Fabrication of Carbon Steel and Stainless Steel

8.3.1. General

Steelwork shall generally be constructed, fabricated and erected in accordance with the applicable requirements of SANS 1200 H (or similar approved).

Welding shall comply with the clause “Welding”.

Sharp edges, pits, inclusions, weld spatter, undercuts, indentations, or other surface defects are not acceptable.

Edges shall be rounded to a radius of at least 2 mm.

Designs shall avoid inaccessible pockets and hollows.

Sharp edges on items fabricated from thin sheets will not be acceptable and sharp edges shall preferably be avoided by good design.

Inspection of fabrications shall generally be done after fabrication is complete.

8.3.2. Carbon Steels

Structural steelwork shall be of grade S 355 JR or of grade S 355 JO in accordance with SANS 50025 (or similar approved).

The requirements of the Hot Dip Galvaniser's Association of South Africa shall be complied with if the item is to be hot dip galvanised. Designs shall provide proper access for safe and complete entry of the molten zinc into open spaces so that subsequent drilling at the galvaniser's yard is avoided.

Surfaces to be coated shall be accessible by blast and spray equipment. Inaccessible pockets, such as bad weld profile as well as hollow structures, are unacceptable and the angle of impact of blast material and sprayed coatings shall not be less than 45 degrees. Edges shall be rounded for safety reasons and also to be suitable for the coating system to be applied.

8.3.3. Austenitic Stainless Steel

Fabrication of austenitic stainless steels shall comply with the recommendations in the "Pocket Guide" issued by Columbus Stainless. Compliance with publications from equivalent authorities will be acceptable.

Stainless steel fabricators shall use permanently dedicated storage and fabrication areas and shall use machines, tools and handling equipment which are suited and permanently dedicated to this type of material.

Fabrications shall be pickled and passivated over their full surface to achieve an even colour. If grinding is required before pickling, the final grinding shall be done with a fine disc in order to remove coarse grinding marks.

8.3.4. 3CR12

Fabrication of 3CR12 shall comply with the requirements for austenitic stainless steels except that the recommendations for Utility Ferritics in the "Pocket Guide" issued by Columbus Stainless shall be used. Compliance with publications from equivalent authorities will be acceptable.

8.3.5. Highly Alloyed Stainless Steel

Fabrication of duplex, super austenitic and other highly alloyed stainless steels shall follow the metal producer's own guidelines.

Welding of duplex stainless steel pipework shall be in accordance with BS 4515 Part 2 or equivalent.

8.4. Welding

8.4.1. Standards

Welding shall be in accordance with SANS 15614-1 or similar approved by the Employer

Welders shall be experienced artisans approved in accordance with BS 4872 or equivalent approved by the Employer.

The Contractor shall ensure that all structural welding, including all welding of pipework, is done in accordance with a welding procedure specification (WPS). The welding supervisor shall ensure compliance with the WPS. The document shall be always available for scrutiny.

8.4.2. Preparation

Wire brush and de-grease both surfaces to at least 30 mm from the weld.

Cleaning of stainless steel shall utilise non-chlorinated fluids only.

8.4.3. Continuous Welding and Elimination of Crevices

Welding shall be continuous on all sides of any joint. Designs which do not allow this shall be re-designed.

Crevices, including those arising from welding on one side only, shall be eliminated. This requirement applies to the welding of all metals and welding procedure shall be designed to prevent unacceptable deformation.

Welds which are only accessible from one side shall be prepared so that the root run provides an acceptable profile and prevents the formation of crevices. Pipework shall be designed so that such welds can be inspected and, where applicable, pickled and passivated.

In special cases only, non-continuous welding might be accepted in writing by the Employer.

8.4.4. Welding Appearance

Welding shall be free of blowholes, projections, pinholes, splatter and undercuts and all welding flux, weld spatter and other sharp imperfections shall be removed. Weld beads with a surface irregularity exceeding 3 mm or with sharp crests having a radius under 2 mm shall be ground.

8.4.5. Site Welding

Site welding shall be kept to a minimum and shall only be undertaken with the acceptance of the Engineer.

8.4.6. Welding of Stainless Steel and 3XR12 – Additional Requirements

Fabrication of austenitic stainless steels and 3CR12 shall comply with good practice and as described in the recommendations in the publications issued by Columbus Stainless. Compliance with publications from equivalent authorities will be acceptable.

Stainless steels to be welded shall be of the low carbon grade; e.g. 1.4306 rather than 1.4301 and 1.4404 rather than 1.4401.

The welding rods used shall be the most suitable for the metal and purpose.

Only welders experienced with welding stainless materials shall be used.

Welds which are accessible from only one side shall be executed in a manner to prevent heat tint or shall be post-weld treated in order to remove all traces of heat tint.

Type 309 stainless steel welding rods shall be used for welding 3CR12 unless otherwise accepted in writing. 3CR12 shall be welded as recommended by Columbus Stainless.

All possible steps shall be taken to ensure maximum corrosion resistance and strength of the welds and welded material. Special care shall be taken to avoid prolonged heating. Welds shall be passivated. Discolouration and steel contamination must be removed by pickling or electro cleaning as accepted by the Engineer but should rather be avoided by taking the appropriate measures.

8.5. Corrosion Protection

8.5.1. General

Unless stated otherwise in the contract document, corrosion protection shall be suitable for the high corrosivity category (C4 of SANS 12944-2 or similar approved).

Corrosion protection shall comply with SPE-JJ-0003.

Corrosion protection systems used shall be suitable for an expected item life of at least 30 years in the environment for which they are designed. Corrosion protection for items which are buried or cast into concrete shall be designed for a life of 70 years.

8.5.2. Systems

The Contractor shall submit the proposed corrosion protection systems to the Engineer for review.

Hot-dip galvanised surfaces to be painted shall be sweep blasted with air pressure less than 2,5 bar and a nozzle distance of at least 500 mm.

