STANDARD SPECIFICATIONS FOR MECHANICAL WORKS

DEPARTMENT: MECHANICAL AND ELECTRICAL BRANCH

WATER AND SANITATION

ETHEKWINI MUNICIPALITY

WATER AND SANITATION

MECHANICAL AND ELECTRICAL BRANCH

DESIGN – BUILD OF MECHANICAL WORKS

STANDARD SPECIFICATION FOR MECHANICAL WORKS

CONTENTS

SECTION A

STANDARD SPECIFICATION FOR MECHANICAL WORKS

A1. GENERAL

The Standard Specification for Mechanical Works shall apply wherever it is relevant to the Contract unless it is superseded in accordance with the precedence stated and, in particular, by the detailed Particular Specification.

A2. ENVIRONMENT

A2.1 General

Sites, with the exception of Wastewater Treatment Works, shall be considered as coastal with some industrial pollution.

A2.2 Wastewater Treatment Works

Besides being coastal, treatment works have large open liquid areas which are aerated and/or agitated and the environment is damp. The high prevailing winds can also carry spray and foam not only from the plant but in some areas also from the sea.

This environment is very corrosive to ferrous metals and, where the use of such metals cannot be avoided, the metals must be adequately protected, such protection systems being designed for a life of at least 15 years.

Sewage gas is also present throughout the treatment works and this may contain hydrogen sulphide which, in addition to being corrosive to ferrous metal, is also corrosive to most non-ferrous metals. **The effect on copper alloys can be particularly severe, often with disastrous effects on the reliability and life of switchgear, control systems, slip-rings, etc. Such equipment must therefore be adequately sealed and protected.**

A3. CLIMATIC CONDITIONS (DURBAN)

A3.1 Weather

Durban can generally be described as subtropical with a warm summer and mild winter. The mean annual temperature is 20.6˚C and the annual range is 8˚C. Highest mean temperatures are experienced in February and lowest mean temperatures in July. Temperature is highly variable in any particular area in Durban as a result of topography, type of surface cover, and artificial heat production due to combustion activities in industries and motor vehicles.

Relative humidity in Durban is fairly high owing to the supply of moisture from the adjacent Indian Ocean. These are higher during summer months as warmer air holds moisture.

The total annual rainfall in Durban is usually greater than 1000 mm, of which the majority is received in summer. Approximately 60% of the annual precipitation occurs between November and March.

Durban lies within the southern subtropical high pressure belt, coming strongly under the influence of eastward migrating high pressure systems. Parallel winds dominate the coastline with south westerly and north easterly winds roughly balanced in frequency. There is generally high wind variably.

A4. DESIGN

A4.1 General

This Specification lays down the performance, quality and overall system requirements of the Works. Deviation from the Specification will only be considered if the Engineer considers such deviation an improvement.

A4.2 Safety

Safety shall be an all-important and overriding consideration and proper attention shall be paid to this aspect at the design stage. The regulations of the Occupational Health and Safety Act, Act 85 of 1993, as amended, shall be strictly observed.

Equipment which is potentially dangerous shall be designed in accordance with a relevant South African or international Standard.

The following must be noted:

(a) Hazards must be avoided or guarded. Nip points shall be guarded; sharp corners shall be rounded off; operating handles, supports and protrusions shall be kept clear of access ways; and so forth.
(b) The Contractor's Drawings and specifications shall clearly specify the structural requirements of the Works and the Contractor shall be responsible for covering all unsafe gaps and openings left in structures after installation.
(c) Moving parts shall be properly guarded to the satisfaction of the Engineer.
(d) An emergency stop button shall be installed in a convenient position next to each machine. The installation shall be designed to provide immediate access without the danger of accidental operation. In addition, trip wires which will stop the driving motor when pulled shall be provided along the accessible side/s of moving conveyor belts, chains and the like irrespective of operating speed and irrespective of guards provided. Installations considered unsafe by the Engineer shall be corrected by the Contractor at no cost to the eThekwini Municipality.

A4.3 Design Aspects

A high quality standard is required and reliability, long life, trouble free operation, efficiency, ease of maintenance and operation, and neatness are essential.

All plant and equipment shall be of robust construction and the design shall, as applicable, be based on:

(a) the full range of duties which can be reasonably anticipated;
(b) the power and torque transmitted by the driver system under full load and stalled conditions;
(c) the maximum pressure or vacuum which can be produced by pumps, blowers and compressors under all conditions including blocked or closed inlet and outlet circuits;
(d) conservative service and safety factors based on approved standards or laid down in the printed specifications of reputable and approved manufacturers;
(e) a safety margin of at least 20 % in addition to any service or safety factors which apply;
(f) twenty four hour per day operation;
(g) a minimum life of 100 000 hours before repair or major part replacement;
(h) prevention of serious damage from normal operational problems such as blockages, blinding, jamming, seizure, malfunction and, as far as is practical, maloperation; if these occurrences cannot be avoided by good design.

Machines with non-overloading characteristics shall be selected wherever possible; eg: motors shall be sized so that they cannot be overloaded by the driven machine.

A4.4 Fail-Safe Operation and Protections

Where damage can occur from normal operational or other foreseeable problems, plant, equipment and systems must be designed to be fail safe; i.e. must have built-in redundant elements, or be fail-to-safe; i.e. must return to a safe condition where no further damage can be done in the event of a failure, malfunction, maloperation, overload and, as far as practical, misuse. All reasonable and economically justifiable protections to prevent or limit damage to plant and equipment, particularly in high risk situations, must be incorporated. Protections shall:

(a) be directed at the source of the problem, limit forces to safe levels and act quickly enough to prevent damage (electrical thermal type overloads are inadequate);
(b) stop or prevent from starting all equipment at risk;
(c) activate an alarm with a labelled indicator on the control panel whenever a protection operates;
(d) not permit unauthorised tampering;
(e) operate reliably after long inactive periods exposed to corrosive and dirty conditions.

Tenderers shall highlight equipment limitations which can be exceeded during operation and cannot be guarded against.

A4.5 Moving Parts

The following general requirements apply not only to machines but to all equipment with moving parts such as headstocks, extension spindles, swiveling davits, heavy duty hinges, pivots and the like:
(a) All rotating or swivelling shafts, pins and the like, shall be adequately supported, guided and restrained by lubricated or self-lubricating bearings, collars and/or bushes.
(b) Swivelling joints on linkages and the like shall be of the "universal" or fork and rod type with bearings or bushes fitted to the eyes or forks.
(c) On abrasive applications abrasion resistant materials and slow speed operation shall be utilised. Raw sewage and sludge shall be regarded as very abrasive.
(d) All applications associated with wastewater shall be regarded as corrosive and materials of construction shall be selected to suit.
(e) Susceptibility to fatigue failure shall be minimised by proper design and manufacturing procedures. In particular, changes in section shall be radiused and care must be taken to avoid the use of welded components in areas of fluctuating stress.
(f) The locking of nuts and pins in position shall be done to the approval of the Engineer.

(g) Wearing parts shall be designed for interchangeability and ease of removal and replacement.

A4.6 Arrangement and Mounting

The arrangement and general design shall take the following requirements into consideration:

(a) Lifting eyes, lugs, hooks, etc., shall be provided on heavy or large items to facilitate handling.
(b) Castings or fabrications shall have machined pads for seating and be mounted on either soleplates or baseplates as appropriate.
(c) Where accurate alignment is required, positioning pins and/or jacking screws shall be provided.
(d) The needs of operation and maintenance including neatness, access, working space, safety, cleaning, adjustment, handling, assembly, alignment, disassembly, removal, etc.
(e) With plant and equipment to be mounted on or against concrete or brick structures built by others, provision shall be made for adjustment in the mechanical design. Any special accuracy requirements must be specified on the Contractor's Drawings.

A4.7 Prevention of Corrosion

The Contractor shall review all designs from a corrosion protection point of view prior to commencing work. Any details which might have a negative effect on the corrosion protection and the future application of coatings are to be brought to the Engineer's attention for a ruling prior to commencement of work.

All items shall be designed to minimise corrosion in the environment in which they shall be exposed. Particular emphasis shall be placed on accessibility for surface preparation and the application of coatings. The general requirements of SANS 10120 – 3 HC shall apply.

Mastics, sealants, insertion rubber or suitable gasket material shall be used to seal unavoidable crevices such as bolted connections; e.g. under guardrail feet.

The design of articles shall ensure that surfaces of corrodible materials, such as carbon steel, shall be accessible for initial coating and for maintenance. The use of back-to-back angles, partially open box sections or inaccessible stiffeners shall be avoided. Fabrication openings shall be of sufficient size to enable fettling, blast cleaning and painting.

A5. INSTALLATION

A5.1 General

The Works shall comply with the following:

(a) When erected and installed, the plant and equipment shall be of neat and workmanlike appearance, solidly and evenly supported, true to line, level, plumb and in proper working order.
(b) The requirements of Sub-clause "Arrangement and Mounting" (see Clause "Design") must be noted.
(c) The Contractor shall provide all foundation bolts, supports, hangers, brackets, etc. required for the support and fixing of equipment.
(d) The use of more than three shims in the alignment of equipment will not be permitted.

Machined spacers shall be prepared where necessary. Shims and spacers shall be of a corrosion resistant material such as stainless steel.

(f) Corrosion protection requirements shall be carefully attended to and the relevant paragraphs of Sub-clause "Paint Application" (see Clause "Corrosion Protection: Paint Coatings) must be noted. All mating faces must be coated before and sealed after assembly.

(g) A small amount of a nickel-based, anti-seize compound shall be applied along the full length of fastener threads before the nut is applied.

(h) Crevices which are formed between two metal surfaces shall, prior to final fastening, be filled with a suitable formable packing, Denso tape or equivalent, or with a suitable mastic or sealant.

D5.2 Alignment of Shafts

Shafts for drives, such as motors, with an output above 150 kW shall be aligned to the driven shaft as follows:

(a) Final alignment shall be done after installation and before commissioning and shall be checked in the presence and to the approval of the Engineer. Alignment shall be sufficiently accurate to ensure that no initial pre-load is placed on the shaft coupling.

(b) Each motor shall be aligned to its pump by alignment specialists using laser aligning equipment with real time computer display.

(c) The use of pourable epoxy resin chocks (Epocast 36, Chockfast or equivalent) shall be acceptable. If pourable chocks are used, the baseplate feet do not have to be machined but each machine foot shall be provided with a screw for vertical alignment. The chock thickness shall not be less than 20 mm.

A6. MATERIALS

A6.1 Materials – Generally

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

A6.2 Steel

All structural steel shall comply with the requirements of SANS 1431 grade 300W and shall be legibly marked with the maker's name or trade mark and identification marks.

A6.3 Stainless steel

The AISI grade of stainless steel to be used will normally be specified in the Detailed Mechanical Specification. Unless otherwise specified, rolled material shall be supplied with a matt, annealed and pickled or otherwise de-scaled surface finish. For wrought steels, the equivalent BS 970 grade may in each case be used.

The common applications are as follows:

APPLICATION	AISI	BS 970
Wastewater Treatment Works (all applications)		
Welded	316L	316S12
Not welded	316	316S16
Low Corrosion Interior		
Welded	304L	304S12
Not Welded	304	304S15
Exterior and Corrosive Interior		
Welded	316L	316S12
Not Welded	316	316S16

A manufacturer's test certificate shall be provided for each batch of stainless steel giving details of the material analysis and any mechanical tests carried out on the material. Each stainless steel item supplied shall be clearly and permanently marked with the grade of stainless steel and cross-referenced to the applicable test certificate.

Where grades 316 and 304 are mentioned in the Tender Documents:

(a) these shall be taken synonymously with grades 316L and grade 304L, respectively.
(b) Contractors may offer grade EN 1.4162 in place of grades 316 and 304.

A6.4 3CR12

This is the titanium stabilised, 12 % chrome steel as produced by Columbus Stainless, South Africa.

3CR12 shall always be supplied with an annealed and pickled finish. 3CR12, in cases where it is to be coated, shall be suitably abrasive blasted to ensure adherence of the prime coat.

A6.5 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 approved in writing by the Engineer before supply.

A7. CASTINGS

Castings shall comply with the relevant South Africa or British 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
Copper and Copper Alloy	SANS 200	BS 1400

Particular attention shall be paid to cleanliness, soundness and neat fettling and dressing of castings. Surfaces shall be smooth and irregularities caused by mould washaways, and the presence of porosity and sand and slag inclusions 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 and **welding will not be permitted on cast iron castings.**

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.

A8. FABRICATION OF CARBON STEELS

A8.1 Standards

Steelwork shall be constructed, fabricated and erected in accordance with SABS Standard Building Regulations, Chapter 6, "Structural Steelwork", and with SANS 1200 H where applicable.

A8.2 Finish

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

Weld spatter and other protrusions shall be removed.

A8.3 Requirements for Corrosion Protection

In addition to finishing requirements, the requirements of corrosion protection application shall be taken into consideration. Surfaces must be accessible for surface preparation and coating. Inaccessible pockets and open hollow sections and similar hidden surfaces shall not be permitted unless the corrosion protection system specified for the fabrication is hot-dip galvanizing without painting.

Pits, undercuts, indentations, etc. which would prevent access to blast material are unacceptable.

A8.4 Drawings

General and detailed fabrication drawings shall be submitted by the Contractor for approval by the Engineer. Full details of the welding procedures and standards which he proposes to use shall be shown on these drawings.

A8.5 Inspections

The Contractor shall arrange for the Engineer to inspect fabrications, including fabricated pipework, in the fabrication workshop and prior to corrosion protection.

A9. FABRICATION OF STAINLESS STEELS

The requirements regarding the fabrication of carbon steels applies to the fabrication of stainless steel as well. In addition, the following requirements apply to the fabrication of stainless steels:

(a) Fabrication of stainless steels and 3CR12 shall follow the recommendations in "The Stainless Steel User Manual" and "The 3CR12 Fabrication Guide" issued by Columbus Stainless. Only fabricators experienced with stainless steel will be considered acceptable. Such fabricators shall use permanently dedicated storage and fabrication areas and shall use machines, tools and handling equipment suited and permanently dedicated to this type of material.

(b) Surfaces which become contaminated with steel or otherwise stained or otherwise marked so as to be of uneven colour, shall be cleaned by pickling or electro-cleaning rather than by grinding.

(c) The Contractor shall arrange for the Engineer to inspect fabrications, including fabricated pipework, in the fabrication workshop.

A10. WELDING

A10.1 General Welding Requirements

A10.1.1 Standards

Standards complying with good modern practice, and acceptable to the Engineer, shall be adopted. These include the following:

BS EN 1011 - Arc welding carbon and carbon manganese steelwork.
BS 4677 - Arc welding austenitic stainless steel pipework.
BS 2633 - Class 1 Arc welding of steel pipework.
BS 2971 - Class II Arc welding of steel pipework.
BS 806 - Design and construction of ferrous piping in connection with land boilers (used for arc welding specification of all pipe flanges).

Welders shall be experienced competent artisans approved in accordance with BS 4872.

A10.1.2 Continuous Welding and Elimination of Crevices

Welding shall be continuous on all sides of any joint. All crevices, including those arising from welding on one side only, shall be eliminated. This requirement applies to the welding of all metals

and, in this respect, it should be noted that welding deformation results from incorrect welding procedure rather than from continuous welding.

In special cases only, non-continuous welding might be approved in writing by the Engineer. The resulting crevices shall be sealed with either a coal tar product which can be applied at thicknesses of up to 1 000 µm such as Carboline Bitumastic 50 or equivalent; or a two part solvent free epoxy which can be applied at thicknesses of up to 600 µm such as Sigmaline 523 or equivalent.

A10.1.3 Weld Appearance

Welding shall be free of blowholes, projections, pinholes, splatter and undercuts and all welding flux shall be removed. All weld spatter and other sharp imperfections shall be removed prior to abrasive blasting. Prior to painting, weld beads with a surface irregularity exceeding 3 mm or with sharp crests having a radius under 2 mm shall be ground. Weld grinding must not be performed on 304L or 316L stainless steel, however, unless unavoidable and in approval by the Engineer.

A10.1.4 Site Welding

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

A10.2 Welding of Stainless Steel and 3CR12

The following applies in addition to all of the above.

A10.2.1 Stainless Steel Welding

Stainless steels shall be welded strictly as recommended in "The Stainless Steel User Manual" issued by Columbus Stainless.

A10.2.2 3CR12 Welding

3CR12 shall be welded strictly as recommended in "The 3CR12 Fabrication Guide" issued by Columbus Stainless.

A10.2.3 Stainless Steel Type

Austenitic stainless steels to be welded shall be of the low carbon grade (i.e.: 304L, 316L, etc.).

A10.2.4 Welding Rods

The welding rods used shall be the most suitable for the metal and purpose. Type 309 stainless steel welding rods shall be used for welding 3CR12 unless otherwise approved in writing.

A10.2.5 Welders

Only welders experienced with welding stainless materials shall be used.

A10.2.6 General

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 approved by the Engineer but should rather be avoided by taking the appropriate measures.

A11. CORROSION PROTECTION: APPLICATION AND CONTROL

A11.1 Painting Contractor

Surface preparation and coating application shall be carried out by suitably trained and experienced industrial painting contractors who are fully equipped and staffed to do such work in their own covered premises strictly in accordance with the paint manufacturer's recommendations. Before proceeding with the corrosion protection coatings, the Contractor shall submit the name of the painting sub-contractor and the proposed works supervisor for approval by the Engineer.

A11.2 Site Work

Surface preparation and coating application shall not be done on Site except for minor repairs, for application of the final aesthetic coat, where specifically called for in the detailed Particular Specification or where permitted by the Engineer in writing.

A11.3 Systems to be used

A11.3.1 Systems

The corrosion protection systems to be used on the plant and equipment will usually be specified in the detailed Particular Specification, but if not, the Contractor shall recommend a suitable system for approval by the Engineer. If doubt exists as to the system or colour to be used, the Engineer's requirements must be ascertained.

A11.3.2 Alternative Systems

Alternative systems superior to those specified may be used if approved in writing by the Engineer.

A11.3.3 All Items to be Painted

Except where otherwise specified, all metal surfaces shall be painted. This includes hot-dip galvanized items and metal-sprayed coatings. In the latter case the paint shall be in the form of a sealer. Details of approved painting systems to be used are given below.

A11.3.4 Grade 316 Stainless Steel

It is not usually necessary to paint 316 stainless steel. If corrosion of 316 stainless steel does occur, and depending on the appearance or extent of the problem, the Engineer may call for pickling, electro-cleaning, painting or replacement of the item at no additional cost. Painting may however be required if contaminated or stained surfaces cannot be properly cleaned or where stitch welding has been approved.

A11.4 Quality Control of Coating Application

A11.4.1 Quality Plan and Records

The Contractor shall provide a Quality Plan which shall include all steps in the surface preparation and corrosion protection process plus technical data sheets for all products proposed.
Records of compliance with the Quality Plan shall be maintained.

A11.4.2 Responsibility and Rectification

The Contractor is responsible for the quality of the work and materials used, irrespective of any quality surveillance that may be carried out by the Engineer. If unacceptable work is found on Site, the full area associated by the engineer with that unacceptable area shall be redone after the Contractor has submitted a method proposal.

A11.4.3 Inspections

The Contractor shall arrange for the coating application on fabricated steelwork to be inspected throughout by the Engineer. The Engineer may approve inspections by an independent competent person (hereinafter called the Inspector) appointed by and at the cost of the Contractor. Inspections shall be adequate to ensure compliance with the Specification and shall be done at the following stages as a minimum:

Coating (Hot-Metal Spray, Paint, etc.)
After fabrication but before surface preparation.
After surface preparation but before application of the first coat.
After application of the final hot-metal sprayed coating or after application of the paint primer or first coat (as applicable).
After the final factory applied paint or sealing coat.

Hot-dip Galvanizing
After fabrication but before hot-dip galvanizing.
After hot-dip galvanizing.

Duplex Protection (Hot-dip Galvanizing and Coating)
After fabrication but before hot-dip galvanizing.
After hot-dip galvanizing but before application of the first coat.
After application of the primer.
After the final Site-applied paint coat.

A11.4.4 Witnessing of Inspection

If the coating is to be done in KwaZulu Natal by an inspector other than an engineer, the Contractor shall, nevertheless, arrange for the Engineer to witness the inspections at the latter's discretion.

A11.4.5 Dry Film Thickness

The dry film thickness of any coat or coating system shall be determined in accordance with SANS 2808. The test method defines that the instrument is to be calibrated on a substrate that represents the surface to be coated.

A11.4.6 Inspection Report

A written report of the inspections, prepared by the Inspector and signed by both the Inspector and the Contractor, shall be submitted for appraisal by the Engineer before delivery of the equipment to Site.

A11.4.7 Inspector Qualifications

Inspectors appointed by the Contractor shall hold an appropriate qualification from one of the following:

(a) Corrosion Institute of Southern Africa.
(b) South African Institute of Welding.
(c) South African Institute for Non-Destructive Testing.
(d) South African Qualification and Certification Committee.

A11.4.8 Identification of Items

Every item to be coated shall be identified by a welded or hard-stamped code. Records shall be maintained for each item.

A12. CORROSION PROTECTION: SURFACE PREPARATION

A12.1 Imperfections

Welding shall be free of blowholes and all welding flux removed. All weld spatter, sharp edges and other imperfections shall be removed prior to abrasive blasting. Prior to painting, weld beads with a surface irregularity exceeding 3 mm or with sharp crests having a radius under 2 mm shall be ground.
(Weld grinding must not, however, be performed on stainless steel). Areas to be painted shall be free of crevices.

A12.2 Edges

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

A12.3 Cleanliness

The provision of acceptable cleanliness entails not only the removal of existing mill scale, coatings and/or corrosion product, but also the removal of surface contaminants such as oil, grease and soluble salts. Water soluble salts present on the steel before application of the primer shall not exceed 10 µg/cm^2.