8.6. Electric Motors Smaller Than 30 kW

8.6.1. Preamble

Induction motors smaller than 30 kW shall comply with this clause.

8.6.2. General Requirements

Motors shall be rated for operation on a 3-phase, 4-wire, 400/230 Volt, 50 Hz, AC supply.

Motors shall be squirrel cage motors in accordance with SANS 60034 or similar approved by the Employer. Cooling shall be IC 0141 (similar to “tefc”) and the motors shall be suitable for a damp environment. Ingress protection shall be IP 55 or higher.

Motors shall be suitable for both "continuous running duty", Duty Class S1, and "intermittent periodic duty", Duty Class S3. Windings shall be insulated with Class F material (100 ºC rise capability) with a designed Class B temperature rise (80 ºC). The motors shall be suitable for up to 60 starts per hour and shall be suitable for consecutive starting.

A stainless-steel rating plate shall be secured to the frame with stainless steel fasteners. This shall include the motor’s lubrication details. If the manufacturer’s nameplate does not comply with these requirements, the Contractor shall provide additional nameplates.

Motors above 30 kg shall be provided with lifting eyes or lugs.

8.6.3. Performance Requirements

Motors shall perform in accordance with the requirements of the specified mechanical equipment but the rated power of the motor shall, nevertheless, not be less than 20 % in excess of the designed power requirement of the driven

equipment (the Engineer might waive this latter requirement if the motor forms part of a factory packaged unit).

Motors shall be designed to provide their rated power output at an ambient temperature of up to 40 ºC and at an altitude of at least 2 200 masl.

8.6.4. Operation and Control

Protection against both starting overload and running overload shall be provided.

8.6.5. VFC Driven Motors

The Contractor shall submit correspondence from the motor manufacturer/designer which confirms that the motor is designed for supply from the particular make and model of variable frequency converter to be provided in the application without shortening of the motor's lifespan.

Unless of the submersible or immersible type, VFC driven motors shall be cooled by a separate, constant speed fan (this requirement will be waived if the Contractor provides documentation confirming that the drive and motor design can operate in the application, with shaft-mounted fan, without exceeding its designed temperature rise).

Motors shall incorporate protection against damage to the bearings from induced currents.

8.6.6. Bearings

Bearings shall be of the rolling element type (i.e. ball or roller) and may be either oil or grease lubricated.

Grease lubricated bearings shall be re-greasable during motor operation. They shall be provided with stainless steel grease nipples and shall be suited for external applications. A port for relief against over-greasing shall be provided. Greasing points shall be provided with stainless steel extension tubes where access is restricted.

L-10 design life shall not be less than 100 000 hours.

8.6.7. Corrosion Protection

Motors shall be provided with a corrosion protection system which is suitable for the high corrosivity category, C4, of SANS 12944-2 (or similar approved).

The fan cowl shall preferably be of cast iron or of stainless steel. For internal applications, plastic fan cowls are acceptable. Carbon steel cowls are acceptable if hot dip galvanised. Painted carbon steel cowls are not acceptable.

8.6.8. Hazardous Locations

If the specification calls for a motor to suit a hazardous location in terms of SANS 10108 (or similar approved), then suitable motors complying with SANS 60034-5 or SANS 61241 (or similar approved), as appropriate, shall be supplied.

The relevant SANS (or similar approved) certificates, clearly indicating the location classification in which the machine may be operated, shall be submitted to the Engineer before delivery of the motors.

Each motor shall be clearly and permanently marked with the applicable certificate number.

8.6.9. Safety

Rotating parts shall be guarded as required by legislation.

8.7. Electric Motors of 30 kW and Larger

8.7.1. Preamble

Cage and slipring induction motors of 30 kW and above, with the exception of 3,3 kV, 6,6 kV, 11 kV and 15 kV motors, shall comply with this clause.

3,3 kV, 6,6 kV, 11 kV and 15 kV motors shall comply with the specification for MV motors.

8.7.2. General Requirements

Motors shall be in accordance with SANS 60034 (or similar approved).

The type of motor and starter to be provided by the Contractor shall be determined by the requirements of the application specified and by any starting limitations specified. In the absence of such specifications, a squirrel cage motor shall be provided. If a special motor is required to obtain special starting characteristics and/or variable speed, this shall be to a standard at least equal to this specification and shall incorporate all aspects of electrical protection.

Motors with a rating below 1 000 kW shall be squirrel cage motors with cooling to IC 0141 (similar to “tefc”). Ingress protection shall be IP 55 or higher.

Motors with a rating above 1 000 kW shall be squirrel cage motors of CACA configuration with an ingress protection rating of at least IP 55 and shall be provided with oil lubricated sleeve bearings.

Motors shall be suitable for both "continuous running duty", Duty Class S1, and "intermittent periodic duty", Duty Class S3. Windings shall be insulated with Class

F material (100 ºC rise capability) with a designed Class B temperature rise (80 ºC). The motors shall be suitable for 60 starts per hour and shall be suitable for consecutive starting.

Wound rotor motors shall have a separate enclosure for the slip-ring assembly to ensure that dust from the slip ring followers does not enter the motor. The enclosure shall have the same ingress protection as the main motor enclosure but shall have covers for direct access. The rings shall preferably be of stainless steel.

Motors shall be structurally suitable for DOL starting regardless of the specified starting system.

The frame and end covers shall locate on a spigotted register to ensure concentricity and parallelism.

Motors shall be provided with lifting eyes or lugs.

An earth terminal shall be provided on the frame.

Access shall be provided to the winding neutral point.

All monitored motor parameters; e.g. bearing temperature, winding temperature, current, etc.; shall be appropriately indicated.

Motors shall be of the reduced noise level type.

At least one internal cooling circuit fan shall be provided for frame sizes 355 and larger.

Motors of size 75 kW and above shall be fitted with "pocket" heaters. These shall be arranged to switch on when the motor stops operating and switch off when the motor starts operating.

A stainless steel rating plate shall be secured to the frame with stainless steel fasteners. This shall include the machine’s lubrication details. If the manufacturer’s nameplate does not comply with these requirements, the Contractor shall provide additional nameplates.

Measured vibration severity at the bearings shall meet the requirements of Zone A or Zone B of ISO 10816.

When motors are transported, care shall be taken to prevent damage to bearings.

8.7.3. Performance Requirements

Motors shall perform in accordance with the requirements of the specified mechanical equipment but the rated power of the motor shall, nevertheless, not be less than 15 % in excess of the designed power requirement of the driven equipment.

Motors shall be designed to provide this rated power output at an ambient temperature of up to 40 ºC and at an altitude of at least 2 200 masl.

Motors shall reach full operating speed within 5 seconds unless driven by electronic soft start or variable speed drive.

Protection against both starting and running overload shall be provided.

8.7.4. 400 Volt Motors

400 Volt motors shall be designed to operate on a 3-phase, 4-wire, 400/230 volt, 50 Hz, AC supply.

8.7.5. TEFC Motors

The fan cowl shall preferably be of cast iron or of stainless steel. For internal applications, plastic fan cowls are acceptable. Carbon steel cowls are acceptable if hot-dip galvanised. Painted carbon steel cowls are not acceptable.

If it is specified that the motor shall produce low sound output, the fan cowl shall be provided with internal damping.

8.7.6. CACA Motors

The heat exchanger shall be provided with lifting eyes or lugs.

Silencers shall be provided for cooling air inlets and outlets.

Rotors shall be dynamically balanced.

Ports shall be provided for air gap measurement at the drive end and at the non-drive end.

Vertical jacking shall be provided at each holding down point.

8.7.7. VFC Driven Motors

Motors fed by frequency converters shall comply with the following:

- Motors shall be rated to allow for additional harmonic losses in accordance with SANS 60034-17 (or similar approved). The voltage stress withstand capability of the motor shall be checked against the converter supplier’s

specification. The stress due to converter operation shall be lower than the repetitive voltage stress withstand capability of the motor winding insulation system.

- Motors shall incorporate an insulated bearing and an earthing brush (or other approved protection against damage to the bearings from induced currents).

- Motors, unless submersible or immersible, shall be cooled by auxiliary constant speed motor driven fans.

The Contractor shall submit the following to the Engineer.

- Confirmation that the motors comply with the requirements of SANS 60034-25 (or similar approved) for the application.

- Motor manufacturer's written confirmation that the motor is suitable for drive by the VFC make and model to be provided, including confirmation that the motor's voltage withstand capability is sufficient for the voltage stresses that will occur at the motor terminals.

- Guaranteed VFC harmonic performance including sample output wave forms with harmonic distortion levels at 40, 45 and 50 Hz for the VFC for the load.

- Guaranteed VFC dip ride through capability curve.

- Copy of VFC type test certificate (this is required if type tests have been carried out on the model).

8.7.8. Bearings

Grease lubricated rolling element bearings shall be re-greasable during motor operation. They shall be provided with stainless steel grease nipples and shall be suitable for external applications.

A port for relief against over-greasing shall be provided. Greasing points shall be provided with stainless steel extension tubes where access is restricted.

Bearings for motors of 250 kW and above shall be provided with temperature measurement, indication and alarm.

Bearings for motors in belt drive applications shall be of the rolling element type; i.e. shall not be slide bearings.

8.7.9. Instrumentation

Motors of 30 kW and up to (but not including) 150 kW shall be provided with thermistors embedded in the windings of each phase. The thermistor tails shall be "brought out" to separate terminals mounted near the motor winding terminal block.

Motors rated at 150 kW and above shall be provided with PT 100 type RTDs. Two RTDs shall be provided per phase winding. All six shall be incorporated into the control system; three to provide monitoring and three to provide high temperature trip functions.

8.7.10. Corrosion Protection

Motors shall be provided with a corrosion protection system which is suitable for the high corrosivity category, C4, of SANS 12944-2 (or similar approved).

8.7.11. Hazardous Locations

If the specification calls for a motor tor suit a hazardous location in terms of SANS 10108 (or similar approved), then suitable motors complying with SANS 60034-5 or SANS 61241 (or similar approved), as appropriate, shall be supplied.

The relevant SANS certificates, clearly indicating the location classification in which the machine may be operated, shall be submitted to the Engineer before delivery of the motors.

Each motor shall be clearly and permanently marked with the applicable certificate number.

8.7.12. Safety

Rotating parts shall be guarded as required by legislation.

8.8. Plinth & Base Frames – Permanently Mounted Equipment

8.8.1. General

Permanently mounted rotating equipment shall be mounted on a metal base frame and shall not be mounted directly onto concrete plinths.

The Contractor shall provide the base frame, anchor fasteners, grouting, chemical anchor, etc. and is responsible for all installation work, including anchoring of the base frame to the plinth.

The concrete plinth shall be designed by the Contractor for the application.

Equipment up to 1 000 kW shall be mounted on common base frames. Separate base frames may be provided for equipment above 1 000 kW and such base frames shall be grouted within (encapsulated in) their concrete plinths.

Equipment shall be secured to base frames with both flat washers and spring washers (or another locking mechanism) of adequate size. Through bolts shall be used; i.e. a nut shall be used to secure the bolt.

The Contractor shall submit the base frame workshop drawings to the Engineer for acceptance.

8.8.2. Plinths

The Contractor shall take into account all dynamic and static forces in the design of the reinforced concrete plinth and shall submit the design calculations and drawings to the Engineer for acceptance. The calculations shall confirm that the equipment's enforcing vibration will cause no resonant condition. If the plinth rests directly on soil, the calculations shall demonstrate that the design is suitable for the ground conditions. The design shall ensure that all forces, including the motor breakdown torque (or equivalent force if the driver is not a motor) and the torque experienced at power failure, will be properly withstood.