A12.4 Abrasive Blasting

Before coating, all new steel surfaces shall be abrasive blast cleaned in accordance with Section 4.3 of SANS 10064 to a preparation grade of ISO-Sa3 in accordance with ISO 8501. The blast profile, measured in accordance with SANS 5772 (dial gauge), shall be in the range of 50 to 75 µm. The abrasive shall comply with SANS 10064 and shall be free from all traces of oil, grease, foreign matter and corrosive contaminants such as chlorides, etc. The blasted surface shall be cleaned and degreased as required. The prepared surface shall be given the first coat of the painting system within 4 hours after blasting.

In instances where stainless steel and 3CR12 are to be painted, the surface shall be suitably abrasive blasted prior to primer application.

A12.5 Between Coats

Between coats or with previously painted surfaces in good condition, all traces of oils, greases, soluble salts and corrosive air borne contaminants shall be thoroughly washed from the surface to be painted using a detergent type cleaning agent, rinsed and dried. The previous coat shall then immediately be lightly sanded or otherwise prepared as recommended by the paint manufacturer, wiped clean, dried and painted. Solvents are not acceptable as a surface cleaning agent.

A12.6 Hot-Dip Galvanized Surfaces

Hot-dip galvanized surfaces to be painted shall not be passivated and shall be free from white rust and shall be cleaned with an approved water based galvanizing cleaner using non-metallic abrasive pads until a "water break free" surface is obtained. The surface shall then be thoroughly rinsed with clean potable water to remove all residues and dried immediately prior to painting. Where necessary to obtain adhesion a sweep blast of the surface shall be done after cleaning.

A13. CORROSION PROTECTION: METAL COATINGS AND DUPLEX COATINGS

A13.1 General

Fabrication of items to be protected by metal coatings shall be in accordance with SANS 14713.

A13.2 Hot-Dip Galvanizing

A13.2.1 General

Hot-dip galvanizing shall be done in accordance with SANS 121 and the following shall apply:

(a) Coatings shall be to the thicknesses detailed in the Standard.
(b) Hot-dip galvanized material which is to remain unpainted shall be passivated as specified in SANS 121. Items to be painted after hot-dip galvanizing shall be air dried and not passivated.
(c) Hot-dip galvanized material shall be substantially free from white rust when it is erected on site. Stacking and storing shall at all times be done in a manner to prevent white rust forming.
(d) Damage to hot-dip galvanizing caused by welding, grinding, etc. is not acceptable. Repair to hot-dip galvanizing damaged by handling or transport shall be done by cleaning the area and applying 3 coats of a zinc rich primer giving a dry film thickness of at least 100 µm and containing at least 94 % zinc in the dried film. If the Engineer considers that damage is excessive, such items shall be replaced by the Contractor without cost to the eThekwini Municipality.
(e) Welding after hot-dip galvanizing is not acceptable.
(f) The Contractor shall supply a galvanizer's guarantee or test certificate prior to installation.

A13.2.2 Duplex Systems

Preparation and application of organic coatings on hot-dip galvanizing shall be done in accordance with the Hot Dip Galvanizers Association Southern Africa’s Code of Practice for Surface Preparation and Application of Organic Coatings.

The duplex system shall be as follows:

(a) Hot-dip galvanizing; without passivation of the zinc coating.
(b) Application of one coat of an epoxy primer (two part; for hot-dip galvanised surfaces) with a dft of 75 µm.

(c) Polyurethane enamel top coat (two part) with a dft of 50 µm; done on Site after suitable repair to the primer.

Acceptable coating products are specified elsewhere.

A13.3 Hot-Metal Sprayed Coatings

A13.3.1 General

Fabrication and surface preparation of items to be protected by hot-metal spray shall comply with the requirements specified in this Standard Specification for Mechanical Works (including General Works).

Hot-metal sprayed coatings shall be in accordance with SANS 2063 and shall comply with the following:

(a) The minimum coating thickness for both aluminium and zinc shall be 150 µm. Greater thicknesses may be specified in the detailed Particular Specification.
(b) The thickness shall be checked on every surface plane at points not more than 300 mm apart for small articles and 500 mm for large articles. Angles shall be checked along all 4 surfaces, channels along all 6 surfaces, pipes in 4 planes. The minus tolerance on thickness in isolated areas shall also not exceed –10 % and such low areas shall not be larger than 50 mm in diameter.
(c) The time between surface preparation and coating shall be shortened from 4 hours to 2 hours at any application area closer than 10 km from the coast.
(d) Unless otherwise specified, all hot-metal coatings shall be sealed and coated immediately after hot-metal spraying. The system shall consist of a low viscosity sealant, which is applied until absorption is complete, followed by a suitable coating system.

The sealant systems outlined below are acceptable (where appropriate for the particular application).

A13.3.2 System 1 (for immersion applications)

Application of an epoxy zinc sealer to a dft of 60 µm (Sigmacover 522, or equivalent).

Application of two coats of epoxy pipe coating to a dft (per coat) of 125 µm; (Sigmaguard 720, or equivalent).

A13.3.3 System 2 (for non-immersion applications)

Application of a two part epoxy primer to a dry film thickness of 40 µm; (Intergard 269, Carboline Rustbond Penetrating Sealer, or equivalent).

Application of one intermediate coat chemical resistant vinyl copolymer to a minimum dry film thickness of 70 µm (Carboline Polyclad 938 HB, or equivalent).

Application of one coat of vinyl copolymer chemical resistant enamel to a minimum dry film thickness of 40 µm (Carboline Polyclad 938-2, or equivalent).

A13.3.4 System 3 (suitable for crane beams, gantries, etc.)

Application of one coat of a two-part epoxy primer to a dry film thickness of 40 µm; (Carboline Rustbond Penetrating Sealer, Intergard 269, or equivalent).

Application of two coats of a two-part polyurethane enamel (two part) to a minimum combined dry film thickness of 70 µm.

A13.3.5 System 4

Application of micaceous oxide pigmented polyamide cured epoxy to achieve a dry film thickness of 60-80 µm; (Sigmacover 522, or equivalent).

One coat of solvent borne modified acrylic coating to achieve a dry film thickness of 70 µm; (Sigma Topacryl coating, or equivalent).

One coat of solvent borne modified acrylic finish to a dry film thickness of 30-45 µm; (Sigma Topacryl finish, or equivalent).

A14. CORROSION PROTECTION: PAINT COATINGS

A14.1 Paint

A14.1.1 Paint Quality

Paint shall be of best quality, of approved manufacture and brand and comply with the requirements of the relevant SANS (South African National Standards) or BS specifications.

A14.1.2 Compatibility

All materials in a paint system shall be purchased from one paint manufacturer.

A14.1.3 Packaging

All coating materials shall be delivered in the manufacturer's original, sealed containers of maximum 25 litre capacity, clearly marked with the following:

(a) Manufacturer's name.
(b) Product Brand and Reference Number.
(c) Batch Number, which may incorporate the date of manufacture.
(d) Date of manufacture, unless already incorporated in the batch number.
(e) Abbreviated instructions for storage and use of the material, which shall include mixing ratios of components for multi-component materials, minimum temperature of application, method of application, and minimum and maximum overcoating times where applicable.

A14.1.4 Confirmation of Suitability

Contractors shall obtain confirmation from their paint suppliers that, when using their paints, the systems specified are technically correct and suitable for the application and the material being coated.

A14.2 Paint Application

A14.2.1 Surface Preparation

All surfaces shall be properly prepared as specified in Clause "Corrosion Protection: Surface

Preparation". Coats shall be clean and free from dust, oil and moisture before overcoating. The primary method for determination of oil and grease contamination of surfaces shall be visual inspection. Any surface that exhibits obvious signs of oil and grease, as well as variations in surface rusting and flash rusting, shall be regarded as having oil or grease contamination. All surfaces which have been machined or have had holes drilled shall be regarded as having oil and grease contamination.

A14.2.2 Environmental Conditions

Paint shall not be applied if:

(a) the conditions are windy or dusty.
(b) the surface temperature is less than 10 ºC.
(c) the surface temperature is less than 3 ºC above dewpoint.
(d) the surface temperature is above 35 ºC.
(e) the conditions are contrary to the manufacturer's recommendations.
(f) the relative humidity is 85% or above (the determination of humidity may be made using moisture sensitive hair-type gauges, electronic gauges or sling psychrometers (whirling hygrometers) having a resolution of at least 1% humidity. Electronic gauges shall have calibration certification not more than 6 months old. Moisture sensitive hair-type and analogue gauges shall have a calibration certificate not more than 1 month old. The accuracy of thermometer used in sling psychrometers shall be tested by placing at least 4 thermometers displaying temperatures within half a degree Centigrade of a mean shall be used).

A14.2.3 Mixing

Coating materials shall be mixed thoroughly by a power stirrer.

In the case of two-pack materials, each component shall be thoroughly stirred separately. The two components shall then be mixed together in the proportions supplied by the manufacturer until the mixture is completely homogeneous. The use of part of the contents is not acceptable.

In the case of solvent based epoxy materials, the mixed material shall be allowed to stand for the induction period recommended by the material manufacturer.

A14.2.4 Painting

Paints shall be applied strictly in accordance with the manufacturer's instructions by tradesmen skilled in this class of work. Thinning of paint shall only be allowed for spray application and the manufacturer's recommended thinners shall be used.

A14.2.5 Stripe Coats

All edges and welds shall be provided with at least one stripe coat. This coat shall, preferably, be the same as the primer but can be the same as the intermediate coat.

A14.2.6 Coating of Hidden Areas

Areas which will be inaccessible after erection and surfaces resting on floors shall receive the full paint system prior to erection.

A14.2.7 Surfaces in Contact

Mating or contact surfaces shall be treated with one of the following systems, the system being chosen to suit the application:

(a) Surfaces shall be prepared and primed and brought together while the paint is still wet; or,
(b) Each surface shall be provided with one coat of inorganic zinc silicate; or,
(c) Surfaces shall be provided with a mastic or sealant; or,
(d) Surfaces shall be provided with insertion rubber or other gasket material.

A14.2.8 Crevices

Crevices will not be permitted. Where unavoidable crevices are accepted by the Engineer, such crevices shall be sealed with either a coal tar product which can be applied at thicknesses of up to 1 000 µm such as Carboline Bitumastic 50 or equivalent; or a two part solvent free epoxy which can be applied at thicknesses of up to 600 µm such as Sigmaline 523 or equivalent.

A14.2.9 Items Encased in Concrete

Metal to be encased in concrete shall be painted externally up to 30 mm inside the concrete section, leaving the remainder bare so as to facilitate bonding with the concrete.

A14.2.10 Protection of Machined Surfaces

Where painting of machined surfaces is not possible or advisable, these surfaces shall be coated with an approved proprietary anti-corrosion compound giving 12 months protection under operating conditions. Shaft ends and machined mating or mounting surfaces or pads shall be so coated and shall not be painted.

A14.2.11 Coating Thickness

The dry film thickness shall be measured using a non-destructive thickness testing machine and shall comply with the Specification. 90 % of all thicknesses measured shall comply with the minimum requirements of the Specification. Up to 10 % of all readings may be below the specified minimum thickness, but may not be less than 80 % of the specified minimum thickness.

A14.2.12 Repair

Painted areas damaged during transportation, erection or any means whatever shall be repaired as follows - Rusted spots shall be removed and cleaned by means of a wire brush or emery paper to a bright metal finish and the surrounding paint which is still intact shall be feathered for a distance of 50 mm beyond the damaged area. Spot priming and repair shall consist of all the coats previously applied and shall overlap the undamaged area.

A14.2.13 Protection on Site

Proper and adequate use of cover sheets and other means shall be made to protect the existing paintwork from damage and from metal dust and sparks when welding, grinding, and wire brushing on site. Similarly, effective steps shall be taken to prevent spillage or splashing or other damage to floors, walls and equipment when painting on site and any damage or mess caused shall be corrected at the Contractor's cost.

A14.2.14 Final Coat

A continuous, smooth finish with a uniform colour is required. The final external coat/s shall, where applicable, be applied on Site after installation.

A14.3 Final Colour Code – General

Colours shall comply with the National Colour Standard, SANS 1091.

The final colour marking shall be in accordance with SANS 10140.

Where SANS 10140 does not specify a requirement, the colour marking shall comply with the following (please note that wastewater treatment works are dealt with separately below):

PIPEWORK				
CONTENTS OF PIPE	BASIC COLOUR	COLOUR OF INDICATOR		
		1 BAND	2 BANDS	3 BANDS
AIR				
Compressed, Power	Arctic Blue (F28)		-	-
Aeration	Arctic Blue	Canary Yellow (C61)	-	-
Instrument	(F28)	Salmon Pink (A40)	-	-
Vacuum	Arctic Blue	Primrose (C67)	-	-
Lime Transfer	(F28)	Crimson (A03)	-	-
Backwash	Arctic Blue	Verdigris Green (E22)	-	-
CHEMICALS				
Aluminium Sulphate	Jacaranda (F18)	Verdigris Green (E22)	-	-
Sodium Aluminate	Jacaranda (F18)	Crimson (A03)	-	-
Ferric Sulphate	Jacaranda (F18)	Canary Yellow (C61)	-	-
Lime (dry powder)	Jacaranda (F18)	Salmon Pink (A40)	-	-
Activated Carbon	Jacaranda (F18)	Light Stone (C37)	-	-
Polyelectrolyte	Jacaranda (F18)	Cloud White (G80)	-	-
GASES (other than air); liquefied or gaseous				
Butane, Propane	Light Stone	-	-	-
Ammonia	(C37)	Ultramarine (F09)	-	-
Blast Furnace	Light Stone	Crimson (A03)	-	-
Carbon Dioxide	(C37)	Light Brunswick Green (H07)	-	-
Coke Oven	Light Stone	Light Grey (G29)	-	-

Producer	(C37)	Verdigris Green (E22)	-	-
GASES (other than air); liquefied or gaseous				
Chlorine, Hypochlorite	Light Stone	Canary Yellow (C61)	-	-
WATER				
Cold Drinkable	Brilliant Green (H10)	Cornflower (F29)	-	-
Hot Drinkable	Brilliant Green (H10)	Crimson (A03)	Cornflower (F29)	
Boiler Feed (Distilled)	Brilliant Green (H10)	Crimson (A03)	Cloud White (G80)	Crimson (A03)
Boiler Feed (De-mineralised)	Brilliant Green (H10)	Cloud White (G80)	-	-
Industrial, Raw	Brilliant Green (H10)	Golden Yellow (B49)	-	-
Reclaimed	Brilliant Green (H10)	Jacaranda (F18)	-	-
Backwash	Brilliant Green (H10)	Light Stone (C37)	-	-
De-sludge	Brilliant Green (H10)	Canary Yellow (C61)	-	-
Stove Circulating	Brilliant Green (H10)	Salmon Pink (A40)	-	-
Hydraulic Power	Brilliant Green (H10)	Terra Cotta (A10)	-	-
Final Treated Effluent	Aquamarine (E67)	-	-	-
Interchange, Stage	Drakensberg Green (H36)	-	-	-
Raw Sewage	Olive Green (H05)	-	-	-
Sea Water	Light Brunswick Green (H07)	-	-	-
Primary Sludge	Dark Brown (B03)	-	-	-
Waste Activated Sludge	Light Brown (B03)	-	-	-
Digested Sludge	Light Brown (B15)	Light Olive Green (H21)	-	-
Pasteurised Sludge	Light Brown (B15)	Cloud White (G80)	-	-
OIL				
Diesel Fuel	Golden Brown (B13)	Cloud White (G80)	-	-
Hydraulic Power	Golden Brown (B13)	Salmon Pink (A40)		
Lubricating	Golden Brown	Verdigris Green		

	(B13)	(E22)		
Transformer	Golden Brown (B13)	Crimson (A03)		
Paraffin	Golden Brown (B13)	Arctic Blue (F28)		

PLANT AND EQUIPMENT	
EQUIPMENT	COLOUR CODE
FIRE FIGHTING	
Equipment and Pipework	Signal Red (A11)
ELECTRICAL	
Distribution Boards, Switch-Gear, Terminal Boxes and Conduits	Light Orange (B26)
Emergency Stop	Signal Red (A11)
MACHINE GAURDS	
Inside	Light Orange (B26)
Outside	Colour of Machine
Protruding Shafts, Exposed Gear Wheels and Rotating Parts	Light Orange (B26)
HANDRAILS	
Horizontal Rails and Chains	Golden Yellow (B49)
Stanchions	Black
Protrusion, Side of Ramps	Black and Yellow Diagonal Stripes
GENERAL	
Scour Pipes	Deep Buff (B24)
Valves	Basic colour of pipeline
WORKSHOP FLOOR DEMARCATION	
Demarcation Lines	Golden Yellow (B49)
Working Areas	Pastel Grey (G54)
No Parking, No Storage	Golden Yellow (B49)
Aisles and Walkways	Brilliant Green (H10)
Storage Area	Terracotta (A10)
Urethane based paint is to be used for concrete surfaces Traffic paint is to be used for tarred surfaces	

A14.4 Final Colour Code – Wastewater Treatment Works

Colours shall comply with the National Colour Standard, SANS 1091.

The final colour marking shall be in accordance with SANS 10140.

Where SANS 10140 does not specify a requirement, the colour marking on wastewater treatment works shall comply with the following:

PIPEWORK				
CONTENTS OF PIPE	BASIC COLOUR	COLOUR OF INDICATOR		
		1 BAND	2 BANDS	3 BANDS
WATER				
Fresh Water	Cornflower (F29)			
Sea Water	Light Brunswick Green (H07)			
Cooling Water	Aquamarine (E67)			
Final Treated Effluent	Aquamarine (E67)			
Fire Fighting	Signal Red (A11)			
SLUDGES				
Interchange	Drakensberg Green (H36)			
Raw Sewage	Light Olive Green (H21)			
Primary Sludge	Dark Brown (B03)			
Waste Activated Sludge	Light Brown (B15)			
Digested Sludge	Light Brown (B15)	Light Olive Green (H21)		
Pasteurised Sludge	Light Brown (B15)	Cloud White (G80)		
OTHER LIQUIDS				
Drainage	Black			
Hydraulic Oil	Salmon Pink (A40)			
Lubricating Oil	Verdigris Green (E22)			
Polyelectrolyte	Aquamarine (E67)	Dark Violet (F06)		
Diesel Fuel	Golden Brown (B13)			
GASES				
Chlorine, Hypochlorite	Canary Yellow (C61)			
Digester Gas	Smoke Grey (F20)			
Air	Arctic Blue (F28)			
Oxygen	Cloud White (G80)			
Ventilation Air	Pale Grey (G26)			

Steam	Silver (Aluminium)			
Hydrogen	Poppy Red (A14)			
Bands shall be 250 mm wide, 4000 mm apart.				
Hot liquid lines shall have a 50 mm wide band of Crimson (A03) every 4000 mm.				
PLANT AND EQUIPMENT				
EQUIPMENT		COLOUR CODE		
ELECTRICAL EQUIPMENT				
Motors : External		Light Grey (G29)		
Motors : Fans, Cowl internal surfaces		Light Orange (B26)		
Electrical switchgear, other than starting and stopping devices and emergency stop controls		Light Orange (B26)		
Terminal boxes, conduits		Light Orange (B26)		
Emergency stope and control devices		Signal Red (A11)		
MECHANICAL EQUIPMENT				
Pumps		To suit liquid being pumped		
Blowers, Compressors, incl. ancillary equipment		Strong Blue (F11)		
Turning shafts, Couplings, Pulleys, Fans, etc.		Light Orange (B26)		
Baseplates		Black		
Direction arrows, Unit no., etc.		Black on white, White on other colours.		
Valves		To suit liquid being handled.		
Handwheels		Signal Red (A11)		
Bridges for settling tanks		Light Admiralty Grey (E46), or Arctic Blue (F28)		
Bulk mechanical equipment, Gearboxes, General Fabrications, Brackets, Supports, etc.		Light Grey (G29)		
Cranes and Crawl Beams		Golden Yellow (B49)		
DANGER AREAS				
Guards : Internal surfaces		Light Orange (B26)		
Guards: External surfaces		As per adjusted surfaces, but always contrasting with B26		
Turning shafts, couplings pulleys, fans, etc.		Light Orange (B26)		
Fire fighting		Signal Red (A11)		
Protrusions, Low beams, etc.		Black/Golden Yellow Stripes (-/B49)		
Guardrails: Top horizontal and chains		Golden Yellow (B49)		
Guardrails : Bottom horizontal		Black		
Guardrails : Stanchions		Black		

Items made of 316 or 316L stainless steel may be left unpainted provided the surface is of uniform self-colour without blemishes, rust, marks or stains. If blemished, the surfaces must either be painted or cleaned by pickling and/or electro-cleaning (not grinding or other mechanical means).

A14.5 Painting Systems

A14.5.1 Definition of Terms

The abbreviation "dft." used in this Specification shall mean dry film thickness given in microns and, except where otherwise specified, is the minimum (not average) thickness permissible.

A14.5.2 System for Large Immersed Steel Fabrications

This system is suitable for steel items subject to immersion, semi-immersion and non-immersion such as tanks, pipes, etc.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO-Sa3 in accordance with ISO 8501	
2	Apply three coats of low solvent, high solids, polyamine/amide cured, epoxy (two part)	350
		Total = 350 µm
The coating shall undergo EID detection over the full surface in accordance with SANS 1217. This test shall be done by an inspector holding an appropriate qualification from either the CISA, the SAIW or the SAQCC. When applied to hot-dip galvanized surfaces, a suitable epoxy primer shall be used after carefulsurface preparation before applying this system. This system shall be applied by a specialist applicator prior to delivery to site with particular attention to the required interval between coats. The first and third coats shall be a different colour to the second coat.		