Plinths shall comply with all of the following:

- Plinth shall be of reinforced concrete.
- Plinth mass shall be greater than 4,5 times the sum of the masses of the driver and the driven equipment.
- Width of plinth shall be greater than the height between the shaft centreline and the bottom of the plinth.
- Height of plinth shall be greater than one fifth of the width.
- Height of plinth shall be greater than one tenth of the length.
- Plinths for rotating equipment above 130 kW shall be isolated from the surrounding floor and other machinery plinths (this requirement does not apply to machinery which is isolated from the floor by proprietary anti-vibration mounts).

8.8.3. Soleplates

Soleplates; i.e. plate supports for equipment feet which are individually anchored into the concrete plinth; are acceptable as base frames for equipment above 1 000 kW. They shall be grouted within (encapsulated in) their concrete plinths.

The soleplates to a depth of 50 mm within the concrete plinth/grout shall be of EN Grade 1.4401 (316) stainless steel or better for corrosion resistance. Carbon steel is acceptable for portions of the soleplates with concrete cover of 50 mm or more.

The soleplate's structure shall be designed so that air will not be captured under it during grouting.

8.8.4. Base Frames

8.8.4.1. Dimensions

Base frames shall have dimensions which comply with the larger of the following:

- The main frame members shall have a height of at least 0,095 times the length of the base frame.
- The main frame members shall have a height of at least 0,18 times the width of the base frame.
- Base frames fabricated from members which are cold formed from plate shall also comply with the following:
- The plate thickness shall have a thickness greater than 0.0037 times the length of the base frame (but with a minimum of 4,5 mm).

8.8.4.2. Materials

Base frames shall be fabricated from carbon steels complying with SANS 50025 for grade S 355 JR or S 355 JO or from 3CR12 or from EN Grade 1.4162 (LDX 2101) stainless steel.

8.8.4.3. Mounting Pads

The base frame shall incorporate machined mounting pads for each equipment foot. The thickness of the mounting pads before machining shall be at least 1,25 times the diameter of the holding down bolts. The pads shall be drilled for inserting through-bolts (i.e. not machine screws in threaded holes) and access to the underside shall be provided.

Machining of the top surfaces of mounting pads shall be done after fabrication, stress relieving and hot-dip galvanizing, if applicable, are complete. In the period between machining and installation of the equipment, the machined surface shall be protected against corrosion by a removable coating. After installation, a non-hardening compound, Valvoline Tectyl Multipurpose 506 or equivalent, shall be

liberally applied to exposed machined surfaces and to the crevices formed at the foot of the equipment.

8.8.4.4. Jacking Points

Base frames shall be provided with robust jacking points for alignment of the motor to the driven equipment.

Jacking screws shall be hot dip galvanised.

8.8.4.5. Fabrication

Fabrication and welding shall comply with the requirements elsewhere in this specification.

The Contractor shall arrange for the Engineer to inspect the fabrication of the base frame before corrosion protection.

8.8.4.6. Corrosion Protection

8.8.4.6.1. General

The design of the baseplate shall consider all practical aspects of the corrosion protection system, for example:

- accessibility for surface preparation and coating.
- hidden surfaces are not acceptable.
- inaccessible pockets and hollow spaces which cannot be accessed by blast and spray equipment shall be avoided or shall be welded closed;.
- structures to be hot dip galvanised shall provide proper access for safe and complete entry and exit of the molten zinc.

Base frame designs shall prevent pooling of water. They shall be grout filled and/or shall be provided with large drain holes in all side members (before corrosion protection).

Holes in the base frame and welded lugs for mounting of conduits, etc. are acceptable on condition that these are provided prior to galvanising or prior to pickling and passivation, whichever is applicable. They shall preferably be positioned near the neutral axis of steel sections.

8.8.4.6.2. Carbon Steel Base Frames

Carbon steel base frames shall be hot dip galvanized in accordance with SPE-JJ-0003.

Base frames which are drilled, welded or ground after galvanising will be rejected. Machine milling of mounting pads, with subsequent protection against corrosion as specified, is acceptable.

8.8.4.6.3. Stainless Steel and 3CR12 Base Frames

3CR12 shall be coated with a suitable system complying with SPE-JJ-0003.

EN Grade 1.4162 (LDX 2101) stainless steel and other stainless steels need not be coated.

8.8.4.7. Anchor Support

8.8.4.7.1. Requirements for All Base Frames

Base frame anchor fasteners shall be of EN Grade 1.4401 (316), or better.

Fasteners shall comply with the requirements for fasteners elsewhere in this specification.

The base frame and plinth shall form a structural unit (i.e. the base frame and plinth shall vibrate as a unit) and, to achieve this, the base frame anchors must transfer force into the concrete (i.e. it is not acceptable to provide a levelling nut below the base frame as the anchor will not be properly pre-stressed into the plinth).

Anchor fasteners shall be provided with both a lock washer and a flat washer of adequate size.

8.8.4.7.2. Installation

Not more than three shims may be used at any point and these shall be of a corrosion resistant material.

Concrete surfaces under base frames shall be scabbled before the base frame is placed and shall be clean. Dust shall be removed from the surface by compressed air immediately before grouting.

Base frames shall be grouted in a manner which will eliminate collection points for water or dirt.

The material used for grouting shall be a non-shrink, cementitious grout (ABE Duragrout 1000, or equivalent).

Final equipment alignment shall be done after grouting has been completed.

8.9. Skid Mounted Equipment

Skid base frame shall comply with the design requirements for anchored base frame. They shall be single fabricated units.

The base frame shall be provided with four jacking points and four lifting points.

Equipment shall be secured to the base frame on anti-vibration mounts.

Skid base frame shall be placed on anti-vibration rubber mats, “Tico pad” or equivalent. These shall provide a gap between the skid and the concrete in order to prevent pooling of liquids (in addition to vibration isolation). The elastomeric materials shall be resistant to oil.

8.10. Machine Guards

Guards shall comply in all respects with the Occupational Health and Safety Act of 1993 as amended.