A14.5.3 System for Large Immersed Steel Fabrications (non-chalking surface)

This system has similar applications to the system above but which also require a non-chalking surface.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	System for Large Immersed Steel Fabrications	350
2	One coat of polyurethane enamel (two part)	40
		Total = 390 µm

A14.5.4 System for Large Immersed Steel Fabrications (not requiring decorative finish)

This system is suitable for steel items subject to immersion, semi-immersion and non-immersion such as archimedes screw pumps, large tanks, etc.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surfaces to ISO-Sa3 in accordance with ISO 8501	
2	Coat of polyamine/amide cured coal tar epoxy	140
3	Coat of polyamine/amide cured coal tar epoxy	140
	Coat of polyamine/amide cured coal tar epoxy	140
		Total = 420 µm
Each coat shall preferably be a different colour. Two coats will be acceptable if recommended by the paint manufacturer.		

A14.5.5 System for non-immersed Steel in Coastal Atmosphere

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surfaces to ISO-Sa3 in accordance with ISO 8501	
2	Coat of two component zinc epoxy primer.	100
3	Coat of two component epoxy intermediate.	150
4	Coat of polyamine/amide cured coal tar epoxy	50
		Total = 300 µm

A14.5.6 System for non-Immersed Steel in Moderate Atmosphere

This system is suitable for heavy fabricated steel items requiring a hard, high gloss colour finish; eg. bridges, structural steel, mobile equipment, etc.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surfaces to ISO-Sa3 in accordance with ISO 8501	
2	Coat of inorganic zinc silicate of two component zinc epoxy primer.	75
3	Coat of epoxy intermediate coat	75
4	Coat of polyurethane enamel (two part) polyamine/amide cured coal tar epoxy	40
		Total = 190 µm
The complete system must be factory applied and touch ups will be required on Site. The primer shall be tested for full cure before applying the subsequent coats. This system shall not be used for items subject to immersion.		

A14.5.7 System for Hot-Dip Galvanized Steel (Duplex)

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	After hot-dip galvanizing, do not passivate	
2	Coat epoxy primer (two part for HDG surfaces)	75
3	Coat of polyurethane enamel (two part)	50
		Total = 125 µm

A14.5.8 System for Repair to Coating on Steel and Cast Iron (“Maintenance Coating”)

This system is suitable as a maintenance coat over weathered coatings and partially failed coatings.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Surface preparation shall include, as a minimum, removal of all loose mill scale, non-adherent rust and loose paint prior to wire brushing and de-greasing and shall comply with ISO-St3 (ISO 8501) or with SSPC-SP3 (Steel Structures Painting Council of the USA).	
2	Coat of aluminium filled epoxy (two part). epoxy primer (two part for HDG surfaces).	100
3	Coat of epoxy intermediate.	150
4	Coat of polyurethane enamel (two part)	40
		Total = 290 µm

A14.5.9 System for Cast Iron Components

This system is suitable for motors, gearboxes and other cast iron components.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO-Sa2 1/2 in accordance with ISO 8501	
2	Coat high build epoxy primer	100
3	Coat of polyurethane enamel (two part)	60
		Total = 160 µm

A14.5.10 System for Steel in Dry Applications up to 200 ºC

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO-Sa3 in accordance with ISO 8501	
2	Coat of a two part micaceous iron oxide pigmented polyamine/amide cured epoxy sealer/coating (Sigmacover 522 or equivalent).	60
3	Coat of a two part micaceous iron oxide pigmented polyamine/amide cured epoxy sealer/coating (Sigmacover 522 or equivalent).	60
		Total = 120 µm

A14.5.11 System for Steel in Dry Applications up to 200 ºC

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO-Sa3 in accordance with ISO 8501	
2	Coat of inorganic zinc silicate.	75
3	Coat of modified silicon heat resisting coating for 200 ºC.	75
		Total = 150 µm
Particular care shall be taken to obtain the recommended anchor pattern during abrasive blasting and to achieve the required primer thickness on all surfaces in one coat. The primer must be factory applied. The primer shall be tested for full cure before applying the subsequent coat.		

An intermediate coat suitable for 200 ºC shall be included between the primer and top coat if so recommended by the paint manufacturer. The top coat must cure at ambient temperatures.

D14.5.12 System for Steel in Potable Water up to 100 ºC

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO-Sa3 in accordance with ISO 8501	
2	Coat of a two part micaceous iron oxide pigmented polyamine/amide cured epoxy sealer/coating (Sigmacover 522 or equivalent).	80
3	Coat of a two part micaceous iron oxide pigmented polyamine/amide cured epoxy sealer/coating (Sigmacover 522 or equivalent).	80
4	Coat of a two part micaceous iron oxide pigmented polyamine/amide cured epoxy sealer/coating (Sigmacover 522 or equivalent).	80
		Total = 240 µm

A14.5.13 System for Steel and Cast Iron in Dry Applications up to 540 ºC

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO-Sa3 in accordance with ISO 8501	
2	Coat modified silicon	40
3	Coat modified silicon	40
4	Coat modified silicon	40
		Total = 120 µm

A14.5.14 System for Steel Grid Flooring (where HDG is not suitable)

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO- Sa2½ in accordance with ISO 8501	

2	Apply a glass flake resin by dipping in catalysed resin	

A14.5.15 System: Fusion Bonded Epoxy

This system is suitable for immersed objects, cast iron valve bodies, pipework, etc.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO- Sa3 in accordance with ISO 8501	
2	Apply fusion bonded epoxy in accordance with the manufacturer's instructions for the item to be coated.	300
		Total = 300 µm
This is a water resistant, non-toxic and non-tainting, fusion bonded epoxy pipe coating in accordance with SANS 1217. The material used shall be of Type 2; i.e. a thermosetting powder-coating material. Pre-heating is needed to achieve the required coating thickness. No reading shall be less than 200 µm. The Contractor shall execute EID detection over the full surface in accordance with SANS 1217. The items to be coated shall be prepared in accordance with the relevant clauses of this Specification and, in particular, shall have edges ground to a radius of curvature of at least 3 mm.		

A14.5.16 System: Hot-Applied Thermoplastic

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Blast steel surface to ISO- Sa3 in accordance with ISO 8501	
2	Apply one coat of a synthetic thermoplastic polyamide.	300
		Total = 300 µm
No reading shall be less than 200 µm. The coating shall be applied by dipping into a fluidised bed of the polymer after the object has been suitably heated. The coating shall be executed strictly in accordance with the recommendations of the polymer supplier and the applicator shall be certified by the supplier for application of the coating. The Contractor shall execute EID detection over the full surface in accordance with SANS 1217. Objects to be coated shall be prepared in accordance with the relevant clauses of this		

Specification and, in particular, shall have edges ground to a radius of curvature of at least 3 mm.

A14.5.17 System for Repair of Coatings on Submerged Steelwork

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Abrade corroded areas to St 2 in accordance with ISO 8501.	
2	Feather existing coating and lightly abrade existing coating.	
3	Clean and degrease surfaces to be coated and allow to dry.	
4	Apply coat(s) of a two part, solvent free epoxy which is suitable for application to wet steel.	800
		Total = 800 µm
Coating shall be done in accordance with the manufacturer's instructions.		

A14.5.18 System to Provide Thick Coating for Complex Surfaces

These systems are thick coatings for covering complex surfaces normally including crevices which are formed by fasteners, seams, edges and corners and are generally applied either before or after the parent surfaces have already been suitably coated. Suitable for immersed and non-immersed applications.

STEP	PREPARATION/COATING METHOD	Minimum dft (µm)
1	Clean and degrease surfaces to be coated and allow to dry.	
2a	Two coats of a solvent free, two part epoxy which can be applied at thicknesses of up to 600 µm such as Sigmaline 523 or equivalent.	600
	OR	
2b	Single part, cold applied coal tar coating which can be applied up to a dry film thickness not less than 1 000 µm; Carboline Bitumastic 50 or equivalent.	1000
		Total > 1000

A14.6 Acceptable Materials and Suppliers

The table below lists acceptable materials and suppliers. In all cases, other equivalent materials and suppliers are acceptable.

GENERIC	MATERIAL/ SUPPLIER
Hot-Dip Galvanizing	Hot-dip galvanisers shall hold the certification mark for SANS 121.
Powder Coating	Plascon epoxy/polyester powder : CEP series, Sigmalining FBE 27.
Universal Undercoat	Sigmarine 40, Carboline GP-64 Undercoat, Plascon Plasconamel 189 Undercoat.
High-Gloss Alkyd Enamel	Carboline AD-51 Finish, Plasconamel 1000 Finish, Sigmarine 49.
HB Epoxy Primer : Two Part	Plascon Plascotuff HB Epoxy MLE series, Sigmazinc 109HS, Carboline 193 Primer.
Epoxy Primer : Two Part (for hot-dip galvanized surfaces)	International Interguard 269, Sigmacover 280.
Polyamine/Amide Cured Epoxy Sealer/Coating : Two Part	Carboline Rustbond Penetrating Sealer, Plascon Plascoguard Copon EA3 Primer, Sigmacover 522
Epoxy Intermediate Coat	Sigmacover 456, Carboline 190 HB, Plascon Plascosafe 18 Primer, Sigmacover 435.
Low Solvent, High Solids, Polyamine/Amide Cured Epoxy : Two Part	Plascon Plascoguard Copon KSIR88, Sigmaguard 720 Ameron Amercoat 385, Carboline 891.
Polyamine/Amide Cured Coal Tar Epoxy : Two Part	Sigmacover 300, Carbomastic 200, Ameron Amercoat 78HBB.
Solvent Free Epoxy repair Coating	Plascon Plascoguard Copon Hycote 151, Sigmaguard 575.
Aluminium Filled Epoxy : Two Part	Ameron Amerlock 400 AL, Carbomastic 15, Sigmacover 630.
Two Part Solvent Free Epoxy For Submerged Applications	Sigmarite Submarine Coating, Carboline 1208, InterZone 954, Jotamastic 87.
Zinc Phosphate Primer	Carboline GP-18 Primer, Plascon Plascoprime 183 HB, Bildphos M10 Primer.
Inorganic Zinc Silicate	Plascon Plascozinc 233, Sigmazinc 160, Carboline Carbozinc 11, Ameron Dimetcote 11.
Modified Silicon	Carboline 4631, Plascon Plascotherm Silicone 540 – Aluminium, Sigmatherm 520.
Silicone Acrylic	Plascon Plascotherm Silicon – Acrylic 200 T, Carboline 1248.
Polyurethane Enamel : Two Part	Sigmadur 550, Carboline 134 over polyamine/mide coatings, Carboline 133 HB over zinc coatings, International Interthane 990, Plascon Plascothane Recoatable Enamel CPC Series, for two-coat systems, Plascon Plascothane Recoatable Enamel CPQ Series, for single coat systems.
Glass Flake Resin	Power Blast Vitaglass or equivalent.

Hot-applied Thermoplastic	Rilsan or equivalent.
Thick Coating for Complex Surfaces	Sigmaline 523 or Carboline Bitumastic 50.

A15. FASTENERS

A15.1 Standards

Bolts and nuts shall be hexagon head type complying with SANS 1700 with threads of the coarse pitch series. Allen head screws of any type shall not be used without the Engineer's written consent.

A15.2 Fasteners M12 and Smaller

All fasteners M12 and smaller shall be of grade 316 SS, or better.

A15.3 Fasteners Larger than M12 - in Corrosive Areas

All fasteners in corrosive areas shall be of 316 SS, 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 internal and external areas in the vicinity of the inlet works of a wastewater treatment works. All fasteners embedded in brick, concrete or soil shall also be of 316 SS, or better.

A15.4 Fasteners Larger than M12 - Non-Corrosive Areas

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

A15.5 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.

A15.6 Material Compatibility

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

A15.7 Washers

Washers of similar material to the bolts shall be provided under each nut and setscrew head. Multiple washers or shims shall not be used. Spring washers or other approved locking arrangement shall be used on all fasteners subject to vibration.

A15.8 Anti-Seize Compound

Before assembly, threads shall be treated with a nickel based, anti-seize/corrosion protection compound; Chesterton 725: Nickel Anti-Seize Compound, or equivalent. The Contractor shall note:

(a) Copper-based compounds are not acceptable and, if used, shall be cleaned off before the correct compound is applied.
(b) If it is found during inspection that compound has not been applied, the Contractor shall disassemble all fasteners and comply with this requirement.
(c) A small amount of compound shall be applied along the full length of the thread before the nut is applied. Excessive compound visible on the thread after the nut has been applied shall be cleaned off.

A15.9 Thread Projection

Bolt threads shall project between 1 and 6 mm 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.

A15.10 Corrosion Protection

After installation the exposed surfaces of bolts not made of 316 SS or of EN 1.4162 shall be coated as for the items being fastened. If the use of Allen head or similar fasteners has been approved by the Engineer, the recessed heads shall be filled with a suitable non-hardening sealing compound.

A16. ANCHOR FASTENERS

A16.1 Type and Material

All anchor fasteners shall be of grade 316 SS, or better. Anchor fasteners for water retaining structures and for brickwork shall be of the chemical anchor fastening type. Anchor fasteners for other applications may be of the expanding type or chemical anchor type.

A16.2 Hook Bolts

Grade 316 SS, or better, hook bolts 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.

A16.3 Alternative Anchor Bolts

The use of 316 stainless steel "Hilti Kwik Bolt" stud bolts or equivalent may be used as an alternative where approved by the Engineer. If steel reinforcing bars are encountered while the holes are being drilled, the Contractor shall knock a hole in the concrete around the steel and grout in a stainless steel hook bolt as described above.

A16.4 Through-Bolt Anchors

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, these, together with associated washers and brackets, shall also be of grade 316 SS, or better.

A16.5 Anti-Seize Compound

A small amount of a nickel-based, anti-seize compound shall be applied along the full length of fastener threads before the nut is applied.

A17. GRID FLOORING

All platforms and stairways shall be constructed with a non-slip profile or finish.
Consideration may be given to use glass fibre grating only in applications of non-elevated heights and where theft is a potential problem. The grating shall be of open grating type and not less than 38mm in depth. The mesh size shall not be less than 38mm x 38mm and the resin shall be Vinyl Ester.

All elevated walkways and stairways shall be Mild Steel Dipped Galvanised construction.

The depth of bearer bars in steel grid flooring shall not be less than 30 mm with a bearer bar pitch of not greater than 40 mm. The bearer bars shall be across the shorter span.

Panels shall be set level and fixed to angle frames to prevent rocking.

Cut-outs in grid flooring for pipes, valve spindles, etc. are to be made and banded before any corrosion protection is done. The edges of removable grid access covers must also be banded.

Grid flooring and frames shall be hot-dip galvanized after fabrication. Alternatively, a glass flake resin which is applied by dipping the flooring in catalysed resin, is acceptable; such as Power Blast's Vitaglass or equivalent. The grating shall be of open grating type and not less than 38mm in depth. The mesh size shall not be less than 38mm x 38mm and the resin shall be Vinyl Ester. All GRP type grating shall include an anti-slip coating. Painted coatings will not be acceptable.

Where grid flooring rests on painted surfaces, strips of rubber insertion material shall be secured under the grid to protect the paint.

The fixing clip set (saddle clamp and locking plate) shall be of hot-dip galvanised steel or stainless steel. All fasteners shall be of grade 316 SS, or better.

A18. GUARD RAILING

A18.1 General

Guard railing shall be provided in accordance with legislated requirements and shall be provided generally, in positions where the vertical change in level is 1 000 mm or greater.

Guard railing shall comply with SANS 10104.

Fabrication and installation requirements are specified elsewhere in this Standard Specification for Mechanical Works.

A18.2 Guard Railing for Equipment Installations

Guard railing for equipment installations shall comply with the following specific requirements:

(a) Guard railing shall be of grade 316 stainless steel and shall comprise hand and knee rails not less than 32 mm diameter and stanchions spaced at not more than 1,8 m except where specifically directed otherwise in writing by the Engineer.

(b) 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**.

(c) 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.

(d) For applications covered by this Specification, the rails and stanchion shall withstand, without permanent deflection, a proof force of 890 N and 1780 N respectively, applied at any point and in any direction. This requirement is in addition any strength requirement specified in SANS 10104. Contractors shall provide proof that their guard railing has been tested and withstands these loads.

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

(f) 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.

(g) Welded guard rail installations are preferred. Installations which incorporate jointed sections shall be secure and without relative movement of the components under loading. “Pop” riveted installations will not be acceptable. Joints shall be smoothly finished, without corners.

(h) 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 endings will be permitted.

(i) Stanchions shall generally be base-mounted to suit the arrangement requirements and shall be of solid or welded construction. Welding shall be continuous and shall be smoothly finished and then passivated.

(j) Stanchions which are hollow shall be self-draining.

(k) 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.

(l) 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 just prior to final tightening of nuts.

(m) A small amount of a nickel-based, anti-seize compound shall be applied along the full

length of fastener threads before the nut is applied.

(n) All components shall be supplied in the pickled and passivated condition which may also be polished. All surfaces must be uncontaminated and unmarked to ensure maximum corrosion resistance. A manufacturer's test certificate shall be provided for each batch of stainless steel giving the chemical analysis of the material.

(o) Where kickplates are required by legislation, these shall extend to 150 mm above the walkway level.

A18.3 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 must also be complied with:

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

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

A19. PERMANENT LADDERS AND STAIRS

A19.1 General

Permanent ladders shall comply, primarily, with the requirements of the OSH Act and, secondarily, with BS 5395. Stairs shall comply with BS 5395, Part 3.

Unless other materials are specified, ladders and stairs shall be of carbon steel and hot-dip galvanized after all fabrication has been completed.

Unless other materials are specified, bolts shall be hot-dip galvanised but anchor bolts in concrete and brickwork shall be of grade 316 SS, or better, and shall be no smaller than M16.

A19.2 Permanent Ladders

Ladders shall comply with the following detail design aspects:

(a) Access points to the head of ladders from platforms and walkways shall be protected by self-closing gates or by chains.

(b) No part of the ladders shall project into the passageway.
(c) The width between strings shall be between 380 mm and 450 mm.
(d) A minimum clear space of 230 mm must be allowed behind the rungs.
(e) The diameter of the rungs shall be approximately 25 mm and these shall be formed from HT steel reinforcing bar.
(f) Additional rungs shall be provided in the same horizontal plane as the top rung in order to close the gap between the platform and the ladder. Sufficient rungs shall be provided to ensure a maximum gap of 75 mm. These top rungs shall be at the same level as the floor or platform to which access is being provided.
(g) Strings shall be formed from flat bar.
(h) The vertical distance between the ladder support brackets shall not exceed 1 800 mm.
(i) The strings shall extend to 1 100 mm above the floor or platform and shall be matched with any guard rail protections at this level. Connections between hot-dip galvanized steel

ladders and stainless steel guard railing shall be bolted. Unless laterally supported by the guard rails, these strings shall be supported by vertical structural sections (not flat bar) whose footings shall comply with this Specification for guard rail stanchion feet.

(j) All rises in a flight shall be uniform and the surface of the top rung shall be level with the top platform or landing. The height chosen for the rise shall be between 225 mm and 255 mm.

(k) Except on chimneys, the height of a ladder should not exceed 6 000 mm. Greater heights shall be provided with intermediate landings between each 6 000 mm ladder section.

(l) If the height between start and end levels is over 4 000 mm, the ladder shall be fitted with a safety cage. The safety cage shall extend at least 1 000 mm above the higher landing. The cage *"shall afford firm support along its whole length for the back of the person climbing the ladder, and for which purpose no part of the cage shall be more than 700 mm away from the level of the rungs." (as per OHS General Safety Regulations)*. The cage shall comprise no fewer than seven vertical elements.

(m) Strings, rungs and support members shall be of solid structural sections (e.g. flat bar, round bar, square bar, angles, etc.) and no hollow sections will be accepted for any part of the ladder.

A19.3 Stairs

Stairs shall comply with BS 5395.

A20. PIPEWORK

A20.2 Pipes and Fittings

A20.2.1 Steel Pipe – General Duties

Steel pipes for general non-corrosive, non-abrasive duties for liquid, air and gas shall be as follows:

Up to DN 150 - SANS 62 medium class.
Over DN 150 - SANS 719.

Unless otherwise specified, steel pipework and fittings shall be hot-dip galvanised and painted.

A20.2.2 Steel Pipework – Design

Pipework up to DN 600 shall be in accordance with SANS 1476. Pipework for the conveyance of water shall, in addition, comply with CCT-WS 11 Standard Specification for Steel Pipe, Fittings and Specials.

A20.2.3 Stainless Steel Pipework

Stainless steel pipework shall be to ASTM 312. Schedule 10 pipes and fittings shall be used except where otherwise specified.

A20.2.4 Steam Pipework

Steam pipework smaller than DN 50 shall be of 316 stainless steel to ASTM A-312 Schedule 40 or approved equal. Steam pipework DN 50 and larger shall be manufactured to SANS 62 heavy class, ANSI B36.10 STD/Schedule 40 or to BS 1600 Schedule 40. Steel pipework shall be

supplied with a suitable temporary corrosion protection both internally and externally in order to prevent corrosion during the storage, installation and pre-commissioning period. A primer similar to Plascon SNK 2, phenolic modified polyvinyl butyral self-etch primer, would be suitable.

A20.2.5 Hydraulic and Oil Pipework

Hydraulic pipework shall be to BS 778 or equal. All hydraulic and oil pipes and fittings shall be thoroughly degreased, descaled and cleaned internally and externally after fabrication by abrasive blasting or pickling, thoroughly cleaned and rinsed, dipped in a hot iron phosphate solution and coated internally with a corrosion inhibiting, oil soluble preservative. After treatment and drying all openings shall be sealed until the pipes are installed.

A20.2.6 Butt Weld Fittings

Steel butt welding pipe fittings shall be to ANSI B 16.9, BS 1965 or BS 1640 of the same schedule as the pipework or heavier. Butt weld fittings in stainless steel shall be to ASA B 36.19 for schedule 5S and 10S and ASA B 16.9 for schedule 40S and 80S. Alternatively, fittings may be to BS 1640.

A20.2.7 Malleable Cast Iron

Malleable cast iron fittings shall be to SANS 14.

A20.2.8 Cast Iron

Cast iron pipes and fittings shall comply with BS 2035 (Class D) and shall be pressure tested in accordance with Clause 12 of that Standard. The requirements of the Standard's Clause 6 regarding freedom from defects and casting appearance and Clauses 8, 9 and 10 regarding casting accuracy will be strictly applied. The requirements of the Standard with regard to protection and flanges shall be modified to comply with this Specification. Also refer to Clause "Castings" of this Specification.

A20.2.9 Copper

Copper pipes shall be to BS 2871 or approved equal.

A20.2.10 Plastic Pipework

Polyethylene or Polypropylene pipes shall comply with SANS 533 and SANS 1315 respectively and shall carry the SABS mark. The contractor manufacturing and installing the pipework shall satisfy the requirements of SANS 9001. PVC pipework is not acceptable except where specified.

An operating life of 50 years shall be designed for and appropriate derating factors shall be applied to suit the application. The rated maximum working pressure at operating conditions of the class of pipe selected shall be not less than 1,5 times the actual maximum operating pressure. If the material used has insufficient resistance to solar radiation (U.V. light) for the application, suitable protection must be provided to achieve the required life.

Note that nominal bores and pipe diameters specified must be regarded as the minimum inside diameter.

A20.3 Pipework Design

A20.3.1 Pipe Type and Material

The type and material of pipe to be used will be given in the Detailed Mechanical Specification.

A20.3.2 Pipe Diameters

Unless otherwise specified in the detailed Particular Specification, pipe diameters shall be based on the following velocities. The velocities shall be based on the compressed volume at the operating pressure in the case of steam, air and other gases. Valves and other ancillaries shall generally be of the same nominal diameter as the pipe. Non-standard sizes shall not be used.

FLUID	FLUID FLOW [ℓ/s]			
	0-2,5	2,5-15	15-100	100-500
	ALLOWABLE FLOW VELOCITY [m/s]			
LIQUID				
GRIT FREE:	0.75 max	1,25 max	1,5 max	2 max
HIGH SOLIDS OR GRIT:		0,8 min	1 min	1 min
		1,5 max	1,75 max	2 max
STEAM	10 max	15 max	20 max	25 max
AIR AND GAS				
above 10 kPa	5 max	8 max	10 max	12 max
below 10 kPa	2,5 max	3 max	4 max	5 max

A20.3.3 Coupling Arrangement

Screwed fittings may be used on DN 50 and smaller provided that sufficient unions or flanges are provided for disassembly and removal of equipment. Reducing sockets and reducing bushes shall be used where required.

All steel pipes larger than DN 50 shall be flanged or fitted with mechanical pipe couplings as applicable.

Suitable pipe couplings shall be incorporated wherever necessary to facilitate maintenance or isolate vibration. A coupling shall be provided on each pump suction. Couplings shall be adequately restrained by harnesses as specified in the Clause "Pipe Couplings".

A20.3.4 Draining, Venting and Purging

On liquid lines provision shall be made for draining and venting where necessary. Vents shall be

provided at all vertical down bends on gravity lines. On gas lines provision shall be made for purging.

A20.3.5 Condensate Drains for Air Lines

Automatic condensate traps with isolating valves and valved by-passes shall be provided at all necessary points including ahead of any globe type valve, orifice plate or concentric reducer in a horizontal line, at each change of level and immediately ahead of the user equipment.

A suitable well of a diameter equal to the pipe diameter with a bottom drain shall be provided at each condensate removal point. Condensate traps and valves shall be accessible and condensate shall be piped to the nearest drain. Pipework shall be sloped in the direction of flow towards a drain point with a slope of 1 in 150 and care shall be taken to avoid sagging at any point.

A20.3.6 By-Passes

Isolating valves and valved by-passes shall be provided around condensate traps, pressure reducing valves and valves with solenoid or other actuation which do not have provision for manual operation.

A20.3.7 Encased Pipes

Pipework to be permanently encased in concrete, cement or similar shall be of cast iron or 316 SS, or better, for steel and stainless steel pipework respectively. The encased portion shall be a short, straight length of pipe, flanged both ends with adequate clearance between the wall surface and the flanges for inserting flange bolts. Victaulic type couplings may in some instances be permitted instead of flanges.

Pipe sections through walls below ground or water level shall be provided with a puddle flange the same diameter as a standard flange. The encased area shall in such cases be uncoated up to 30 mm inside the wall surface and coated to Specification from there on.

A20.3.8 Isolation

The layout design shall make provision for isolation and easy removal of mechanical equipment.

A20.3.9 Nozzles for Fittings, Gauges, etc.

Nozzles on pipework (for installation of gauges, transmitters, drain pipes, cooling water take-offs, air release valves, etc.) shall be designed so that the pipework corrosion prevention system is not affected.

Nozzles shall consist of a flanged, welded tee-off of at least 100 mm diameter, painted or cement-lined internally and provided with a non-corrosive blank flange, e.g. grade 316 stainless steel. The blank flange shall be provided with tapped holes suitable for the equipment installation.

Internally painted, small diameter carbon steel nozzles and screwed carbon steel tee-offs are not acceptable. Carbon steel pipework may be provided with small diameter, grade 316 stainless steel nozzles which are welded into the pipework if the Engineer considers this acceptable in the application.

A20.3.10 Flow Straighteners

If a flow straightener is specified in the Detailed Mechanical Specification, this shall be provided in accordance with drawing number ME-A4/1520 : Pump Suction Flow Straightener – Plain Ended Pipe. This design is for plain ended pipes on the suction side of pumps but the blade configuration shall apply where applicable to other applications.

A20.4 Pipework Installation

A20.4.1 Appearance

Pipes and fittings shall be conservatively selected to suit the application, neatly installed, straight to line and level, adequately supported and shall operate without vibration.

A20.4.2 Valve Orientation

On sludge or raw sewage pipelines, check valves shall, wherever possible, be mounted horizontally and isolating valves with spindles vertical. Valve handwheels shall be arranged so that they are accessible to the operators.

A20.4.3 Supports

Proposed designs of pipe supports shall be submitted to the Engineer for acceptance prior to manufacture. Specific requirements are:

(a) Steel supports shall be fabricated from heavy duty hot-rolled steel sections. The complete assembly shall be hot-dip galvanised after all fabrication is completed.
(b) Welds shall be “all-round”.
(c) Each foot shall feature at least four anchor fasteners.
(d) For cantilevered pipe supports, the spacing between anchor fasteners shall be not less than one third of the cantilevered length

The spacing between pipe supports shall be as follows:

APPROXIMATE DISTANCE BETWEEN SUPPORTS FOR STEEL PIPE	
Pipe Diameter (DN)	**Distance Between Supports (mm)**
0-15	800
20-50	1500
65-100	2500
125-200	3500
250-500	5000
>500	6000
Distance between supports must be halved for pipe materials other than carbon steels and stainless steels	

Pipe supports shall be so located that when an item of mechanical equipment is removed, the associated valves and pipework are still adequately supported. Supports shall be provided close to heavy items such as valves. No external loads shall be placed on items of mechanical equipment such as pumps, compressors, etc. Adequate provision shall be made for expansion and contraction due to variations in temperature or pressure.

3 mm thick neoprene strips shall be placed between pipes and supports or clamps to protect the paintwork and limit corrosion. Where roller or sliding supports are used to accommodate movement, suitable wear blocks shall be fixed to the pipe to prevent damage.

Floor pipe supports shall be aligned using a nut above and below the foot. A space of at least 20 mm shall be left between the foot and the floor and this space shall be filled using non-shrink grout in accordance with the manufacturer's recommendations once alignment has been completed. Alternative designs and installations may be submitted by the Contractor. Wall pipe supports shall be similar.

Where the Engineer approves the use of concrete pipe supports to be built by a civil contractor under a separate contract, these will be constructed after installation of the pipework and temporary supports shall be provided by the Contractor in positions which will not interfere with the construction of the concrete supports.

A20.4.4 Pressure Testing

All pipelines shall be pressure tested to 1,5 times maximum working pressure. This shall be done before covering up the pipeline in any way where applicable and shall be witnessed by the Engineer.

A21. PIPEWORK FOR PUMP SUCTION

A21.1 General

Pump suction pipework shall be designed in accordance with good engineering practice. The following, in particular, shall be complied with:

(a) **Suction pipework shall be sized, where practical, to ensure that the flow speed is no higher than 1,5 m/s.**
(b) High points shall be avoided and it is preferred that the pipework slopes up toward the pump.
(c) Air leaks shall be avoided / prevented.
(d) Reducers shall be of the unequal type.
(e) Reducers shall have a diametral reduction of no more than 50 mm per 300 mm length and shall have a parallel-sided length between the tapered portion and each flange.
(f) “Lobster-back bends” shall have a minimum of five segments. The segments welded to the pipe flanges shall be perpendicular those flanges.
(g) Flow straighteners shall be provided where specified in the Detailed Mechanical Specification.
(h) Strainers shall be provided where specified in the Detailed Mechanical Specification.

A21.2 Bell-Mouths

All pump suction piping which draws the pumped liquid from open sumps shall be provided with bell-mouth inlets. The bell-mouth shall have an integral flange and shall be bolted to a flange on the suction pipework.

The preferred material for the bell-mouth is glass-fibre or stainless steel 316, however cast iron suitably coated, may be acceptable.

A22. FLUID STRAINERS FOR PIPEWORK

A22.1 General

This clause deals with strainers required for removing substantial solid particles from fluid flow and does not deal with automatically-operated, fine screen strainers. Fluid strainers shall be selected to be suitable for the application.

A strainer is required on the suction side of all centrifugal and positive displacement pumps which draw from fluid bodies such as tanks, channels, sumps, reservoirs, etc., which have open surfaces.
The Detailed Mechanical Specification gives specific requirements for strainers.

A22.2 Type, Design and Arrangement

Strainers shall preferably be of a proprietary type, A.R.I Semi Globe Filter, Krombach y-type, Bermad 70 F or equivalent. They shall be of the double-flanged configuration. Circular strainer elements are preferred.

The strainer element's hole diameter shall be decided in conjunction with the Engineer.

Differential pressure reading across the strainer shall be provided. Gauges shall be provided with isolation valves as well as protection from solids contamination.

Strainers whose baskets exceed 20 litres in volume shall incorporate:

(a) top pull-out configuration;
(b) a lifting device, such as a crawl beam with hoist or a davit arrangement; and the strainer basket shall be provided with a suitable lifting eye.
(c) a hot-dip galvanized steel support or a concrete support plinth.

The ratio of open area in the strainer element to inlet pipe area for non-proprietary units shall exceed 7 and shall be designed to suit the application. Strainer elements shall be made of stainless steel perforated plate with an opening size to be decided in conjunction with the Engineer. If the Engineer approves the use of wire grid for strainer elements, the wire shall be of at least 2 mm diameter and shall be of stainless steel. Strainer elements shall be robustly constructed, shall be provided with adequate flow passages between the strainer element and body and shall withstand the differential pressure developed when a strainer element is partially blocked. Flat surfaces shall be adequately braced to prevent buckling collapse. Lids shall incorporate an O-ring type seal and shall be secured with grade 316 SS, or better. Handles shall be provided on baskets of 20 litres or smaller.

All sharp edges on the strainer's internal surfaces and on the basket shall be removed.

A22.3 Corrosion Protection

Strainer housings and lids shall be either:

(a) coated cast iron;
(b) 316 SS, or better;
(c) glass reinforced plastic;
(d) plastic; or,
(e) hot-dip galvanized carbon steel.

Coated carbon steel will only be acceptable if the design is such that internal scraping of the surface is unlikely to occur. In such cases, the System for Large Immersed Steel Fabrications or System "Fusion Bonded Epoxy" or System “Hot-Applied Thermoplastic” or the System for Large Immersed Steel Fabrications (not requiring a decorative finish) will be acceptable.

A22.4 Testing

Strainer bodies shall be pressure tested to a minimum of 500 kPa and vacuum tested to 70 kPa before delivery to Site.

A23. FLANGES

A23.1 Standards

All standard flanges shall comply with SANS 1123. For flange sizes not included in the SANS, BS 4504 shall be used. Cast iron flanges and their mating flanges shall have flat faces. The flange table shall be as specified or, if not specified, selected to suit the maximum possible operating pressure but not less than Table 1000. Drilling and installation of flanges shall be "off-centre".

A23.2 Flange Fixing

Flanges DN 50 and smaller may be of the screwed on type. Metal flanges above DN 50 shall be welded on in accordance with BS 806 Type 6 unless otherwise agreed or specified.

A23.3 Machining of Flanges

All flanges shall be machined on the sealing face. Flanges cut from plate shall also be machined on the bore and outside diameter. Cast iron flanges shall also be machined or spot faced on the back of the flange to ensure a flat bearing surface for the fastener's head or nut and washer. All edges, including bolt-holes, shall be chamfered or rounded to a 2 mm radius.

A23.4 Butt Flanges

If the use of a loose hot-dip galvanized butt flange arrangement with stainless steel pipework is specified or approved by the Engineer, such arrangement and design shall comply with BS 4504 Table 6/6 or 10/6 as appropriate. The butt welded shouldered end for the pipe may be rolled from hot rolled stainless steel angle section. The hot-dip galvanized butt flange must be electrically insulated from the stainless steel pipework.

A23.5 Gaskets

The jointing material used on flange joints shall be of rubber or compressed asbestos fibre at least 3 mm thick complying respectively with BS 2494 or BS 1832, as applicable. Full face gaskets shall be used for full face flanges. Inner bolt circle gaskets shall be used on raised face flanges and when clamping items such as wafer type valves between flanges inside the bolt circle. Properly designed O-ring seals are also acceptable.

A24. PIPE COUPLINGS

A24.1 General

Where pipework movement, misalignment or dismantling must be allowed for, or if necessary for any other reason, pipe couplings may be used if approved by the Engineer. Pipe couplings shall be of the mechanical type, stainless steel bellows type or rubber bellows type.

A24.2 Supports and Anchors

Pipework using couplings shall be supported and anchored strictly in accordance with the coupling manufacturer's recommendations.

If the pipework configuration does not provide axial restraint, harnesses against separating forces shall be provided. Systems incorporating additional flanges or lugs and connected by tie bars or positively fixed to anchors will be acceptable. Systems relying purely on friction will not be acceptable. Tie bar harnesses shall incorporate three tie bars or more.

A24.3 Mechanical Pipe Couplings

Mechanical pipe couplings shall:

(a) be of rolled steel, forgings or of high grade castings;
(b) be coated;
(c) have rubber seals of a suitable grade;
(d) shall have stainless steel fasteners, and,
(e) be supplied without centre register unless otherwise specified.

Pipe ends shall be in accordance with the coupling manufacturer's recommendations. Where machining is required, as in the case of cast iron pipes, the length of machining on each pipe shall be approximately equal to the total length of the coupling to ensure that the coupling can be separated for pipe removal.

Couplings for air applications below 60 ºC shall be hot-dip galvanized for air applications above 60 ºC shall be of stainless steel. Couplings for liquid applications shall be coated in accordance with System – “Hot-Applied Thermoplastic” or System – “Fusion Bonded Epoxy”. Couplings for stainless steel pipework shall be stainless steel.

Fasteners, including coupling studs, **stub studs** (i.e. studs welded to the flanges of flange adaptors), washers and nuts shall be of grade 316 SS, or better.

When couplings are part of a buried pipeline, the metallic surfaces shall be coated as specified above and then covered and wrapped. Couplings shall be covered with mastic to a smooth finish, wrapped with tape and then wrapped with a polythene sheet which is strapped in place. "Denso mastic" and "Denso tape", or equivalent products, are suitable. If the operating temperature is likely to exceed 70 ºC, the mastic and tape shall be replaced with suitable grease or a suitable sealer.

A24.4 Stainless Steel Bellows Pipe Couplings

Stainless steel bellows shall incorporate stainless steel flanges and fasteners.

A24.5 Rubber Bellows Pipe Couplings

Rubber bellows couplings are acceptable for machinery which is flexibly mounted and also in applications which require isolation of driven machinery from the surrounding pipework and/or structures.

The flexible material used for rubber expansion joints shall be chosen specifically for maximum

resistance to bursting.

Metal backing flanges for rubber expansion joints shall be of stainless steel or hot-dip galvanized steel.

A25. CONDENSATE TRAPS FOR SEWAGE GAS

Condensate traps shall be of the automatic float operated type which shall not permit the escape of gas. For pipeline condensate removal a valve with l" BSP pipe connections shall be used. Sewage gas is generally at a very low pressure and often contains sticky solids. The valve of the condensate trap shall therefore be provided with an orifice and a seat of large area using a soft sealing element. The valve shall not be subject to sticking and shall preferably be of a ball type.

The body shall be of either cast iron suitably coated internally and externally or of aluminium. All other parts shall be of 316 stainless steel.

Condensate traps shall be provided with an isolating valve and valved bypass.

A26. FLAME ARRESTERS

Flame arresters shall have 316 stainless steel or aluminium bodies and 316 stainless steel elements. For all normal duties flame arresters shall be of a type which incorporates a fusible plug controlling an automatic shut off valve. Alternatively a separate thermally operated valve may be incorporated. Flame arresters used to protect relief valves shall however not incorporate a shut off valve.
Provision shall be made in the arrangement for access to the flame barrier element for maintenance. Valves shall be incorporated to isolate the flame arrester.

The gas has a very high moisture content and the flame trap design shall minimise the entrapment of water and suitable drainage petcocks shall be provided.

Suitably valved pressure tappings shall be provided upstream and downstream of the flame arresters.

A27. PRESSURE RELIEF AND VACUUM BREAKER VALVE WITH FLAME ARRESTER UNIT

The valve is generally used to protect anaerobic digesters and shall suit this duty.

The valve shall be of a type using removable lead weights on the pressure pallet. Each lead weight shall represent a pressure of 25 mm W.G. and the valve shall be supplied with sufficient weights for the pressure given in the detailed Particular Specification. Below this pressure the valve shall not leak. The vacuum pallet shall be set to 50 mm W.G.

The valve shall be of aluminium construction with 316 stainless steel wire mesh screens over the intake and exhaust ports. Pallets shall be centre and side guided and provided with seat inserts of a suitable material which is not subject to distortion. Seat rings and pallets shall be removable.

A flame arrester (of a type not incorporating a shut off valve) shall be installed between the digester and the relief valve.

The complete relief valve/flame arrester unit shall be sized to permit a pressure relief gas capacity of 5 m^3/min with a pressure increase not exceeding 25 mm W.G. and a vacuum relief air flow of 10 m^3/min at a vacuum of approximately 150 mm W.G.

A28. VALVES FOR LIQUIDS OR GASES

A28.1 General

The valves to be used on the more common applications are specified below.

Where special valves are necessary for special applications, these will be specified in the detailed Particular Specification but, if not, tenderers must select suitable valves and provide details in the tender.

The handwheel, lever, etc. on valves, valve actuators and valve gearboxes to be supplied and installed for the Bulk Water Department of the eThekwini Municipality shall be configured to be anti-clockwise closing unless unobtainable. All valves supplied and installed for other Departments in the eThekwini Municipality shall be clockwise closing.

A28.2 Requirements for All Valves

All valves shall comply with the following (unless inapplicable):

(a) Valves shall be designed and constructed to ensure reliable operation after long periods of non-operation.
(b) Valves shall be double-flanged unless unavailable or otherwise specified.
(c) Valves and their method of actuation shall be designed to operate under the full pressure rating of the valve.

(d) If not obvious from the configuration, all valves, including valves with gearboxes and valves with actuators, shall be provided with an indication of the current position as well as an indication of the closing and/or the opening direction.
(e) Spindle covers shall be provided for valves with rising spindles.
(f) The specific application shall be taken into account in the corrosion protection of valves.
(g) Cast iron valve components, including valve bodies, shall be protected with System – “Fusion Bonded Epoxy” or System – “Hot-Applied Thermoplastic”.
(h) Metal plating of ferrous materials is not an adequate corrosion protection system.
(i) Lever handles on small bore valves and position indicator plates shall be of stainless steel.
(j) Fasteners shall be of grade 316 SS, or better. This applies to all fasteners on the body of the valve and its gearbox. Pipework flange bolts are specified elsewhere.

A28.3 Cast Iron Gate Valves with Resilient Seals

Resilient seal gate valves may be used on raw sewage, raw water, effluent and general duties where some solids may be present but must not be used on high solid applications such as sludge and grit duties. The valves shall comply with the following:

(a) The valves shall comply with SANS 664 or SANS 665, Class 10 or higher as required.
(b) The valves shall be double flanged.

(c) Valves shall have rising spindles unless otherwise specified or necessary because of space restrictions. Non-rising spindle valves shall be fitted with indicators showing the valve opening position.
(d) Handwheels shall be of cast-iron.
(e) The spindle shall be of grade 316 SS, or better.
(f) Fixing lugs for end of travel limit switches shall be provided.
(g) Handwheel size and construction shall permit easy opening of the gate when subjected to a differential pressure equal to the maximum operating pressure anticipated. Suitable gearboxes shall be fitted to provide easy opening when necessary. These gearboxes shall be grease filled.
(h) Valves larger than DN 150 shall be provided with bypass arrangements.

A28.4 Cast Iron Gate Valves (Wedge Gate)

Wedge gate valves shall be used on raw water and treated water duties but shall not be used on raw sewage, raw water, effluent, sludge and general duties where some solids may be present. The valves shall comply with the following:

(a) The valves shall comply with SANS 664 or SANS 665, Class 10 or higher as required.
(b) The valves shall be double flanged.
(c) The material of the body seat and the material of the gate trim shall be of copper alloy or stainless steel.
(d) The body shall be provided with channel guides for gate travel. The gate shall be provided with shoes which slide within the channel guides. Guides and shoes shall be of a copper based alloy or of stainless steel and shall guide the gate along the complete travel distance.
(e) Fixing lugs for end of travel limit switches shall be provided.
(f) Valves shall have rising spindles unless otherwise specified or necessary because of space restrictions. Non-rising spindle valves shall be fitted with indicators showing the gate position.
(g) The spindle shall be of grade 316 SS, or better.
(h) Handwheels shall be of cast-iron. Handwheel size and construction shall permit easy opening of the gate when subjected to a differential pressure equal to the maximum operating pressure anticipated. Suitable gearboxes shall be fitted to provide easy opening when necessary. These gearboxes shall be grease filled.
(i) Valves larger than DN 150 shall be provided with bypass arrangements, normally isolated by brass ball valves.
(j) Valves larger than DN 250 shall be provided with doors for inspection and cleaning.