Guards are required to cover all moving or revolving components of machinery and shall prevent a person from touching any moving protrusion. Guards which do not adequately cover moving protrusions such as keys, lock nuts, lock washers, setscrews, etc., or irregularities such as keyways, will under no circumstances be accepted.

Guards shall be neatly and rigidly constructed and fixed and shall not vibrate or cause noise during operation.

Where expanded metal or similar mesh is used, the mesh opening shall not permit a circular object 10 mm or larger to penetrate. Mesh shall not be used for chain guards but on belt drives the side of the guard most conveniently sited for inspection shall be constructed of expanded metal or similar. Mesh should similarly be used in other situations where inspection or ventilation is required.

Allowance must be made for adjustment where adjustment will be required such as on belt guards.

It shall be possible to remove guards easily for maintenance purposes.

Guards shall preferably be fabricated of EN Grade 1.4401 (316) stainless steel (uncoated) but may also be hot-dip galvanized, hot metal zinc-sprayed or hot metal aluminium-sprayed carbon steel, coated to Specification in all these cases. Fasteners shall be M10 or larger and shall be of EN Grade 1.4401 (316) stainless steel.

8.11. Shaft Couplings

Shaft couplings shall be selected to reduce transmission of misalignment forces and of torsional oscillations between the driving and the driven machine. The service factor for electric motor drives shall be at least 1,5; for electric motors on variable frequency converter drives shall be at least 2 and for internal combustion engine drives shall be at least 2,5.

Couplings shall preferably be of the rubber tyre or rubber compression type, keyed to the shafts. Elastomeric elements shall be urethane based.

The design shall respect the requirements of the machine bearings in order to counter thrust forces and limit axial movement.

Flexible metallic elements shall be of stainless steel. Couplings shall not require lubrication.

Spacer couplings shall be used where required for disassembly of the equipment. It shall be possible to dismantle the coupling without having to move either the driver or the driven equipment.

Coupling guards shall comply with the requirements of the OHS Act and shall be to the approval of the Engineer.

After installation, shaft alignment shall be checked by the Contractor in the presence of the Engineer or a person delegated by him. Alignment shall be accurate and to the approval of the Engineer.

8.12. Belt Drives

Belt drives shall be designed to suit the power rating of the motor using service factors appropriate to the driving and driven machinery. Drives shall be designed, manufactured and installed in accordance with BS 3790 and ISO 4184 or equivalent, utilizing taper lock pulleys with taper locks keyed to the shaft.

Where alternative pulley diameters can be selected, preference must be given to the larger pulley diameters to minimize the belt loading on bearings.

The bearing arrangements of driving and driven machinery shall be designed to cope with the loads imposed by belt drives. Rolling element bearings shall be designed for an L-10 life exceeding 100 000 hours.

Belt drives shall incorporate lay shafts where necessary. Lay shafts shall be supported by bearings mounted in bearing housings which are adequately sealed and fitted with grease nipples. Bearing units incorporating open, shielded bearings are not acceptable.

Belt driven machinery shall be equipped with rolling element bearings; i.e. shall not be equipped with slide bearings.

8.13. Driven Gearboxes

8.13.1. General

Driven gearboxes shall be supplied with environmental protection to IP 55 or higher.

The gearbox ratings shall be provided for an ambient temperature of 40 degrees Centigrade.

Gearboxes shall have an efficiency of not less than 96 % on two stage reduction and 95 % on three stage reduction.

8.13.2. Service Factor

8.13.2.1. Motor Driven Gearboxes

The service factor to be used for the design of gearboxes in uniform load duty shall be at least 1,25 for electric motor driven applications. A minimum service factor of 1,5 shall be used for moderate shock applications and a minimum service factor of 2 shall be used for heavy shock applications.

8.13.2.2. Engine Driven Gearboxes

The service factor to be used for engine driven gearboxes shall not be less than 2.

8.13.3. Design Requirements

Gears shall be case hardened, profile ground and lapped, helical and spiral bevel gears.

The gearbox housing shall be of rigid cast construction preferably split in the horizontal plane.

Unless close coupled, each gearbox shall be mounted on machined sole plates fitted with jacking screws to assist with alignment.

Rolling element bearings shall be designed for an L-10 life in excess of 100 000 hours.

A breather designed to prevent moisture from entering shall be fitted.

8.13.4. Lubrication

Oil-bath gearboxes shall have suitable oil level indicators or dipsticks which indicate the allowable levels. Inaccessible oil drain points shall be provided with extensions so that the oil can be easily drained. The drain line shall be of EN

Grade 1.4401 (316) stainless steel and shall be fitted with a ball valve and square head plug.

Grease lubrication points shall be easily accessible. Grease nipples shall be of stainless steel.

8.13.5. Oil Change

The Contractor shall drain and replace oil in all gearboxes during the Defects Notification Period.

8.13.6. Corrosion Protection

Gearbox external surfaces shall be provided with a coating suitable for the high corrosivity category (C4 of SANS 12944-2 or similar approved) and the dry film thickness shall not be less than 200 micron.

8.14. Manual Gearboxes

An over-torque limiting device shall be incorporated.

Grease lubrication points shall be easily accessible. Grease nipples shall be of stainless steel.

A breather designed to prevent moisture from entering shall be fitted.

8.15. Bearings

8.15.1. Bearing Choice

Bearing design shall suit the requirements of the equipment and the installation.

Greased lubricated bearings are acceptable for units with power ratings up to 100 kW but oil lubricated bearings are preferred for larger machines.

Units with power ratings above 1 000 kW shall be provided with slide bearings (oil film type). Slide bearings are also preferred for units with high speed shafts and for high temperature applications.

8.15.2. Operational Requirements

Bearing designs shall ensure safe shut down without damage following electrical supply failure.

Bearing designs for variable speed drive applications shall be suitable for the full expected speed range.

8.15.3. Seals

Bearings shall be provided with seals to prevent the ingress of water and solids.