A28.5 Knife-Gate Valves

Knife-gate valves shall be used on water sludges as well as on primary, waste activated and digested sludge duties. They shall also be used on raw sewage and other liquid/solids application and may be used for duties specified under Clause "Cast Iron Gate Valves with Resilient Seals".

The valves shall comply with the following:

(a) Valves shall have cast iron bodies, stainless steel blades, cast handwheels, and shall have no carbon steel parts.
(b) Valves shall be clockwise closing (with the exception of valves for the Bulk Water Branch which shall be anti-clockwise closing).
(c) Valves shall have chamfered blade edges and resilient body seals.
(d) Blade faces shall be surface ground or otherwise provided with two flat, parallel surfaces.
(e) The blade seal shall be protected by a non-metallic scraper or similar device.

(f) Suitable sealing shall be provided to prevent leakage from the valve and it shall be possible to adjust these seals while the valve is in line under pressure.
(g) Valves shall be droptight but need not be designed for bi-directional flow unless called for in the Detailed Mechanical Specification.
(h) Internal and external surfaces of the valve body shall be protected with a water resistant, non-toxic and non-tainting, FBE pipe coating in accordance with System – "Fusion Bonded Epoxy".
(i) Valves shall be double-flanged and shall suit the standard flange rating but may incorporate drilled and tapped fastener holes (wafer type valves will be considered for acceptance only where it is unlikely that the pipe or flanged item on either side will have to be removed or if isolation will not be necessary if it is removed). Fasteners may be studs or setscrews manufactured to suit the tapping depth.

A28.6 Waterworks Type Butterfly Valve

These are the type which utilise a replaceable rubber seal with retaining ring and shall be used on raw and potable water duties.

A28.7 Resilient Seal Butterfly Valves

These are the type which either utilise a resilient body liner with a stainless steel disc or utilise a resilient-lined disc for sealing. They may be used on air, gas and clean liquid duties where approved by the Engineer and shall comply with the following:

(a) Shafts and fittings shall be of stainless steel and bearing bushes shall be of Teflon or similar. Seals shall be selected to suit the application. No carbon steel components shall be permitted internally and externally such components shall be properly protected.
(b) Valves shall be air, gas and water tight when closed, as applicable.
(c) Hand lever valve actuation with a locking system for incremental valve setting from fully shut to fully open shall be provided for valves up to and including DN 200. Valves larger than DN 200 shall be equipped with robust, weatherproof grease-filled gearboxes with an indicator to show the degree of valve opening.
(d) For normal usage, the valves may be of the type which is clamped between two flanges. Where it is necessary to remove equipment on either side for maintenance purposes, suitable spacer pipes must be provided or the valves shall be flanged and provided with drilled and tapped holes.
(e) The valves shall be installed with their disc shafts in horizontal orientation.

A28.8 Bronze Isolating Valves

These may be used for isolating duties on clean air and liquid duties up to DN 50.

Bronze gate valves shall be to SANS 776.

Ball or plug valves of appropriate construction may also be used where preferred.

A28.9 Diaphragm Valves

Diaphragm valves may be used on air, sewage, sludge and other dirty or corrosive liquid duties as well as clean liquid duties. The diaphragm material shall be suitable for the fluid to be carried.

Valves shall be double-flanged and shall preferably be of the straight-through type. The weir type may be used for control valve duties. The design shall allow for replacement of the diaphragm without removal of the flanges from the line.

This type of valve shall not be used on the suction side of pumps or on any line subject to vacuum unless designed specifically to cope with design conditions.

A28.10 Needle Valves (above DN 150)

Needle valves, VAG Plunger Valve or equivalent, shall be used for the regulation of flow and/or pressure in pipelines containing water where the size is DN 150 or greater unless this is overridden by the requirements of the Detailed Mechanical Specification. The configuration shall be double-flanged with co-axial flanges unless otherwise specified.

The seal seat and associated downstream parts shall be selected to prevent any cavitation for the application. Such parts shall be of stainless steel or copper based alloy.

A28.11 Telescopic Overflow Valves

Telescopic overflow valves, (Fulton, or equivalent), shall be vertically mounted and shall be specifically designed for the purpose intended.

Operation shall be by handwheel mounted on an independently mounted headstock. Rising spindles are preferred. The outer tube shall be flanged and bolted to a similarly flanged vertical pipe. The inner tube shall incorporate a conical bellmouth. The bridge connecting the inner tube to the valve's spindle shall be attached to the outside of the bellmouth in order to limit the effect of fouling rags, etc.

The spindle shall be of grade 316 SS, or better. The outer tube and inner tube shall be of 3CR12. The headstock and handwheel shall be of painted cast iron or painted 3CR12.

A28.12 Level Control Valves

Level control valves which do not incorporate pilot control are preferred, VOSA Series 7354 or equivalent.

Level control valves which incorporate pilot control shall be simple to check and to maintain. A suitably sized strainer shall be provided to prevent blockage of the pilot. The strainer shall be self-cleaning or shall be easily cleaned.

Level control valves which are not proprietary items and which incorporate linkages shall be designed with overall strength and rigidity in mind. The design shall incorporate an allowance for fatigue effects.

A29. CHECK VALVES

A29.1 General

Where special valves are necessary for special applications, these will be specified in the detailed Particular Specification but, if not, tenderers must select suitable valves and provide details in the tender. Check valves to be used on the more common applications are specified below.

Single-door and double-door check valves shall comply with SANS 1551-1 unless overridden by the requirements of this Clause.

Bronze swing type check valves may be used for pipework up to DN 50.

A29.2 Requirements for All Check Valves

Check valve installations shall comply with the following:

(a) Valves shall be designed and constructed to ensure reliable operation after long periods of non-operation.
(b) Valves shall be double-flanged unless unavailable or otherwise specified.
(c) Valves shall be designed to function correctly under the full pressure rating of the valve.
(d) The specific application shall be taken into account in the corrosion protection of valves. Steel and cast iron valve components, including valve bodies, shall be protected with System – "Fusion Bonded Epoxy" or System – "Hot-Applied Thermoplastic".
(e) Fasteners shall be of grade 316 SS, or better. Flange fasteners are specified elsewhere.
(f) Check valves shall be sized to open fully at the system's design flow rate.
(g) The check valve installation shall ensure that the valve is able to operate without interference from a physical obstruction such as a shut-off valve, bend, mortar lining, etc. Where a check valve is located close to another valve, a straight pipe shall be provided and this shall have a flange-to-flange length of not less than 1,5 times the valve diameter.
(h) Indelible body markings, as per SANS 1551-1, shall include the manufacturer's name, pressure rating (PN), nominal size (DN) and the direction of flow.
(i) A shut-off valve shall be installed downstream of each check valve.

A29.3 Axially-Sprung Check Valves for Water

Axially-sprung check valves (nozzle check valves) for treated water and raw water duty shall be double-flanged; RGR Concentric, Vent-O-Mat Maxiflo or equivalent.

The valve design shall prevent shock closing and shall incorporate a hydrodynamically efficient flow path to minimise head loss.

The spring shall be of stainless steel and the guide rod shall be supported within a non-corroding, non-galling bearing material.

A29.4 Double-Flap Check Valves for Water

Double-flap check valves for treated water and raw water duty shall be of the positive-closing type; Crane Duo-Chek II or equivalent.
Bodies shall be of cast-iron or cast-steel. Flaps shall be of the light, leaf type, shall be of bronze or stainless steel with machined sealing faces, shall be specifically designed to be non-sticking, and shall have teflon bearing washers. Seals shall be of resilient material. The axis of rotation of the flaps shall be vertical, pins shall be of 316 SS, or better, and closure shall be initiated by stainless steel springs, suitably rated for the duty so that closing is initiated prior to the onset of reverse flow.

Positive, external indication of the position of both plates shall be provided.

A29.5 Rubber Diaphragm Check Valves

Rubber diaphragm check valves shall be of the double-flanged configuration and shall Incorporate a hydrodynamically efficient flow path to minimise head loss; VAG Top-Stop or equivalent. Valves featuring multiple small orifices will only be acceptable for nominal flow speeds below 0,5 metres/second.

The flexible rubber diaphragm shall be replaceable.

A29.6 Ball Check Valves

Ball check valves, AVK Series 53 or equivalent, may be used on sewage, sludge or similar applications.

The ball shall be rubber coated and it shall be possible to inspect and/or replace it without removing the valve from the pipework.

A29.7 Swing Check Valves

Suitably designed swing check valves may be used on sewage, sludge or similar applications. Orientation of the valve shall comply with the manufacturer's recommendation.

Swing check valves shall:

(a) be of double-flanged configuration.
(b) have ductile iron bodies.
(c) be suitable for a working pressure of at least 1 000 KPa.
(d) be fitted with a side lever and adjustable weight.
(e) be provided with a bolted cover which provides access, without dismantling or removing the valve, to the swing flap.
(f) have stainless steel hinge pins.
(g) have engineered plastic or non-ferrous bearings.

A30. AIR RELEASE VALVES

A30.1 General

Air release valves for water pipework shall be of the non-slamming type, A.R.I. or Vent-O-Mat or equivalent.

Valves for sewage and similar duties shall be specifically designed for the application.

A30.2 Arrangement and Installation

Air valves shall be installed above pockets designed to collect the air entrained with the water flow. The pockets shall be designed in accordance with the requirements for nozzles in the Clause "Pipework". The diameter of the nozzle shall be at least half the diameter of the parent pipework.

Valves shall have flanged connections and shall be provided with upstream isolating cocks.

A31. PENSTOCKS

A31.1 General

Penstocks shall be of the rising spindle stem configuration. Where impractical preference shall only be given to non-rising spindles in instances where limited head room is available

A31.2 Design

Penstocks shall be designed to be operated under full design pressure for both manual and power actuated operation. Penstocks shall be designed for a minimum operating life of 15 years. The headstock beam shall be designed to accommodate the door opening and closing forces with no visible deflection while under maximum on/off-seating head pressure.

Preference for a P-Type seal arrangement or equivalent for a positive action bearing pressure on seal surface when hydraulically loaded.

A system of adjustment shall be provided for ensuring that the penstock door is held against the seal correctly. Side wedge door adjusters shall be provided. Top and bottom wedge door adjusters shall be provided where required by the installation.

The upper and lower frames shall be split and bolted for ease of installation. The frame shall have jacking bolts for perpendicular and horizontal alignment (taken in both plains).

The door shall slide between polymer, elastomer or non-ferrous alloy materials. Direct contact between the door and the frame is not acceptable. Seals shall be mounted on the face of the gate. The mounted seal shall have protrusion in the range 5-10mm.

Wedges, guides, seals, door nuts and drive sleeves shall be replaceable.

Spindle covers shall be provided for penstocks with rising spindles. Spindles shall be designed such that they are of sufficient section to prevent buckling or deformation when subjected to:

- The actuator at maximum stall torque
- 270N rim pull force applied to the hand wheel

In applications where penstocks are installed without Power Actuators the design shall be such that a minimum rim pull force of 100N / 10kg is required to open or close the valve manually.

Spindle bearings shall be spherical flange mounted thrust bearings. Brass end travel stops need to be fitted to prevent damage to the Spindle thread when over tightened.

Penstocks which are acted on by long stems shall be provided with guides along the length of the stem and the spacing between these guides shall not exceed 1 800 mm.

All power actuated penstocks shall include manual override and the power actuators shall be of fail-safe design. Lubrication of spindles shall be considered during design and specified in the operation and maintenance manuals.

A31.3 Materials

The penstock door and frame shall be of grade 316L S/S, LDX or better.

The door guides, seals, door nut and drive sleeve shall be of polymer, elastomer or non-ferrous alloy materials.

All fasteners, muff couplings and stem adaptors shall be of grade 316 S/S, or better. Universal joints shall be of stainless steel and shall be provided with rubber gaiters for protection.

Copper alloy seals shall not be used on sewage applications. All material shall be compatible with sewage water and sewage gas.

A31.4 Fabrication

Fabrication of stainless steel shall comply with the fabrication requirements specified elsewhere in this document. In particular, welding shall be continuous and crevices shall be avoided.

All Stainless steel shall be pickled and passivated or polished. In instances where surface contamination is severe a methodology of mechanically abrading or polishing with Ultra High Pressure water blasting with high concentrations of acid is utilized.

In the instances where full continuous welding would have had a negative impact on the design of the Penstock Valves, waver for stitch welding is granted and agreed to by the Engineer, on provision that all the non-welded seams are sealed with a non-hardening Polyurethane Sealant.

Cast iron handles shall be of a minimum diameter 500mm in applications where non-Powered Actuators are fitted and shall be FBE (Fusion Bonded Epoxy) coated or normal epoxy-coated.

Direction of the hand wheel shall be as per the table below. The directions shall be labelled on the handles.

Department	Penstock Closing Direction
Bulk Water	Anti-Clockwise closing
Waste Water and all other	Clockwise closing

A31.5 Packaging and Transportation

Penstocks must be wrapped (bubble) or covered with appropriate means to prevent cross contamination or damage as a result of handling, storage or transportation. The penstocks shall be clearly identified on the outside of any protective packaging. If required, only elastomeric or fabric webbing straps shall be used for lifting purposes during loading, unloading and installation.

A31.6 Installation

Penstocks shall be installed by the Contractor using personnel skilled in such installations.

Suitable gaps shall be left for the application of grout. Grout shall be of the non-shrink type and shall be applied strictly in accordance with the manufacturer's instructions. The first penstock to be installed shall be grouted under the supervision of the grout supplier and in the presence of the Engineer.

A31.7 Leakage Testing

Leakage testing shall be done under maximum expected pressure and after all installation work has been completed. No leakage between the penstock frame and the structure shall be acceptable.

The acceptable leakage rate shall be:
(a) 0,015 ℓ/s/m of seating perimeter/3 m pressure head (for off-seating penstocks);
(b) 0,008 ℓ/s/m of seating perimeter/3 m pressure head (for on-seating penstocks).

On head pressure up to 5m, acceptable leakage rates shall be:

- Less than 0.1 litres per metre per metre of seal periphery for wedge type gates,
- Less than 0.3 litres per minute per metre of seal periphery for all other types of control gates and
- Less than 0.5 litres per minute per metre of seal periphery for stop boards or bulkheads

For head pressure 5m and above, acceptable leakage rates shall be calculated using the following formula:

$R_{lm}=0.1+0.0H_{os}$

Where:
H_{os} = on/off – seating head, in metres
R_{lm} = leakage rate in litres/minutes per metre of seal

A32. VALVE ACTUATORS

A32.1 General

Manual operation, by lever, handwheel, etc., shall be provided on all actuators unless otherwise specified.

The direction of operation of handwheels shall comply with Clause "Valves for Liquids or Gases".

Metal plating of ferrous materials, (e.g. zinc or cadmium plating) is not an adequate corrosion protection system for items such as actuator shafts and such items shall be provided with an additional coating of a semi-setting, thick protective layer, such as a suitable Tectyl product, or equivalent.

A32.2 Electric Actuators

Electric actuators shall be specifically matched to the design duty. Actuators providing modulating duties shall be specifically designed for continuous modulation.

The actuator motor and gearbox shall form one integrated unit. Motors shall be for three phase, 400 Volt, 50 Hz supply, shall be Class F insulated (or better) and shall have an embedded thermostat for overload protection. The complete unit, including installation work, glands and controls shall be ingress protected to IP 68 unless otherwise specified.

If the opening or closing period is specified in the detailed Particular Specification (e.g. to avoid water hammer) this period shall be achieved, without pulsing, by incorporating a suitable gear ratio to allow the motor to operate from fully open to fully closed without stop/starts.

For open/shut duties, the continuous actuator torque rating shall be at least 200 % of the start-opening or shut-off torque, whichever is higher, specified by the valve manufacturer for this application (after the gearbox mechanical advantage has been taken into account). For modulation duties, the continuous actuator torque rating shall be at least 400 %.
All components of the drive shall be designed to prevent backlash.

Electric actuators shall incorporate the following features:

(a) hand operated gearwheel override operation incorporating open/close direction indication.
(b) visual valve position indication at the unit.
(c) the terminal compartment shall be separately sealed from the internal electronics and mechanisms.
(d) the actuator shall initiate a trip if:-
⊕ it does not succeed in moving the valve within a suitable period.
⊕ the motor windings overheat.

Where specified in the Detailed Mechanical Specification, the following shall be provided:

(e) the actuator shall provide an impact effect to overcome:-
⊕ tightly seated valves.
⊕ an unintended loss of movement.

(f) the following information shall be fed back to the control panel or, if applicable, the SCADA system:-
⊕ valve position.
⊕ torque on output shaft.

(g) it shall be possible to configure the control instructions and interrogate the actuator status without removing covers.

A32.3 Pneumatic Actuators

Pneumatic actuators shall be selected to match their valves' operating requirements.

Actuators shall be fabricated of non-corrosive materials and shall be mounted using stainless steel mounts and couplings. Fasteners shall be of stainless steel.

Unless the system configuration clearly does not require it, automatic spring-closing shall be provided to ensure that the valve closes (if open) or remains closed (if closed) upon power failure or failure of the air supply. The spring shall be of stainless steel.

Linear actuators shall be provided with stainless steel cylinder piston, cylinder rod and attachments. For open/shut duties, continuous actuator force rating shall be at least 200 % of the start-opening or shut-off force, whichever is higher, specified by the valve manufacturer for this application (after any mechanical advantage has been taken into account). For modulation duties, continuous actuator force rating shall be at least 400 %.

For open/shut duties of rotational actuators, continuous torque rating shall be at least 200 % of the start-opening or shut-off torque, whichever is higher, specified by the valve manufacturer for this application (after any mechanical advantage has been taken into account). For modulation duties, continuous actuator torque rating shall be at least 400 %.

The air supply upstream of each actuator shall be fitted with a filter-regulator unit with an automatically operating water drain trap.

A33. BASEPLATES

A33.1 Baseplate Configuration

Both direct-coupled and belt-driven machines shall be mounted with their drivers on common cast iron or fabricated steel baseplates of rigid construction.

In applications where baseplates are not practical, machined soleplates, suitably fixed and grouted to the concrete plinths, shall be provided. No machine may be mounted directly onto a concrete base without the use of either a baseplate or soleplate.

A33.2 Corrosion Protection

Steel baseplates shall be hot-dip galvanized unless specified otherwise in the detailed Particular Specification.

A33.3 Drainage

Baseplates shall be configured to prevent pooling of water. Baseplates shall be either fully grout filled or provided with drain holes in all side members.

A33.4 Machined Mounting Pads

The baseplate shall incorporate machined mounting pads at the support and fixing positions of each item of plant and equipment to be mounted on the baseplate. On fabricated baseplates this machining shall be done after fabrication, stress relieving (if applicable) and hot-dip galvanizing are complete. The thickness of the mounting pads shall be not less than 1,25 times the diameter of the holding down bolts. The pads shall not be provided with threaded holes for machine screws but shall be drilled for inserting through-bolts and adequate provision shall made for reaching the nut with a suitable spanner. 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, Tectyl or equivalent, shall be applied to exposed machined surfaces and to the crevice formed at the foot of the equipment.

The above design may be suitably modified if the Contractor uses a pourable resin based chocking system. Such chocks shall be at least 15 mm thick.

A33.5 Shimming

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

A33.6 Jacking Arrangement

At least two diagonally opposed jacking screws shall be provided for belt tensioning in the case of belt-driven units. Direct-coupled motors above 10 kW shall be provided with jacking screws for horizontal alignment and direct-coupled motors above 150 kW shall be provided with jacking screws for vertical alignment as well. Jacking screws shall be of grade 316 SS, or better.

Drilled and tapped flat plate is not acceptable for jacking points. A jacking point shall consist of a suitable hot-rolled steel section welded to the baseplate and with a captured machine nut to accept the jacking screw.

A33.7 Grouting

Baseplates shall be designed and grouted to eliminate collection points for water or dirt. Except where otherwise approved in writing by the Engineer, all baseplates on concrete plinths shall be fully grouted in. Grouting holes must be provided on baseplates having a continuous top plate. Tapped holes and fixing setscrew protrusions shall be suitably protected.

The material used for grouting shall be a non-shrink, cementitious grout (ABE Duragrout 1000, or equivalent). ABE Epidermix 324, or equivalent, is acceptable if the Contractor’s design requires an epoxy grout to be used.

The initial grouting shall be overseen by the grout supplier's technical representative.

A33.8 Fasteners

Anchor fasteners shall be of grade 316 SS, or better.

A small amount of a nickel-based, anti-seize compound shall be applied along the full length of fastener threads before the nut is applied.

A33.9 Alignment

Preliminary alignment of equipment mounted on baseplates shall be done at the factory to ensure that the baseplate has been correctly manufactured, but final alignment shall always be done on Site after installation and grouting has been completed. Alignment shall be accurate and to the approval of the Engineer and a final alignment check witnessed by the Engineer must be carried out by the Contractor prior to start up.

A34. GUARDS

Guards shall comply in all respects with the Occupational Health and Safety Act of 1993 as amended and the following points shall also be noted: -

(a) Guards are required to cover all moving or revolving components of machinery. **Guards which do not adequately cover moving protrusions such as keys, lock-nuts, lockwashers, setscrews, etc., or irregularities such as keyways, will under no circumstances be accepted.**

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

(c) Where expanded metal or similar mesh is used, the mesh opening shall not permit a circular object 10 mm or larger to penetrate.