8.15.4. Rolling Element Bearings

For shaft sizes above 50 mm, the bearing shall be selected for an L-10 bearing life of at least 100 000 hours. This may be reduced if the equipment is expected to operate for less than 3 000 hours in a normal year.

Grease lubricated rolling element bearings shall be provided with relief against over greasing.

Oil lubricated rolling element bearings shall be provided with an oil ring.

8.15.5. Slide Bearings

Slide bearings (“plain bearings”, “oil-film bearings” or “sleeve bearings”) which are oil lubricated shall have lubrication by oil ring, by rotating dish or by pumped feed or by a combination of these.

Lubrication shall be active during normal run down and during power failure and the design shall ensure that the bearing is not damaged.

Loss of pressure in pumped lubrication systems shall lead to shut down of the machinery.

Small diameter bushes shall preferably be self-lubricated sintered metal or of engineering polymer with suitable lubrication.

8.15.6. Motor Bearings

Motor bearings shall be provided with protection against stray currents which cause damage to the bearing.

8.15.7. Thermal Alarms

Thermal alarms on bearing systems shall be set in accordance with the equipment manufacturer’s instructions.

Alarm settings done on Site shall be set after at least 24 hours of operation have occurred.

If high temperature protection is specified for a bearing, the Contractor shall note the equilibrium temperature reached after 30 minutes of normal operation and shall also note the ambient temperature. The high level trip temperature shall then be calculated as follows:

$T_{trip} = T_{equilibrium} + (40^{o}C - T_{ambient}) + 10^{o}C.$

(This assumes that the bearing is operating correctly.)

8.15.8. Belt Driven Equipment

Belt driven machinery and belt drive motors shall be equipped with rolling element bearings; i.e. shall not be equipped with slide bearings.

8.16. Lubrication

8.16.1. Type

Grease lubrication is generally acceptable where design parameters are not severe. Oil lubrication shall be provided where the design parameters are more severe.

Lubrication systems shall be designed to exclude dirt and moisture. Air vents on the oil reservoir shall incorporate filters. Drain facilities shall always be provided.

8.16.2. Grease Lubrication

Where a grease point is not easily accessible, a grease line shall be piped to an easily accessible position for manual greasing. Each grease point shall be provided with its own grease point and pipework.

A distributor shall be provided where motorised lubrication is provided to more than one destination. The distributor shall be a positive displacement device which ensures equal, successive lubrication to all destinations. Only one distributor shall be used for each lubrication pump; i.e. distributors shall not be cascaded.

Pipework for grease distribution shall be of stainless steel.

8.16.3. Oil Lubrication

Where oil lubrication is provided, the Contractor is responsible for the initial oil fill and the first oil change, including flushing, draining and filling, after an initial run in period not exceeding 3 months

Oil level indicators shall be provided for visual checking. Drain valves, including EN Grade 1.4401 (316) fittings where necessary to permit convenient draining, and plugged at the end, shall be provided for oil reservoirs exceeding 1,5 litre capacity. Drains shall be from the lowest point and syphon type drains are unacceptable.

8.16.4. Submerged Bearing Housing

Submerged bearing housings shall be grease lubricated by motorised lubrication. The seals shall be arranged to avoid over greasing of the bearing. These requirements apply to the bottom bearings of equipment such as Archimedes

screw pumps but do not apply to equipment such as submersible pumps in which the bearing housing is contained within the pump set housing.

8.17. Gauges

8.17.1. Construction

Gauges shall be of industrial construction. The case and bezel shall be of stainless steel unless this material is unsuitable for the application.

Pressure, vacuum or compound gauges shall comply with SANS 1062 (or similar approved) and shall bear the Standards mark. Gauges shall be of Accuracy class 1.6 and Durability grade A.

The gauge reading shall indicate gauge pressure unless absolute pressure measurement has been called for.

Gauges shall have a scale diameter of not less than 100 mm.

Calibration shall be in mWC (metres Water Column). The units of measurement shall be clearly marked on the dial.

The scale shall be chosen so that the operating pressure is not less than half full scale reading. In addition, the full scale reading for a gauge on the discharge of a centrifugal pump shall be higher than the pump's shut-off head.

Wherever applicable, gauges shall be clearly strip marked in green to indicate the normal operating range and in red to indicate the non-permissible range of values.

Gauges shall be suitable for continuous operation and shall be glycerine filled on all pump applications and where fluctuations in pressure may cause damage.

Scale markings shall be radial, plain, straight, black lines on a white background and shall be spaced so that one scale division represents approximately 1,5 % of the maximum scale value in values of 1, 2 or 5 multiplied by any power of 10 to suit the maximum operating rating. On circular gauges the scale shall be concentric and the maximum and minimum scale values shall be near the bottom of the gauge, with the scale symmetrically disposed about the vertical centre line of the gauge. The tip of the pointer shall be of the knife edge type extending across the scale divisions and shall be as close as practical to the dial.

8.17.2. Installation

Gauges shall not be mounted directly on equipment subject to vibration.

Gauges for pipework larger than DN 250 shall be remotely mounted, and isolating valves shall be provided at each end of the connecting pipework.

Gauges shall be mounted vertically and in such a position that they can be easily read from floor level.

Nozzles/sockets for gauges shall be provided in accordance with the clause “Steel Pipework; DN 150 and Larger”.

Pressure gauges shall be fitted with an isolating and an air bleed valve. Valves shall be stainless steel ball valves with stainless steel operating levers.

Gauges for sludges and other liquids which contain solids shall have their nozzles on the side of the parent pipe. The configuration shall allow easy cleaning of the passageways.

Gauges used on wastewater, sludge, chemical, solids conveying or other applications where blockage or corrosion of the gauge is possible shall be fitted with a diaphragm type chemical seal, both being liquid filled. The portion of the seal in contact with the process liquid shall be of a suitable non-corroding material.

When used on steam lines a siphon shall be fitted between the steam line and the gauge which shall be filled with water before it is put into service.

8.17.3. Calibration

The Contractor shall calibrate all instrumentation prior to commissioning and shall submit the calibration certificates to the Engineer.