(d) 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.

(e) Guards shall completely enclose drives and shall entirely prevent a person from touching any moving protrusion.

(f) Allowance must be made for adjustment on belt guards or where adjustment will be required.

(g) It shall be possible to remove the guard easily for maintenance purposes.

(h) Guards shall preferably be fabricated of 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 316 stainless steel.

A35. ELECTRIC MOTORS

A35.1 Rating

All electric motors shall be rated for operation on a 3-phase, 4-wire, 400/230 volt, 50 Hz, AC supply at sea level, with an ambient temperature of up to 40 ºC.

The rated power of the motor shall be selected to be not less than 20 % in excess of the designed power requirement of the associated plant unless the motor forms part of a packaged unit and/or where the size of the motor is specified and/or as otherwise approved by the Engineer.

A motor shall be selected so that it shall reach full operating speed within 10 seconds for the method of starting and drive arrangement used.

A35.2 Specifications

Except as otherwise specified, motors shall be standard squirrel cage or slip-ring motors complying with SANS 1804 as amended, with IP55 enclosure and IC 0141 cooling, and suitable for a damp environment. Motors shall be suitable for both "continuous running duty", Duty Class S1, and "intermittent periodic duty", Duty Class S3. Windings shall be copper conductors insulated with Class F material (100 ºC rise capability) with Class B temperature rise (80 ºC). The motors shall be suitable for 6 starts per hour, two of which shall be consecutive.

A35.3 Type

The type of motor (and starter if applicable) to be supplied is determined by the requirements of the specified in the Detailed Mechanical Specification and by the starting limitations specified in the Electrical Specification. In the absence of such specifications, a standard squirrel cage motor complying with this Clause shall be offered.

A35.4 Construction

Motor frames shall be of the totally enclosed fan cooled type with cast iron yoke frames and cast ironend covers. Sheet steel is not acceptable for fan cowls and these shall be of cast iron, tough plastic or stainless steel. The end covers and yoke shall be properly machined and each cover shall locate on a spigoted register to ensure concentricity and parallelism. Bearings shall be of grease lubricated roller and/or ball type, provided with grease nipples (with extension tubes where access is restricted) and sealed to suit external use. Motors required for external use shall be fully weatherproofed.

A35.5 Terminal Boxes

Terminal boxes shall be top mounted wherever possible and arranged for cable entry from either side. The two ends of each stator winding shall be "brought out" to the terminal box. Squirrel cage motors shall be wired to permit both direct-on-line and star-delta starting.

A35.6 Thermistors

Motors of 55 kW and up to (but not including) 150 kW, as well as motors for variable speed drives 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.

A35.7 RTDs

Motors rated at 150 kW and above, both fixed and variable speed, 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.

A35.8 Heaters

Motors of size 75 kW and above shall be fitted with "pocket" heaters. The heater shall be mounted at the bottom of the motor frame and shall be replaceable without dismantling the motor.

These shall be arranged to switch on when the motor stops operating and switch off when it starts operating.

A35.9 Slip-Ring Motors

Slip-ring (wound rotor) motors shall be of the totally enclosed fan cooled type with stainless steel slip-rings. The slip-rings shall be mounted inboard of the non-drive end bearing and shall be fitted and keyed to the shaft as a single unit. The terminal box shall be common to both stator and rotor connections.

The brush holders shall be manufactured from fibreglass and shall be removable from the terminal box as a complete unit. Where the current density in a single brush at the full operating load approaches or is above 80 % of the capability of the brush, then an additional brush shall be provided in a separate brush box.

A35.10 Motor Speed

Motor speeds shall be selected as follows:

(a) motors with ratings below 30 kW can have nominal speeds up to 3 000 rpm.
(b) preference shall be given to motors with nominal speeds up to 1 500 rpm for ratings between 30 kW and 132 kW, both inclusive.
(c) motors with ratings above 132 kW shall have a nominal speed of 1 500 rpm or below.

A35.11 Variable Speed Applications

In applications where the motor speed is controlled by variable frequency drive, the motors shall be cooled by a separate, 50 Hz motor driven "piggy-back" fan. This requirement will be waived if the Contractor can provide documentation to confirm that the drive and motor design can operate in the application, with shaft-mounted fan, without overheating. This requirement does not apply to submerged motor applications.

A35.12 Hazardous Locations

When required to suit a hazardous location in terms of SANS 10108 or in terms of this Specification, suitable motors complying with SANS 60034-5 or SANS 61241, 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.

A35.13 Special Motors

Should the Tenderer wish to offer a different type of motor to those specified so as to obtain special starting characteristics and/or variable speed, a full technical specification of the motor must be supplied and such specification shall be for equipment to a standard at least equal to that of the motors specified above. In particular, no item of electrical protection shall be omitted.

A35.14 Warning

Motor manufacturers must be warned that the motors are to be installed in an extremely corrosive and often damp environment. All motors shall therefore be adequately protected against corrosion.

A36. POWER TRANSMISSION

A36.1 Shaft Couplings

Shaft couplings shall be selected to reduce transmission of misalignment forces and of torsional oscillations between the driving and driven machine. Couplings shall, wherever practical, be of the rubber-tyre or rubber compression type, keyed to the shafts.

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

Spacer couplings shall be used in all cases where this will assist maintenance.

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

After installation, the alignment of all couplings 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.

A36.2 Vee Belt Drives

Vee 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, utilizing taperlock pulleys with taperlocks 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.

Tenderers shall ensure that the bearing arrangements of driving and driven machinery are designed to cope with the loads imposed by vee-belt drives and 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. Tenderers shall submit their design calculations and drawings for lay shaft arrangements for acceptance by the Engineer. Bearings shall be designed for an L_{10} life exceeding 100 000 hours.

A36.3 Motor Driven Gearboxes

Gearboxes shall, unless otherwise specified, be supplied with environmental protection to IP 55.

Gearboxes shall be selected using a service factor of 1,75 based on the drive rating and shall have an efficiency of not less than 96 % on two stage reduction and 95 % on three stage reduction.

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

Roller bearings shall be used throughout. Bearings shall be designed for an L_{10} life in excess of 100 000 hours.

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

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

Oil-bath gearboxes shall have suitable oil level indicators or dipsticks. Unless otherwise decided by the Engineer, the drain from the gearbox shall be extended beyond the base so that the oil can be easily collected. The drain line shall be of grade 316 stainless steel and shall be fitted with a ball valve and square-head plug.

Each gearbox shall be mounted on machined sole plates fitted with jacking screws to assist with alignment.

A37. CONDITION MONITORING

A 37.1. General

Condition Monitoring comprises actions of collecting regular information about machinery condition to detect failures or deterioration of machinery. Measurements and observations shall be carried out during operation of the equipment at various sites within the eThekwini Municipality. A full technical report with corrective measures should be issued upon completion of the work and feedback should be given to the responsible person / people involved.

The purpose of machine condition monitoring is to monitor the state of a machine and detect any deterioration in condition, to determine the cause of this deterioration and predict when failure can be expected. The result is to maximize the availability and utilization of equipment.

A 37.2. Scope

This specification provides for the supply of computerised condition monitoring services within eThekwini Municipality. The service shall be provided by suitably qualified and experienced individuals and shall include labour, material and travel costs.

Data shall be collected by the Contractor onsite with hand held tools and equipment. The captured data shall then be downloaded into a database for trending and analysis.

It will remain the responsibility of the Contractor to co-ordinate his site visits with the relevant personnel prior to visiting the site. On arrival the Contractor must liaise with the relevant personnel and obtain the necessary approvals and permits before proceeding to monitor any equipment.

The Contractor must submit a full report on all data collected. Colour coding shall allow for easy differentiation of trends and data points outside normal accepted parameters.

A 37.3. Vibration Analysis

The mechanical vibration of newly installed machines measured at strategic predetermined points shall be lower than that specified as "good" for that class of machine in ISO 10816 and ISO 2372. The table below shows the classification of vibration severity zones along with the relevant colours.

Table A37.3: Classification of vibration severity zones

VIBRATION SEVERITY (ISO 2372)					
Machine		Class I < 15 kW	Class II 15 – 75 kW	Class III > 75 kW	Class IV > 75 kW
	mm/s				
Vibration Velocity VRMS	0.28	A	A	A	A (Good)
	0.45				
	0.71	B			
	1.12		B		
	1.80	C		B	
	2.80		C		B (Allowable)
	4.50	D		C	
	7.10		D		C (Tolerable)
	11.2			D	
	18.0				D (Not permissible)
	28.0				
	45.0				

These evaluation zones are defined to permit a qualitative assessment of the vibration of the given machine and provide guidelines on possible actions.

Classifications:

Class I: Small (up to 15kW) machines and subassemblies of larger machines.

Class II: Medium size (15kW to 75kW) machines without special foundations or machines up to 300kW rigidly mounted on special foundations.

Class III: Large rotating machines rigidly mounted on foundations which are stiff in the direction of vibration measurement.

Class IV: Large rotating machines mounted on foundations which are flexible in the direction of vibration measurement.

Plant to be monitored:

Analysis may be performed on each individual rotating machine component rated larger and equal to 15kW within an operating speed of 120 rpm and 3000 rpm. Machines to be monitored may include:

- Blowers and Fans
- Electric Motors
- Gearboxes
- Generators
- Pumps
- Turbines

For each point on the motors, gearbox and blower shaft bearings the Fast Fourier Transform (FFT) frequency range must be set correctly to monitor frequencies of interest i.e. bearings and gears. Vibration readings must be recorded on all machine-bearing points in the Radial, Vertical and Axial planes where permissible.

Experience and Qualifications:

Inspection personnel engaged in the execution of this contract shall be adequately qualified and trained. Minimum training requirements for individuals shall be in accordance with ISO 18436-2:2014 Vibration and Condition Monitoring – Category 2 (or equivalent). The Contractor shall submit copies of CV's and training certificates upon request.

Contractors shall state their experience with this type of work by completing the appropriate schedules.

Detailed Vibration Analysis Reports:

Refer to A37.6

A 37.4. Thermography

The Infra-Red camera shall be designed for Preventative Maintenance (PM) use by indicating areas with excessive heat build-up for mechanical and electrical equipment. This shall include electrical switchgear, transformers, motors, pumps, etc. The camera shall be capable of viewing the heat dissipated by equipment in order that preventative maintenance may be undertaken prior to damage of the particular equipment.

Minimum IR Camera Requirements:

- Full analysis and reporting software
- Calibration Certificates
- Minimum IR resolution 160 x 120
- Minimum NETD thermal sensitivity 0.1℃ at 30℃
- Minimum temperature measurement range -20℃ to 150℃
- Temperature measurement accuracy ±2% at 25℃
- Visible camera resolution 2 megapixels
- File formats JPEG, BMP

Detailed Thermography Reports:

Refer to D37.6

A 37.5. Oil Analysis

Category	Key analysis
Machine Wear	• Fine wear metal • Large wear metal elements
Contamination	• Sand and grit • Dilution • Water/Moisture • Alien fluid • Carbon
Degradation	• Oxidation, Nitration, Sulfation • Viscosity

	• Acid number (AN) • Base Number (BN) • Additive package

Oil Sampling Best Practices:

Referring to Original Equipment Manufacturer (OEM), workload of machinery as well as Project Plan where applicable, both vibration testing and oil sampling should be conducted on the same day to minimise site visits and machine lockout.

Pertinent questions to consider when arriving at a sampling interval include:

- Hazard Identification and Risk Assessment
- Criticality of equipment (or lack of redundancy)
- Environment (is it wet, dry?)
- Operating conditions (load, speed)
- What is the failure history?
- How costly is a failure? In repair cost?
- Have operating conditions changed to put more stress on the machine?

In general, a quarterly or monthly sample interval is appropriate for most important industrial machinery, but will be determined by the Project Plan for each individual facility

A representative oil sample should be taken at the same location using the same method each time, as the following table indicates:

Equipment	Sampling Point
Engine Crankcase	-Through dipstick holder -Sample valve on crankcase sump wall -Return line before filter
Hydraulic Systems	-Sampling Valve on return line before filter -Reservoir – mid-point, away from reservoir walls
Compressors	-Crankcase: about midpoint away from crankcase walls -Return line after oil separator
Gearboxes	-Sump: mid-point. Avoid sump floor sludge and side wall deposits
Turbine Systems	-Reservoir – mid-point, keep away from side walls and baffle plates -Main bearing return line -Secondary points-after bypass filtration system

Sampling shall take place under the following conditions:

- While the machine is operating
- Samples shall always be taken from the same point
- Individual clean specimen bottles to be supplied for each sample
- Samples taken shall be immediately labelled in detail to prevent mix up
- Sample accessories (tubes, pipes etc) to be clean & free from contamination
- Drain off dead leg oil/water/debris before sampling
- Vacuum extraction of oil samples to used where permissible
- Samples to be taken from “free flow oil” when permissible to avoid latent contamination

Oil sampling shall not be done immediately after an oil change or makeup.

Facility Accreditation:

Equipment for oil sampling and facilities for testing must be accredited by SANAS according to ISO 17025.

Appropriate Standards:

Appropriate safety standards need to be adhered to such that the eThekwini Municipality's obligations in terms of the OH&S Act NO. 85 OF 1993 and associated regulations are adequately catered for.

The Service Provider shall provide a health and safety plan which could include written safe work procedure. Material safety data sheets (MSDS) to be provided for all chemicals, oils detergents, solvents and cleaning agents.

ISO 4406:1999 Fluid Cleanliness Standard

Contamination classes guideline as per ISO Classification Table:

Turbines ISO Class 14/11, Compressors ISO Class 14/11, Hydraulic Systems ISO Class 15/12, Gearboxes ISO Class 16/13, Engines/Pumps ISO Class 15/12.

Detailed Oil Analysis Reports:

Refer to D37.6

A 37.6. Detailed Reports

All detailed reports shall include:

- Photograph of the monitored equipment nametag
- Existing fault levels
- Existing alarm levels
- Findings and recommendations
- Data capturing and analyses equipment calibration certificates

Vibration Analysis Reports

- Photographs of the monitored equipment depicting drive end (DE) and non-drive end (NDE)
- Vibration amplitude (mm/sec) – assessed against zones as described in the table A37.3
- Frequency (Hz) – refer to ISO 2954
- Plot trends and dynamic data points – Trend, spectrum and wave form
- Trend display and overall vibration levels

Thermography Reports

- IR versus visible image side by side reporting

Oil Analysis Reports

- A detailed analysis report is required with every sample taken

All material which the successful Contractor is required to prepare or develop in the performance and completion of this contract, including exception reports, trend plots, dynamic data plots, notes and reports shall become the sole and exclusive property of the eThekwini Municipality without

limitation when made or prepared, whether delivered or not. The Contractor shall however retain the right to use the same to perform the work under this contract.

It will remain the responsibility of the Contractor to ensure that all data is backed up onto a reliable storage medium.

A 37.7. Condition of Measurement Roots and Points

Before any data may be collected or processed the plant to be monitored must be configured in software to define the points to be monitored. All available machine data, parameters, alarm levels, and known fault frequencies must be noted.

The Contractor shall at all times utilize the most cost efficient and technically reliable technology to accurately diagnose and report on the machine health, identifying any possible defects.

The Contractor shall comment on visual inspections (oil leaks, cleanliness, loose items, blocked vent, open wires, safety issues etc) and general machine as well as factory condition.

A38. NOISE CONTROL

A38.1 General

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

A38.2 Noise Levels

The sound power of any equipment shall not exceed 89 dB(A) (referred to 10^{-12} Watts) unless specifically approved 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 in the Detailed Mechanical Specification.

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.; this shall be clearly pointed out by the tenderer so that appropriate steps can be taken at the design stage to counteract the effects of noise.

A38.3 Acoustic Treatment

Acoustic enclosures are not acceptable unless specifically called for. Acoustic treatment of high noise sources must, however, be included where applicable where this can be done without greatly interfering with operation or maintenance.

When acoustic lagging is called for in the Detailed Mechanical Specification this shall consist of a 100 mm thick layer of rockwool having a density of 60 kg/m_3, 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/m_3 (I.P. Insultex AF720, or equivalent). The outer surface shall be finished off with scrim cloth before being painted.

It is not 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.

A38.4 Measurement

Noise levels will be verified by taking impulse weighted L_{eq} 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.

A39. THERMAL LAGGING

Thermal insulation shall only be carried out after successful pressure testing of the equipment.

The efficiency of the insulation system shall exceed 90 % and the insulation cold face temperature shall not exceed 40 ºC.

Pipe insulation shall consist of pre-formed insulation material having a thermal conductivity of approximately 0,040 W/mK at 60 ºC. The insulation material shall not have any corrosive effect on the pipework and, in particular, it must be noted that fibreglass may not be used on stainless steel.

Inside buildings, or in other protected areas, pipe insulation shall be supplied with a canvas covering having a 50 mm lap at one end and along the longitudinal seam. The laps shall be sealed using a suitable lagging adhesive. On bends the insulation material shall be neatly mitred and covered with canvas. At all flanges the insulation shall be closed off. Flanges, couplings, tees and valves shall be insulated using a removable canvas blanket or jacket fastened in place with brass hooks and eyes.

All insulation shall be coated with a suitable sealer and then painted in accordance with the colour code. The manufacturer shall advice regarding the paint types and system to be used.

Outside buildings or in other exposed areas pipe insulation shall be fixed in position using three bands per section or a suitable adhesive and then clad with aluminium. All longitudinal and circumferential joints shall incorporate a 50 mm lap with each edge grooved. The longitudinal joints shall be positioned in the "twenty past" position with the lap and groove downwards. All ends next to couplings or flanges shall be closed off and sealed before fitting muff type insulation and cladding over the couplings and flanges. All bends, tees and other fittings shall also be insulated and clad but valves need not be insulated. All joints shall be primed and sealed using a silicone or other appropriate sealer and the contractor shall generally ensure that the lagging is weatherproof with particular attention being paid to all joints and pipework support or anchor points.

With large exposed items such as vessels mounted outside, the Tenderer shall recommend a suitable system incorporating a 20 mm thick, smooth layer of weatherproof, reinforced plaster covered with a scrim cloth and overcoated with at least two coats of fibre reinforced resin sealer.

A40. BEARINGS

A40.1 General

Bearing systems shall be designed to provide safe start-up and shut-down, under normal stoppages as well as electrical supply failure, without damage.

Unless prevented from running in a particular direction, rotational bearings shall be designed to support shaft rotation in both directions.

A40.2 Bearing Choice

Bearings shall be chosen primarily to suit the equipment manufacturer's requirements and the plant's design conditions but the following guidelines shall be considered:

(a) Greased lubricated bearings are generally acceptable for units with power ratings up to 100 kW.
(b) Units with power ratings between 100 kW and 1 000 kW shall preferably be provided with rolling element bearings.
(c) Units with power ratings above 1 000 kW and with high speed shafts shall preferably be provided with plain bearings (oil-film type). Plain bearings shall be provided with oil ring lubrication or positively fed lubrication.

A40.3 Design Life for Rolling Element Bearings

Ball and roller bearings shall generally be selected for a design life of 100 000 – 200 000 hours; i.e. the bearing manufacturer's category for machines required to work with a high degree of reliability 24 hours per day.

A40.4 Thermal Alarms

Thermal alarms on bearing systems shall be set in accordance with the specific instructions of the equipment manufacturer or, if it necessary for these to be set on Site, such alarms shall be set after no less than 24 hours of operation have occurred.

A41. LUBRICATION

A41.1 Grease Lubrication

Where greasing points are not easily accessible, grease lines shall be piped to an easily accessible position for manual greasing. Each grease point shall be provided with completely separate 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.

Pipework for grease distribution shall be of stainless steel or non-ferrous metal.

A41.2 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 fitted for visual checking. Drain cocks, including 316 SS 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.

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.

A42. SCREW PUMPS

A42.1 Design Capacity

The duty required of screw pumps to be supplied is specified in the Detailed Mechanical Specification. While the pumps provided shall be arranged to suit this duty, allowance shall be made in the design to permit the pump capacity (speed) to be increased by at least 20 % in the future should this be found to be necessary. Motors, gearboxes, couplings, vee-drives, etc., shall accordingly be rated to suit such an increased duty.

A42.2 Design Details

Screw Pumps shall, in addition to the specific requirements given in the detailed Particular Specification, comply with the following general requirements except as specifically agreed otherwise in writing by the Engineer:

(a) The screw conveyor shall be manufactured of 304 SS or Better, they shall designed and constructed to operate at up to a 26 degree angle.

(b) The central tube, end plates, shafts and fixing arrangements shall be designed to prevent distortion and fatigue in accordance with accepted standards of design. Design, fabrication and the assessment of design life shall be in accordance with BS 5400, as applicable. Other equivalent standards may be used but shall be clearly indicated by the Tenderer. Stress calculations shall not include any allowance that might be claimed by the attachment of the flights to the centre tube or to buoyancy when the screw is lifting liquid. Tenderers shall provide details of their design calculations and design parameters.

(c) A width of at least 50 mm of the screw blade outer and leading edges shall consist of an approved corrosion and abrasion resistant material which shall be welded to the main part of the screw blade. Screw blades shall be evenly spaced and accurately machined to a cylindrical shape.

(d) Welding shall be carried out by the submerged arc or inert gas protected process. Circumferential welds shall not be positioned within the central 25 % of the tube length.

Attachment of the flights shall be by continuous fillet welds on both sides of the flight plating interrupted where it intersects centre tube welds. All welds shall be ground smooth and all weld spatter removed before painting.

(e) Stub shafts shall not have any abrupt changes of section and shall be readily removable for replacement.

(f) The fixing arrangements for stub shafts and end covers shall be air and water tight. All other joints, spigots, threads and crevices of any nature shall also be sealed during assembly using flexible sealants to prevent the ingress of water, moisture or air.

(g) The upper bearing shall be mounted on a rigid support frame which shall also seal the opening in the motor room wall. Cover plates shall be removable. Components sealed inside the building may be hot-dip galvanized and painted carbon steel, but all exposed metal shall be grade 316 stainless steel.

(h) The upper bearing shall be designed to take the axial thrust and the applicable radial load. It shall be possible to easily dismantle and replace this bearing assembly without removing the stub shaft. Means for supporting and holding the screw pump while this is done shall be provided. The bearing arrangement shall be grease lubricated and fitted with seals on both ends. Care shall be taken to ensure that the greasing point is readily accessible. Bearings shall be designed for an L_{10} life in excess of 100 000 hours.

(i) The bottom bearing shall be a sleeve bearing of the grease-lubricated, heavy-duty type mounted in a cast iron housing. The bearing shall be sealed against the ingress of liquids. The design shall be such that rags and similar material do not accumulate around the bearing. The bottom bearing shall be continuously grease lubricated by a grease pump when the screw pump operates. The bearing and seals shall be easily removable.

(j) All fasteners and anchor bolts in the trough or exposed on the outside of the building shall be of grade 316 SS, or better, unless high tensile fasteners are necessary in which case they shall be painted as for the screw pumps. Please note that cap head screws are not acceptable.

(k) Each screw pump shall be direct coupled to a suitable gearbox through a flexible coupling with the gearbox vee-belt driven by a motor. It shall be noted that the gearbox will be mounted at an angle and shall be designed accordingly with the drive motor mounted horizontally.

D42.3 <u>Gearbox</u>

Gearboxes for screw pumps shall comply with the following:

(a) Gearboxes shall comply with the requirements of Sub-clause "Motor Driven Gearboxes" (see Clause "Power Transmission").

(b) Gearboxes shall be selected using a service factor of 1,75 based on the motor power rating and shall have an efficiency of not less than 96 % on two stage reduction and 95 % on three stage reduction.

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

(d) Roller bearings shall be used throughout. The gearboxes shall be constructed with a dry well for the low speed shaft bearing to avoid complete drainage of oil in the event of an oil seal failure and this bearing shall be grease lubricated. The

greasing point shall be easily accessible. Bearings shall be designed for an L_{10} life in excess of 100 000 hours.

(e) The gearbox housing shall be of rigid cast iron construction split in the horizontal plane. Oil drainage shall be provided from the lowest point on the inclined gearbox (syphon type drains are not acceptable). The drain shall be provided with a valved spout extending beyond the base so that the oil can be easily collected. A breather designed to prevent moisture from entering shall be fitted. Suitable oil level indicators or dipsticks shall be provided, these taking the angle of mounting into consideration.

(f) Reverse rotation shall be prevented. If the holdback is separately lubricated it shall be mounted on the upper face of the gearbox for maximum accessibility.

(g) Each gearbox shall be mounted on machined sole plates fitted with jacking screws to assist with alignment.

A42.4 Grease Pump and Configuration

The grease pump for lubricating the screw pump's bottom bearing may be driven by the main screw pump motor or by a separate motor. In the latter case, the main screw pump motor must be so interlocked that it cannot operate unless the grease pump operates.

Suitable facilities shall be provided so that the grease pump can be used for priming the grease pipework without running the main screw pump motor.

The output from the grease pump shall be adjustable between maximum and zero. The amount of grease required by the bearing and the maximum output from the pump shall be stated in the Tender.

The grease container shall have a capacity of more than 1 kg and an indicator shall be provided to indicate the grease level. The container shall be easy to refill without stopping or affecting the operation of the pump. The pump shall be provided with a feature that will release any air trapped in the grease during filling.

A42.5 Grease Pipework

The grease shall be piped to the bottom bearing using high pressure nylon tube with 316 stainless steel fittings or 316L stainless steel tube. The tube shall be enclosed in a rigid polyethylene pipe duct which shall be installed down the side of the trough behind the splash plates.

A device shall be provided to allow the Operator to confirm the grease flow in the pipeline.

A42.6 Corrosion Protection of Screw

The screw drum and blades shall be protected against corrosion by applying the System for Large Immersed Steel Fabrications (not requiring a decorative finish); i.e. polyamine/amide cured coal tar epoxy. The coating shall cover the abrasion and corrosion resistant material used on the screw blade outer and leading edges.

A42.7 Spares

The detailed Particular Specification confirms whether the following spares are required:

(a) For each screw pump provided, one complete spare bottom bearing and all seals shall be

provided. A spare bearing housing and pedestal is not required.

(b) For each screw pump provided, one complete spare top bearing and all seals shall be provided. A spare bearing housing and flange is not required.

(d) For each screw pump provided, at least ten bearing grease refills shall be provided for the operating staff to use during the 12 month Defects Notification Period.

A43. CENTRIFUGAL PUMPS

A43.1 Pump Duty

Details of pump duties are given in the detailed Particular Specification and the type of pump and materials of construction shall at all times be selected to suit the fluid to be pumped and the performance requirements.

Pumps handling sewage and sludges shall be capable of running without choking, clogging, any liquid which may contain long fibrous material; vortex or open impellers are therefore preferred.

A43.2 Pump Type

Centrifugal pumps shall, wherever possible, be of the single-stage, end-suction, back pull-out type, direct-coupled to the motor using spacer type couplings and complete with common baseplate and guard. Close-coupled pumps may be used on clear water applications for motor sizes up to 2,2 kW.

A43.3 Pump Speed

Preference shall be given to pumps which operate at 1 500 rpm or lower. Pump speed and casing test pressures must be given in the Tender.

A43.4 Performance Parameters

Performance characteristics shall be suitable for parallel operation with pump head increasing continuously to shut off. The pump shall be selected to operate as close as possible to best efficiency at duty point and shall be adequately sized to safely permit an increase in capacity of at least 25 % should the head be lower than estimated.

A43.5 Margin of Power

A non-overloading absorbed power characteristic, preferably with maximum power absorbed at best efficiency, is preferred.

The motor's continuously rated power shall exceed the greater of the following:

(a) 10 % above the maximum power demand under any condition of operation for the pump, including open discharge.

(b) 20 % above the pump's maximum power demand over the full range of flow and pressure conditions anticipated in the pump installation.

A43.6 Life

Pumps and motors shall be designed for long life under continuous operation. Bearings shall be

designed for an L_{10} life of not less than 100 000 hours.

A43.7 Impeller

Preference shall be given to pumps whose impeller diameter does not exceed 95 % of the maximum impeller diameter for the volute/diffuser provided. The impeller surface finish shall be up to N7. The peripheral speed of impellers should be designed not exceeding 10.5 m/sec.

A43.8 Lubrication

Unless otherwise specified in the Detailed Mechanical Specification, bearings shall be grease lubricated and adequately sealed against the ingress of moisture or dirt.

A43.9 Vibration

Rotating elements shall be balanced.
The vibration severity of the unit during operation shall not exceed Vrms = 1 mm/s at the pump and motor bearings.

A43.10 Pump Glands

Shaft sealing shall be arranged as follows:

(a) **For clear, non-aggressive liquids up to 200 kPa** discharge pressure - shaft sleeve with packed gland or mechanical seal.

(b) **For clear non-aggressive liquids at pressures above 200 kPa and for clear corrosive liquids at any pressure** - 316 stainless steel shaft sleeve with mechanical seal.

(c) **For liquids with solids in suspension at any pressure** – mechanical seal or packed gland with hardened and/or protected stainless steel shaft sleeve and grease seal. If a mechanical seal is specified, the pump gland shall be arranged to suit a clean water flush. A throttle bushing made of a suitable non-corrosive, self-lubricating material shall restrict the flushing water flow into the pump. Mechanical seals for such applications shall have silicon or tungsten carbide sealing faces.

A43.11 Venting

A vent cock shall be fitted to the highest part of the casing.

A43.12 Connections

Suction and discharge connections shall be flanged for pump connections larger than 40 mm.

Pump connections of 40 mm and smaller may be screwed. Unions shall be incorporated in the pipework close to the suction and discharge connections.

A flexible coupling shall be fitted close to the pump’s suction connection.

A43.13 Isolating and Check Valves

Isolating valves shall be provided on the suction and discharge of all pumps. A check valve shall also be fitted between the discharge isolating valve and the pump except where reverse flow through the pump when stationary cannot occur. Any reducing necessary shall be done immediately next to pump connections.

A43.14 Pressure Tapping Points and Gauges

Pressure tapping points shall be provided near the suction and discharge connections of each pump. These points shall be located, where feasible, on a straight length of pipework where readings will be steady and accurate. Pressure (or suction, as applicable) gauges shall be fitted at these tapping points. Gauges shall measure gauge pressure (i.e. not absolute pressure).

A43.15 Strainers

A centrifugal pump which draws from a tank or sump shall be protected by a strainer, suitably designed for the installation. The strainer shall be installed between a shut-off valve and the pump.

D44. SUBMERSIBLE AND IMMERSIBLE PUMPS

A44.1 General

Details of the duty and performance requirements of submersible and immersible pumps to be supplied are specified in the detailed Particular Specification.

Pumps for sewage and sludge applications shall either be configured or shall be provided with a facility to prevent crusts forming on liquid surfaces as well as debris and sludge collecting on the sump floor.

Pumps must be provided with both suction and discharge pressure gauges.

A44.2 Submersible Pumps

Submersible pumps handling sewage, primary sludge, activated sludge or a similar product shall be of a non-chokeable type and shall be capable of handling a solid size of 100 mm diameter or greater. Impellers designed specifically for the application are preferred. These duties must be regarded as abrasive.

The motor shall be close-coupled to the pump and separated from the pump casing by an oil chamber. A mechanical seal shall isolate the motor from the chamber and a mechanical seal with tungsten or silicon carbide faces shall provide a shaft seal between the oil and the liquid to be pumped.

The motor shall be shut down automatically in the event of leakage into the oil chamber and as a result of overheating of stator windings.

Preference shall be given to pumps whose speed does not exceed 1 500 rpm. The rated output of the motor shall be 15 % in excess of the maximum power which can be absorbed by the impeller fitted to the pump at any pumping duty; i.e. the unit shall be non-overloading.

Pumps required for abrasive duties shall be designed for low wear. Low operating speeds are preferred. The suction cover shall incorporate a replaceable liner of a suitable abrasion resistant material such as high chrome iron. The design shall permit easy adjustment of the clearance between the impeller and suction cover.

Bearings shall be designed for an L10 life in excess of 100 000 hours.

The shaft, all fasteners and all external steel components in contact with the pumped liquid shall be of grade 316 SS, or better. The pump and motor casing shall be of high-quality, close-grained cast iron. A suitable, heavy duty epoxy or polyurethane coating system with a minimum thickness of 400 µm shall be provided on the pump and motor casings.

A44.3 Immersible Pumps

Immersible pumps shall incorporate all features specified in Sub-clause "Submersible Pumps" above except that:

(a) A suitable, heavy duty epoxy or polyurethane coating system with a minimum thickness of 250 µm shall be provided on the pump and motor casings.

The motor for an immersible pump shall be provided with an integral jacket cooling system designed for non-immersed operation at full power. The cooling fluid shall inhibit corrosion and shall be self-contained; i.e. shall not rely on an external flow system. The cooling fluid shall not be the pumped liquid itself. Positive circulation of the cooling fluid within the jacket is preferred.

A45. DRAINAGE PUMPS

A45.1 General

This Clause applies to drainage pumps to be provided for applications involving seepage, slow leakage, etc. Drainage pumps which are to prevent accidental flooding or other large inflows of water shall be specifically designed for the application by a pump engineer.

A45.2 Pump

Pumps shall be of the free-standing, submersible sewage, heavy construction, cast-iron type. Drive motors shall be three-phase units with oil bath and shall have protection to IP 68. The shaft shall be of stainless steel. Switching shall be done in accordance with liquid level by a float switch on cable (pivoting arms will not be acceptable).

A45.3 Installation

Drainage pump installations shall comply with the following:

(a) The discharge pipework shall be rigidly supported at a distance not exceeding 1 000 mm. The discharge point shall be indicated by the Engineer.
(b) The discharge pipework shall incorporate a check valve on the initial upward run of pipework.
(c) The pump's discharge shall be connected to the discharge pipework via a clear flexible hose. It shall be possible to remove the pump and check valve without damaging the pipework.
(d) Discharge pipework shall be of uPVC, Class 12 or higher.
(e) The area of the outlet pipework shall not exceed 200 % of the area of the pump outlet.
(f) Discharge pipework shall be sloped up away from the pump at all points apart from a single final straight run to the drain which may slope downwards at any angle.

A46. POSITIVE DISPLACEMENT PUMPS

A46.1 Type

"Positive displacement pump" refers to both progressing cavity pumps and peristaltic pumps.

Positive displacement pumps shall be suited to handle the fluids specified.

If the fluid to be pumped is sludge, it shall be noted that this contains solids, fibrous matter and grit. Construction materials shall be selected accordingly and the pump size shall be conservatively selected to ensure a very low operating speed. All universals, pins, bushes and so forth operating in the pumped liquid shall be properly lubricated and must be fully sealed.

A46.2 Duty

The pump duty will be specified in the Detailed Mechanical Specification.

A46.3 Drive Arrangement

Each pump shall be direct coupled to a motor/gearbox unit to suit the range of pump duties. The complete drive unit shall have an ingress protection rating of IP 55 or higher. The pump and drive unit shall be mounted on a common fabricated steel baseplate complete with all necessary guards.

All components shall be conservatively selected to suit the specified type of duty with continuous 24 hour per day operation. The continuously rated output of the motor shall exceed the power required at maximum duty and at the worst operating condition by not less than 30 %. The gear unit shall be selected using a service factor of not less than 2, based on the installed motor power.

If applicable, the unit must be prevented from reverse rotation.

A46.4 Variable Speed Drive

Pumps in variable speed applications shall have their drive motors controlled by variable frequency drives (VFDs) which are suitably rated for the torque required by the application. The VFD shall be housed in a cubicle in the electrical control panel which is normally in a separate room. The motor and VFD shall be of suitable design and shall be adequately sized to provide the high torque requirements of the pumps under all operating conditions, particularly start up.

A46.5 Drive Unit Protection

When pumping sludge, it is possible for the pumps to block or seize or have abnormally high starting torque requirements, particularly when operating on a duty/standby rotation basis. The complete installation shall be designed to cope with such operating conditions without damage to equipment.

The drive unit shall be rated to withstand such shock overloads at any torque produced by the motor between full speed and shock stall without any damage. **If any part of the unit could be damaged under such conditions, suitable safeguards shall be incorporated.** Thermal overloads on the motor shall not be regarded as adequate in such a case.

If an overload safeguard system is necessary to protect against overload damage, the system used shall disconnect the load immediately an overload occurs, switch off the unit, activate an alarm indication on the control system and initiate the shutdown of other equipment if this is necessary. A sealed, adjustable and resettable torque limiting coupling between the pump and drive unit would be acceptable. The coupling must be set for the maximum torque which the drive unit can safely handle.

Full details of the drive system must be provided with the Tender.

A46.6 Pump Flushing System

A DN 50 connection shall be provided downstream of a check valve on the suction line of all pumps. A DN 50 flushing line from the domestic water supply, or the service effluent water system (if applicable), shall be connected to this. On each branch a solenoid valve, isolating valve, by-pass with isolating valve and check valve shall be fitted. This system shall automatically flush the pump before each start up and shut down. Manual flushing shall also be possible using the by-pass.

Where a system such as that described above is not possible on, for example, a direct feed hopper system, then an alternative flushing system such as a hopper flushing system shall be devised.

A46.7 Pressure Switches

Where pressure switches are used to protect pumps against closed or blocked lines by interrupting the supply to the motor, a pressure switch shall be mounted on the pump outlet and a vacuum switch shall be mounted on the pump inlet.

The switches shall be installed and mounted in accordance with the Clause “Gauges”.

A46.8 Pressure Gauges

A suitably rated pressure or combination pressure/suction gauge shall be installed on the suction and discharge of each pump.

A46.9 General

The following shall be provided for each positive displacement pump:

(a) a suitably designed strainer on the suction side.
(b) a suitable check valve on the discharge pipework.
(c) protection against running against a closed discharge; i.e. discharge pressure switch or pressure relief valve.
(d) Protection against running dry; i.e. suction pressure switch, pump stator temperature switch or low flow signal from related flow meter.

A46.10 Progressing Cavity Pumps

Progressing cavity pumps shall be installed in compliance with all applicable requirements of Clause “Positive Displacement Pumps”.

The layout of progressing cavity type pumps shall be such that the glands are under the lowest of suction or discharge pressure.

A46.11 Peristaltic Pumps

Peristaltic pumps shall be installed in compliance with all applicable requirements of

Clause “Positive Displacement Pumps”.

The pump/motor/gearbox unit shall be configured so that the pump shaft is separately supported; i.e. the pump shaft shall be supported independently of the gearbox and the motor bearings.

Pumps with suction lines longer than 5 metres shall be provided with pressure pulse damping on the suction side.

Pumps with discharge pressures above 30 m pressure head shall be provided with pressure pulse damping on the discharge side. Diaphragm separation between liquid and air within the damper is preferred.

Hose breakage shall be monitored and the control system shall provide for automatic shut-down when a leak occurs.

Pump installations shall be provided with protection against a no-flow condition resulting from a shut valve or other blockage.

Check valves shall not be provided and the system configuration shall be designed to accommodate this.

The conveying cube material shall be restricted to natural or nitrile rubber to resist loads and stresses induced.

A46.12 Spares

The Detailed Mechanical Specification confirms whether the following spares are required:

(a) For each progressing cavity pump installed, one spare rotor and one spare stator shall be provided as part of the Contract.

(b) For each peristaltic pump installed, one spare hose and ten complete hose lubricant fills as well as a complete set of tools for replacement of the hose shall be provided as part of the Contract.

A47. METERING PUMPS

A47.1 Pumps

Metering pumps shall comply with the applicable design and installation requirements for positive displacement pumps but shall, in addition, comply with the following:

(a) Pumps which feature diaphragms shall be configured or protected so that diaphragm breakage will not lead damage to the internal part of the pump.

(c) All pump fasteners shall be of stainless steel.

A47.2 Pump Installation

The following requirements shall be provided for metering pump installations:

(a) Pumps shall either be mounted on a wall or other rigid vertical mounting surface or shall

be mounted on plinths above ground level.

(b) Pumps shall be provided with an automatic pressure relief system in order to prevent overloading within the pump.

(c) Pumps shall be provided with check valves downstream of their outlets.

(d) The pipework on the inlet and outlet of pumps shall be provided with isolating valves and couplers to allow removal of the pumps without dismantling of the surrounding pipework.

(e) Strainers shall be provided upstream of the pump inlet. The strainers shall be designed and installed in a manner which will allow cleaning of the strainer element without uncontrolled spillage. Strainers shall be provided with inlet and outlet isolating valves.

(f) A facility for calibration of the pump shall be provided. This shall be sized to allow a minimum of one minute operating at full flow.

(g) A facility for connection of a flushing water pipe shall be provided. Permanently connected flushing water systems shall be provided where specifically called for.

(h) The piping in the vicinity of a metering pump shall be provided with a drain facility which shall be designed to minimise the amount of dosing fluid which would be lost during removal of the pump from the pipework.

(i) All mounting fasteners and mounting brackets shall be of grade 316 SS, or better.

A48. PUMP PERFORMANCE TESTING

A48.1 Performance Test

The pump units including the pump coupled to the motor, shall be tested at the manufacture's works in the presence of the engineer or his representative. The cost of carrying the work performance tests shall be deemed to be included in the overall cost of the plant. Tolerance limits and acceptable regulations shall be ISO 9906: Grade 1. The test results should be supplied to the Client Branches within two weeks.

Works tests includes:

a) Balancing of the complete impeller and shaft at the manufacturers place

b) Flow head curves shall be generated at the manufactures premises and checked against the manufacture's listed pump curves for any major discrepancies

A48.2 Testing On Site

The testing of the pumping plant shall be carried out strictly in accordance with ISO 9906 Grade 3 or according to the conditions of contracts where specified in the Detailed Mechanical Specification. During the testing of each unit careful examination will be important and the records are to be kept. The examination records should incorporate the following:

- Differential pressure rise across the pump
- Pressure (suction and discharge)
- Flow (instantaneous and totalized)
- Electrical power consumption
- Efficiency
- Bearing temperatures and vibration analysis

The pumping unit shall be calculated to determine whether these are in compliance with the guaranteed figures submitted by the contractor at the time of tendering.

After commissioning, checks should be carried out for proper functioning, direction and speed of rotation, and power consumption over the Trial Operation Period. Equipment performance will be considered acceptable when the requirements as specified have been met consistently during

test period. The performance of the equipment shall be examined and tested at 1, 3, 6, 9 and 12 months intervals during Defects Notification Period. At each test intervals performance reports including items of examination should be submitted to the engineer.

A49. VERTICAL SHAFT MIXERS

A49.1 General

Suitable mixers shall be chosen for the liquor to be mixed. This applies to both the design of the mixing action for the percentage total dry solids and to the choice of motor and gearbox rating.

Motor and gearbox ratings for continuous operation shall provide a 20 % margin higher than the maximum mixer shaft input requirement.

Vertical shaft mixers shall incorporate stainless steel shafts and impellers. Suitable means of removing and re-installing the mixers during normal operation shall be provided.

The mixer impellers shall be designed to prevent rag fouling.

A49.2 Mounting

Mixer motors and gearboxes shall be mounted on rigid, boxed baseplates which shall be secured using a minimum of four, 16 mm anchors.

The bottom end of the shaft shall incorporate a suitable polymer bearing, incorporating a stainless steel housing bracket, to limit radial deflection of the shaft.

A49.3 Motors

Motors shall feature a cowl, or similar device, which shall be designed to prevent rain reaching the motor shaft.

A49.4 Mixing Design Requirements

In general the mixers are required to thoroughly mix the contents of the tank or chamber, to keep solids in suspension throughout the volume and to prevent a crust forming on the surface.