8.18. Electronic Instrumentation

Environmental protection of electronic instrumentation shall be as follows:

a. Instrumentation and associated displays and transmitters which are either located inside or located outside and above ground level shall have IP 55, or higher, rating.

b. Instrumentation and associated displays and transmitters which are located in underground chambers shall have IP 68 environmental protection. The instrument shall be mounted in an enclosure which shall provide physical protection and shall be self-draining.

c. Instruments and associated displays and transmitters which are located outside buildings shall be mounted in enclosures. Enclosures shall be of polycarbonate construction with transparent front, Fibox EK or equivalent. The complete enclosure installation shall have an IP 55 rating or higher. The enclosure size shall be chosen to provide a clearance of at least 100 mm all around the instrument.

Instruments and their cabling shall be protected so that electromagnetic interference does not affect their operation and signal transmission.

Instruments shall have permanently affixed nameplates.

The Contractor shall calibrate all instrumentation prior to commissioning and shall submit the calibration certificates to the Engineer. Calibration certificates shall be included in the Manual.

8.19. Guard Rails

8.19.1. General

Legislated requirements call for guard railing to be provided in positions where the vertical change in level is 1 000 mm or greater.

Guard railing shall comply with SANS 10104 (or similar approved) and shall be designed for access for maintenance purposes.

8.19.2. Operational Requirements

Guard railing shall be designed to resist, without any damage and without excessive deflection, the loadings in Category E in Table 7 in Clause 9.4 of SANS 10160 2:2011, Edition 1.1, (or similar approved) namely:

a. a force of 1 000 Newtons in any direction (concentrated over a length of 100 mm).

b. a distributed horizontal force of 1 000 Newtons per metre applied along the top rail.

8.19.3. Design Requirements

Guard railing shall be designed to resist the loadings set out in SANS 10160 (or similar approved).

Hand and knee rails shall have an outside diameter of not less than 33 mm and a wall thickness of not less than 2,5 mm and a maximum span of 1 500 mm (greater spans will be acceptable if heavier tube dimensions are used).

Tubular stanchions shall have a wall thickness of at least 3,0 mm.

On platforms, walkways, landings or around dangerous areas the vertical height, measured from the top of the hand rail to the floor or surface, shall be at least 1 000 mm.

On stairways and fixed ladders the rails shall be parallel to the strings, and the vertical height, measured from the top of the hand rail to the nosing of the tread, shall be at least 900 mm.

No opening between rails shall allow the passage of a ball of diameter 600 mm.

Stanchions and rails shall be smoothly finished and free from sharp corners, edges and projections which may injure persons or damage clothing. Stanchion bases shall have the corners rounded or sheared off.

Welded guard rail installations are preferred. Installations which incorporate bolted sections shall be secure and tight under loading. “Pop” rivetted installations will not be acceptable. Joints shall be smoothly finished, without shoulders.

Railings shall be ended off with positively fixed closure bends. At corners, short radius bends with stanchions on both ends shall be employed or, alternatively, stanchions specifically designed for such a position shall be employed. No sharp ends will be permitted.

Stanchions shall generally be base-mounted to suit the arrangement requirements and shall be of solid or welded construction.

Stanchions which are hollow shall be self-draining.

Stanchion feet which are attached to metallic surfaces shall have minimum dimensions of 150 mm X 60 mm X 8 mm. Two fasteners, of minimum size M16, shall be used to secure each foot. Neatly fitting packing, Denso tape or equivalent, shall be fitted under stanchion feet to prevent the formation of crevices.

Stanchion feet which are attached to non-metallic surfaces shall have minimum dimensions of 150 mm X 150 mm X 10 mm. In instances where the horizontal surface to which the foot is to be fastened is less than 150 mm wide, the foot shall be designed to be seated on at least two surfaces. Four fasteners, of minimum size M16, shall be used to anchor the foot. Non-shrink, cementitious grout shall be applied under the foot prior to final tightening of nuts.

Toe plates shall be provided. These shall extend to 150 mm above the walkway level.

8.19.4. Additional Design Requirements for Guard Railing in Public Places

The requirements for guard railing at equipment installations shall also apply for guard railing for public places. The following specific requirements shall also be complied with:

a. The structural design shall be done in accordance with the requirements of SANS 10104 (or similar approved).

b. No opening in guard railing installed in public places shall allow the passage of a ball of 100 mm diameter.

8.19.5. Carbon Steel Guard Rails

Fabrication and welding shall comply with the clauses “Fabrication of Carbon Steel and Stainless Steel” and “Welding”.

The guard rails shall be hot-dip galvanised. Designs shall provide proper access for safe and complete entry of the zinc into open spaces so that subsequent drilling at the galvaniser’s yard is avoided.

If the guard rails are welded or cut after hot-dip galvanising, they shall be returned to the galvaniser for re-galvanising.

8.19.6. Stainless Steel and 3CR12 Guard Rails

Fabrication and welding shall comply with the clauses “Fabrication of Carbon Steel and Stainless Steel” and “Welding”.

8.19.7. Fasteners

All anchor fasteners, including nuts and washers shall be of EN Grade 1.4401 (316) stainless steel.

Fastener diameter shall not be less than M12.

8.20. Fasteners

8.20.1. Standards

Bolts and nuts shall be hexagon head type complying with SANS 1700 (or similar approved) with threads of the coarse pitch series.

8.20.2. Loading/Stress

Fasteners shall be loaded in accordance with their design and shall not be loaded as columns and/or in bending. In particular, anchor fasteners shall only be loaded in tension and sideways forces shall be transferred to the concrete structure in which they are anchored.

8.20.3. Materials

M12 fasteners and smaller shall be of EN Grade 1.4401 (316) or better.

Fasteners in corrosive areas shall be of EN Grade 1.4401 (316) or better. Corrosive areas shall be taken to include any moist or wet area such as in and above settling tanks, in or in the vicinity of open channels, where a continuous spray can be expected and all areas in the vicinity of a wastewater treatment works or wastewater sump.

Fasteners larger than M12 which are in non-corrosive areas shall, except when specified otherwise, be hot dip galvanized.

Plated fasteners are not acceptable.

8.20.4. High Tensile Bolts

Where high tensile bolts are required by the design, they shall be hot-dip galvanized and painted. The bolt holes and crevices shall be filled and sealed prior to painting.

8.20.5. Anchor Fasteners

Anchor fasteners shall be of EN Grade 1.4401 (316), or better.

Anchor fasteners for water retaining structures and for brickwork shall be of the chemical anchor fastening type. Other anchors may be of the expanding type or chemical anchor type.

Where hook bolts are used, these shall be supplied and grouted by the Contractor into pockets which will be provided in the concrete structure in accordance with the information to be supplied by the Contractor. The grouting products shall be used strictly in accordance with the manufacturer's instructions.

Where machinery is anchored by studs or bolts which extend through the supporting structure and is therefore fastened down with the use of nuts from both sides, the studs or bolts, together with associated washers and brackets, shall also be of EN Grade 1.4401 (316), or better.

Anchors shall be tensioned when their nuts are tightened; i.e. it is not acceptable to use a second nut below the baseplate to position it; and the holding down force shall be loaded into the concrete structure rather than the baseplate being held between two nuts.

Submerged anchors shall be secured with chemical anchor designed for submersion.

8.20.6. Material Compatibility

Fastener material shall always be of equal or better corrosion resistance than the items being fastened, e.g. EN Grade 1.4401 (316) bolts must be used to fasten together EN Grade 1.4401 stainless steel flanges and fabrications.

8.20.7. Washers

Flat washers shall be provided under nuts and setscrew heads.

Flat washers shall be provided under bolt heads on painted surfaces.

Flat washers shall be provided under bolt heads where the bolt is positioned in a slot.

Spring washers shall be used on fasteners subject to vibration (other approved locking arrangements will also be acceptable on proprietary equipment).

Anchor bolts for machinery shall each be provided with a flat washer and a spring washer (other locking arrangements are not acceptable).

Washers shall be of the same material as the fasteners.

Flat washers exhibiting visual deformation shall be replaced by thicker washers.

8.20.8. Anti-Seize Compound

Before assembly, stainless steel threads shall be treated with a nickel-based, anti-seize/corrosion protection compound such as Chesterton 725 : Nickel Anti-Seize Compound, or equivalent. Copper based compounds are not acceptable.

A small amount of the compound shall be applied along the full length of the exposed thread before fastening. Excessive compound visible on the thread after the nut has been applied is unacceptable and indicates that the compound has not been used correctly.

8.20.9. Thread Projection

Bolt threads shall project no less than 1 thread and no more than 8 threads from the head of the nuts when fixed. Longer projections will only be allowed if the Contractor can show that bolts of a more suitable length are not manufactured.

8.20.10. Corrosion Protection

After installation, the exposed surfaces of fasteners not of stainless steel shall be coated as for the items being fastened.

“Self-tapping” fasteners are not acceptable.

If the use of Allen head or similar fasteners has been accepted by the Engineer, the recessed heads shall be filled with a suitable non-hardening sealing compound.

8.21. Machine Vibration

The mechanical vibration of machines measured at all important points such as bearings shall be lower than that specified as "good" for that class of machine in BS 7854 (ISO 10816).

Reciprocating machines shall be designed and installed so that the machine vibrations are isolated from the floor structure. Vibration isolation mountings which will eliminate not less than 90 % of the vibrations transmitted by the equipment shall be provided between the base frame and the concrete plinth. When mounted on the vibration isolators, distortion of the base frame shall be negligible in comparison with the permissible and acceptable misalignment of the equipment mounted thereon.

Shafts shall be designed so that the critical speed is outside the operating speed range.

8.22. Noise Control

8.22.1. General

Noise emitted by equipment shall be kept to a minimum and shall not exceed the noise levels specified in these documents.

8.22.2. Noise Control

The sound power of any equipment shall not exceed 89 dB(A) (referred to 10-12 Watts) unless specifically accepted by the Engineer. This is approximately equivalent to a sound pressure level of 81 dB(A) at a radius of one metre from the acoustical centre assuming uniform hemispherical propagation in a free field on a hard floor. In certain instances, a lower noise level may be called for.

Where the Contractor is unable to restrict the noise level of the machines to the maximum specified by the appropriate selection of suitable equipment; e.g. by selecting slow speed or silent type machines, quiet type cooling fans, suitable silencers, etc.; the Contractor shall inform the Engineer so that appropriate steps can be taken to counteract the effects of noise.

8.22.3. Acoustic Treatment

Standard acoustic enclosures shall be provided where called for.

Acoustic treatment of high noise sources shall be provided where this can be done without greatly interfering with operation or maintenance.

If acoustic lagging of pipework or ducting is specified, this shall consist of pre-formed rockwool encapsulated in stainless steel sheet metal. Alternatively, a 100 mm thick layer of rockwool having a density of 60 kg/m3, suitably fixed in place and reinforced to prevent collapse, and covered with 25 mm thick asbestos free plaster having a density of 1 000 kg/m3 (I.P. Insultex AF720, or equivalent). The outer surface shall be finished off with scrim cloth before being painted.

It is not normally necessary to lag flow meters and cast-iron valves on acoustically lagged pipelines.

Components which can move, such as those associated with expansion bellows or mechanical couplings, shall be enclosed by an effective acoustic enclosure designed to prevent sound transmission but able to cope with movement without damage.

8.22.4. Measurement

Noise levels will be verified by taking impulse weighted Leq readings in dBA over ten minutes at the specified positions. Readings so achieved shall not exceed the specified level by more than 2 dBA. Should the noise exceed the specified level or should the level be in dispute, the Contractor will be responsible for obtaining certified sound pressure levels across the full octave band mid-frequency range in order to establish the precise A weighted level.