The mixers shall be sized to maintain an effectively constant suspended solids concentration throughout with not more than 200 mg/ℓ variation from the average at any point in the tank.

In sewage sludge reactor basins, this mixing efficiency must be achieved at activated sludge solids concentrations up to 5 000 mg/ℓ and bulk settling velocities up to 5 m/hr.

The mixers/aerators should function by moving a large volume of water in a range of more than 50 liters per second. They should measure a maximum of more than 1 meter into the air, to enable gas transfer within the tank, inducing circulation and improving water quality. The immense amount of water being propelled into the air and splattered back down onto the water surface, a wave action is spread out outward from the unit to the direction of the tank perimeter. The tip speed of the impeller at 50Hz should not be more than 5 m/s.

Aerators: preference should be given to low rotational speed of turbines. For aerators having a driving motors of over 30 kW the maximum rotational speed shall not exceed 40 rpm and smaller kW motors the velocity shall not exceed 50 rpm.

The mixers shall be of Axial Flow design and be built from robust construction and protected against corrosion. Contractors should provide information as shown in table D49.

Table D49: Design parameters to be obtained from the design of the axial flow rotor.

Number item	Design parameter	Design value obtained
1.	Height of thrown water	
2.	Flow of water thrown by aerator	
3.	Rotor Speed	
4.	Specific Speed	
5.	Number of paddles	
6.	Exit angle, β_2	
7.	Exit angle for the tests, β_2	
8.	Approximate speed constant, Cu	
9.	Diameter of rotor	
10.	Head coefficient, φ	
11.	Inlet angles, β_1	
12.	Velocities: drawing velocity triangles	
13.	Theoretical power consumption (W)	
14.	Submergence	
15.	Gas Transfer (kg O2/kWh)	

A49.5 Mixing Performance Tests

The mixer units including the impeller coupled to the motor, shall be tested at the manufacture's works in the presence of the engineer or his representative. Mixing performance testing shall be as for "Pump Tests".

The Contractor will be required to test the performance of the mixers when commissioning the plant. This test shall consist of taking a minimum of six samples at random points close to the surface and from the bottom of the compartment within five minutes. Duplicate analysis of these samples for suspended solids concentration will then be carried out in a suitable laboratory and the average concentration calculated. The suspended solids concentration of any one sample shall not differ from this average by more than 200 mg/ℓ.

If the equipment fails to pass this performance test, a second test may be carried out. If the mixers still fail the test, the Contractor shall increase the mixing capacity of the equipment and shall achieve compliance with the performance requirements at no additional cost to the eThekwini Municipality.

A50. SUBMERSIBLE MIXERS

A50.1 General Requirements

Suitable mixers shall be chosen for the liquor to be mixed. This applies to both the design of the mixing action for the specified percentage total dry solids and to the choice of motor and gearbox

rating.

Motor and gearbox ratings for continuous operation shall provide a 20 % margin higher than the maximum mixer shaft input requirement.

Details of the mixer application are given in the Detailed Mechanical Specification.

The mixers shall be submersible with a propeller integrally mounted on a submersible motor. The motor shall be separated from the propeller by an oil chamber. A suitable seal shall isolate the motor from the oil chamber and a mechanical seal with tungsten carbide faces shall seal the oil chamber from the mixed liquid. If the mixer incorporates a gearbox an additional seal shall be provided to isolate the gearbox oil system.

The mixers shall automatically shut off in the event of water contamination of the oil, loss of oil, excessive stator temperature, earth leakage or motor overload and suitable probes and switches shall be provided.

Each mixer shall be provided with one flexible cable to accommodate all the required connections within the machine. Cable lengths shall be provided to suit Site requirements but a minimum length of 7 metres shall be allowed for. No joints will be acceptable.

For sludge applications, propellers shall be of a type suitable for handling stringy solids and thick sludges and shall preferably not require a shroud. The motor shall be of adequate size to perform the required duty with sewage sludges having a dry solids content of over 6 % by weight unless otherwise specified.

The mixer body shall be of rugged cast iron or of stainless steel construction. Cast iron shall be coated with a heavy duty epoxy corrosion protection system at least 300 µm thick. If a shroud is necessary this shall be ruggedly and rigidly fixed with it and all brackets being made of a non-corrosive material. The mixer impellers shall be designed to prevent rag fouling. Full details shall be given with the Tender.

Each mixer shall be mounted with a sliding bracket on a guide column fixed to the floor of the tank and at the top of the tank with a suitable bearing or turntable. It shall be possible to rotate the mixer through an angle of 180_{o} while the mixer is operating and to fix the direction and height in the position selected. The guide column shall extend above the walkway level to suit the specified lifting arrangements.

The operating cross bars or handles, the locking arrangement and the fixing arrangement shall not intrude into any walkway and shall not present a hazard in any way. If necessary, operating levers shall be easily removable.

If variation in mixer inclination in the vertical plane is required, the Contractor shall design accordingly.

Suitable lifting arrangements shall be provided for removing each mixer. The general design of the sliding bracket and lifting arrangement shall allow one man to lift the mixer without any jamming, wedging or sticking.

Each lifting arrangement shall incorporate a davit and winch generally complying with this Standard Specification for Mechanical Works except that the guide column and turntable may form part of the arrangement. The height of the davit shall be such as to permit the
mixer to be swung over the handrails along the walkway. Should the Tenderer consider that the guide column height will be too high with the above arrangement, then an alternative system with

gates in place of the guard railing at each mixer will be considered. Removable handrail sections will not be acceptable.

The guide columns and the entire mounting arrangement and lifting device shall be adequately supported and sufficiently rigid to prevent vibration or noisy operation.

Guide columns, support brackets, etc., shall be of hot-dip galvanized low carbon steel (and painted as specified) or of 316L stainless steel. All fasteners, guide pins, turntables, bearings, fixing pins, chains, pivot pins, etc., shall be of 316L stainless steel or, where applicable on items such as bushes, of non-corrosive materials.

Where the mixers are required to operate in sumps or other containers in which the level varies, the mixers shall be designed and arranged to permit the lowest operating level and Tenderers shall state the minimum submergence required. Level controls shall be provided to stop the mixer at the lowest level and restart again at a suitable higher level (except as otherwise specified in the detailed Particular Specification).

A50.2 Mixing Design Requirements

Mixing design requirements shall be as for “Vertical Shaft Mixers”.

A50.3 Mixing Performance Tests

Mixing performance testing shall be as for “Vertical Shaft Mixers”.

A51. COMMINUTORS

A51.1 General

“Comminutors” are cutting devices which act as a screen and are designed to either cut solids which are larger than the screen openings or to block the solid, stop and activate an alarm.

A51.2 Type of Solids

The solids to be handled consist of the usual solid matter found in sewage and include grit, cotton waste, rags, stockings, plastic bags, paper, seeds, and so forth. The comminutor must also be able to cope with hard and tough materials such as wood, leather, canvas, plastic and metal containers, metal bottle tops and so forth without serious damage to the unit or its cutting surfaces.

The effective screening gap shall be 6 mm or less.

A51.3 Design of Comminutor

The comminutors shall be of a slow speed, high torque design suitable for the duty conditions. Two shafts carrying toothed cutting discs shall operate at different speeds.

Cutting surfaces shall be manufactured of corrosion resisting steel having a surface hardness of not less than 50 HRC.

Casings shall be of cast iron and shafts shall be of a corrosion resistant, high quality alloy steel.

Bearings shall be of the roller or ball type, grease lubricated and efficiently sealed by mechanical

seals with tungsten carbide faces. Tenderers shall advise whether any seal flushing arrangement will be required.

Greasing shall be possible whilst the unit is operational and shall comply with the sub-clause "Grease Lubrication".

The drive shall be vertically arranged through a close coupled gearbox with all components adequately rated for a stall condition. The motor shall be mounted clear of all fluid flow.

A51.4 Installation

The configuration of units installed in channels shall ensure that grit cannot collect at the cutting surfaces; i.e. comminutors shall not be installed at low points in the channel.
Comminutors which are installed in-line shall be mounted on a vertical length of pipework with the flow upwards.

A51.5 Control System

The motor size shall be sufficient to permit cutting of any object which will not damage the cutting surfaces or the unit itself. Once an excessive level of power is approached, however, the control system must try to clear the machine by reversing. If this is not successful in clearing the machine, both the comminutor and any in-line equipment shall shut down, sound an alarm and activate an alarm on the control system.

A51.6 Corrosion Protection

Cast iron components shall be protected by applying the System for Large Immersed Steel Fabrications (not requiring decorative finish); i.e. polyamine/amide cured coal tar epoxy, or similar approved coating, shall be used on all cast iron components. Non-corrosive materials shall be used wherever possible.

A52. SCREW CONVEYORS

A52.1 General

Details of the duty, performance and any other requirements for screw conveyors to be supplied will be given in the Detailed Mechanical Specification.

Screw conveyors shall comply with the following:

(a) Conveyors shall be conservatively sized and shall be suitable for handling at least 35 %in excess of the maximum duty specified in the Detailed Mechanical Specification. The conveyor shall also be designed to operate well within the maximum design limits for the type of duty specified.

(b) The capacity of a receiving conveyor shall be at least 5 % higher than its supply conveyor.

(c) Conveyors must be suitable for operating at any duty between no load and full load, either wet or dry, 24 hours per day.

(d) Conveyors shall be of rigid construction and shall be designed for a life before major repair of not less than 10 000 hours. Each unit shall operate quietly and without spillage or leakage. Protection shall be provided against damage from blockage or jamming.

(e) All radial and thrust loads shall be taken by the screw bearings and shall not be transmitted to the driver.

(f) All greasing points shall be piped to a convenient accessible position for manual greasing. The system shall provide positive lubrication of each point either using separate lines or, if the lines are manifolded, a positive displacement grease distributing device shall be provided (Woerner, Lincoln or equivalent).

(g) The conveyor shall be driven by direct-coupled motor and gearbox. Couplings shall be of the rubber tyre type with taperlock bushes keyed to the shaft. Guards shall totally enclose the drive.

(h) Conveyors shall be designed for resistance to corrosion. All fabrications such as shafted screws, troughs and covers, supports, guards, etc., shall be manufactured from 304L SS, 316L SS, or EN 1.4162. All shafts, pins, fasteners, hangers, sleeves, bushes, rollers, gland followers and other small items shall be made of grade 316 SS, or better, or of another equally non-corrosive material. On proprietary items such as motors, gearboxes, couplings, sprockets, etc., particular care shall be taken to apply suitable protective coatings. Welding shall be continuous all round to prevent any crevices and all bolted and other mating faces and mounting pads shall be sealed during assembly with a suitable non-hardening sealer.

(i) Trough covers shall be provided. These shall be light and easily removable but rigid and strong and shall be of a non-corrosive, UV-resistant material. Covers shall be hinged for inspection purposes and to serve as a relief in the event of blockage in the following positions:

⊕ at the discharge point and in line with the screw axis;
⊕ near the inlet.

(j) Trough liners shall be designed to allow easy replacement of the liner without damage to the trough structure.

(k) The design of fixing, supporting and structural arrangements for external applications shall assume prevailing winds of up to 150 km/hr.

(l) Sharp edges on items fabricated from thin sheets will not be acceptable and such sharp edges shall preferably be eliminated by design.

A52.2 Centreless Screw Conveyors

In addition to the general requirements for screw conveyors, centreless screw conveyors shall comply with the following:

(a) The plate thickness used for the helical screw shall be at least 20 mm.

(b) The liner on which the spiral rests shall consist of a polymer featuring a two-colour laminate designed to act as a wear check. Thickness of the liner shall be at least 10 mm.

(c) The complete body shall be of grade 316 SS, of EN 1.4162, or better. It is not a requirement that the screw is of stainless steel.

(d) The drive motor shall preferably be mounted at the high point of the conveyor.

A52.3 Shafted Screw Conveyors

In addition to the general requirements for screw conveyors, shafted screw conveyors shall comply with the following:

(a) The conveyor screw shall be kept clear of the trough and shall be supported at both ends by rolling element bearings. These bearings shall be totally enclosed in coated cast iron or stainless steel housings which shall be adequately sealed against the ingress of moisture and dirt and shall be mounted external to the trough.

(b) The upper bearing of inclined conveyors shall be the thrust bearing and the bottom bearing shall be mounted clear of the trough and cover. The shaft through the bottom cover shall be sealed by means of a gland incorporating at least one throttle bush, a lantern ring, at least three rings of packing, a positively driven, "Stellited", 316 SS, slip fit shaft sleeve with o-ring seal and 316 SS gland follower. The gland shall be grease sealed or water flushed depending on the application.

(c) The centre tube shall preferably be rigid enough to avoid the use of intermediate bearings. Where the use of intermediate bearings cannot be avoided, they shall be supported by suitable hangers which will not interfere with the flow of the product being conveyed. The screw shall also be sized so that the bearing is not immersed in the product being conveyed. The bearings shall be completely sealed in a manner suitable for the application and shall be grease lubricated. A maintenance hatch shall be provided at the hanger.

(d) Provision shall be made in the conveyor design for easy replacement of items such as end bearings, intermediate bearings, throttle bushes, shaft sleeves, coupling tyres, chains, etc., without excessive disassembly and without removal of the complete unit. The general arrangement shall permit convenient access to all parts of the unit and shall permit easy installation or removal.

(e) Where appropriate, the screw conveyor shall be designed for abrasion resistance. All applications handling grit or sludge shall be regarded as highly abrasive. The conveyor shall be designed for slow speed and very low rubbing velocities. Outer edges of the conveyor screws shall be manufactured of, or lined with, an abrasion and corrosion resisting material. The trough shall be completely lined using conveniently replaceable 1 000 mm long sections made of a corrosion and abrasion resistant material. Alternatively the trough shall be lined to a minimum thickness of 6 mm with a repairable material suitable for the particular application such as neoprene, polyurethane, ceramic lining compound, etc. Full details of the manufacturer's proposals shall be provided with the Tender.

(f) The screw shall be fabricated from plate with a thickness of not less than 6 mm. Acceptable materials are specified above.

A52.4 Spares

A52.4.1 Centreless Screw Conveyors

The Detailed Mechanical Specification confirms whether the following spares are required:

(a) Trough liner.

(b) Screw.

A52.4.2 Shafted Screw Conveyor

The Detailed Mechanical Specification confirms whether the following spares are required:

(a) Screw.

b) Complete set of screw bearings.

A53. BELT CONVEYORS

A53.1 Design

The design, manufacture and application of the conveyor shall comply with Conveyor Equipment Manufacturer's Association (CEMA) Standard No. 402. Conveyor components shall comply with SANS 1313, SANS 1669 and SANS 1366, all as applicable.

The conveyor shall be of the troughed belt type running either on non-corrosive troughing idlers or on a stainless steel slider bed as recommended by the Contractor. It must also be noted that the loading on the belt could be relatively low and the conveyor would be operating in a very moist and corrosive environment. During operation all idlers shall rotate freely.

A53.2 Conveyor Belt

The belt width shall suit the duty but shall not be less than 450 mm with at least 2 plies, and with 1,5 mm minimum thickness of covering to both sides. The belt shall be of a neoprene or other material unaffected by moisture or substances normally expected on a sewage application. Alternatives may be offered. Vulcanised splicing shall be used. The use of clips will not be allowed. Belt speed shall not exceed 30 m/minute.

A53.3 Guards

The conveyor shall be so enclosed that all moving parts and nip points are neatly and safely guarded. The head and tail pulley's shall be as safely guarded as possible without causing a hindrance to the operation of the conveyor. Where exposed, the sides and bottom of the conveyor must be covered with corrosion resistant and easily removable panels small enough to handle in a strong wind.

A53.4 Splash Boards

On screenings duty, the Conveyor shall be provided with suitably protected 20 mm thick hard wood or 8 mm polypropylene, angled splash boards not less than 300 mm wide along both sides of the belt and firmly secured to the conveyor frame along its entire length. The bottom edge of the splash boards shall be provided with a rubber skirt which shall be adjustable and adjusted so

that clearance between the skirt and conveyor belt is kept to a minimum. The splash boards shall be so designed and installed as to assist with clean and trouble free loading and discharge of material.

A53.5 Emergency Trip Wire

An emergency trip wire and cut out switch must be provided. The trip wire must extend along the entire length of the conveyor on both sides.

A53.6 Belt Scraper

A belt scraper, either reinforced neoprene or neoprene bladed shall be incorporated below the head pulley designed to remove screenings of a fibrous and sticky nature. The scraper shall be designed to be well clear of the discharge point and not provide collection points for screenings. Pressure between the belt and the scraper shall be maintained by suitable rubber filled torsion holders. The torsion holders shall be mounted on adjustable stainless steel screw type mountings positioned well clear of the discharge from the conveyor.

A53.7 Idlers and Pulleys

Idlers shall be of a non-corrosive abrasion resistant material. All idlers shall have pre-lubricated sealed for life roller or ball bearings and details of the bearing sealing arrangement shall be provided with the tender. Head and tail pulleys shall be crowned and shall be fabricated of 316 SS or shall be of cast iron or carbon steel and neoprene coated in both cases. Pulleys shall have a minimum diameter of 250 mm and be fitted with taperlock bushes. Shafts shall be of 316 SS, or better, and adequately sized and bearings selected for an L_{10} life of 100 000 hours.

All idlers must be mounted in such a way as to facilitate easy removal and replacement.

The pulley shafts shall be supported by spherical roller bearings designed for an L_{10} life exceeding 100 000 hours. The bearings shall be mounted in cast iron bearing housings. Bearing housings shall fully enclose the bearing and open type integral bearing units are not acceptable even if shielded bearings are used. All bearing housings shall be sealed and fitted with grease points piped to a convenient easily accessible block on which nipples shall be fitted. Individual grease pipes shall be provided or, alternatively, positive displacement distribution blocks shall be fitted.

"Take ups" shall be of the protected screw type with a minimum adjustment range of 350 mm. The screws are to be of grade 316 SS, or better.

A53.8 Slider Beds

If used, slider beds shall be of 3CR12 or grade 316 stainless steel not less than 6 mm thick and painted with an approved 3 coat polyurethane paint system. Slider beds shall also be designed so as to be easily replaceable. The slider bed trough shall be open along the centre so as not to provide a collection area for liquids or dirt.

A53.9 Framework

The supporting framework shall be of rigid welded or bolted construction. Tubular construction will not be accepted. All welding shall be continuous and no unwelded or unsealed crevices shall be permitted. All idlers must be mounted in such a way as to facilitate easy removal and

replacement. The corrosive nature of the environment must be noted and all steel work shall be hot-dip galvanized (or hot-metal zinc-sprayed or hot-metal aluminium-sprayed) and painted.

A53.10 Drive

The drive unit shall preferably be of the shaft mounted torque arm gearbox type with motor and gearbox being a combined unit, and mounted directly on the drive pulley shaft. The gearbox shall be selected for continuous operation with a power service factor of not less than 1.5. All bearings shall be designed for an L_{10} life of not less than 100 000 hours. A sight glass for observing the oil level shall be provided and shall be of a type which cannot be easily broken accidentally. Tenderers shall allow for initial fill of lubricants and for draining, flushing and refilling after an initial bedding in period of not longer than 3 months. Although a shaft mounted direct coupled arrangement is preferred, a chain or belt drive shall comply in all respects with the requirements of this Specification. Jacking screws must be provided for tensioning the drive and a movement of at least 50 mm in each direction must be possible. These screws shall be of grade 316 SS, or better.

The gearbox shall comply with the requirements of Sub-clause "Motor Driven Gearboxes" (see Clause "Power Transmission".

A54. COMPRESSORS

A54.1 General Requirements

Each compressor shall be provided with:

(a) isolating valve.
(b) check valve.
(c) lockable pressure relief valve (this shall be in addition to any fitted to air receivers).
(d) discharge pressure gauge.
(e) inlet pressure gauge (if the inlet pressure is not atmospheric).
(f) air intake filter (of the efficient, heavy-duty, dry-type air filter incorporating a centrifugal pre-cleaner with automatic dust ejector, a renewable filter element or cartridge and a servicing indicator).

(g) inlet and outlet silencers.

The volume of air delivered by a compressor shall modulate to match the demand. Provision shall, however, be made for the compressor to shut down should there be no air demand for a predetermined period, and to restart when demand is re-established. During the period before the compressor stops, the compressor shall be arranged to operate in a low power demand, idling mode.

A54.2 Rotary Compressors

Compressors shall be of the air-cooled, rotary type, either directly coupled to, or vee-belt driven by an electric motor, and shall be mounted on a rigid fabricated steel base plate and fitted with suitable guards. Preference will be given to low speed units, and the size of unit shall be conservatively selected.

A final automatic filter drain to remove any trace of oil and water is to be provided.

When an oil separator vessel is needed, this will probably be classified as a pressure vessel and the requirements of the clause “Air Receivers” shall apply. Handholes will not, however, be required where the diameter of the separator is too small. OHS Act requirements shall be complied with and shall take precedence.
The sound level at a distance of 1 metre from the compressor at any operating point shall not exceed 80 dBA.

A54.3 Silenced, Package Type Rotary Compressors

Silenced compressors shall be of the air cooled, rotary type complying with the noise limit of 70 dBA at one metre. In order to achieve this, the compressors shall be of the packaged type mounted in a soundproofed enclosure on anti-vibration mounts with the machine adequately silenced.

All necessary controls and instruments shall be integrally mounted with the compressor enclosure and shall comply with the electrical specifications.

All relevant and necessary check valves, minimum pressure valve, air/oil filters, etc., shall be fitted to the unit.

A54.4 Reciprocating Compressors

Reciprocating compressors may be used for workshop applications where the compressor can be installed externally and the higher noise and vibration levels can be tolerated.

A55. AIR RECEIVERS

Wherever possible, only South African manufactured construction materials shall be used for air receivers which shall be of heavy gauge steel with convex ends, shall be of welded construction and shall be manufactured to a code acceptable to the Department of Manpower Utilisation. This Code of Manufacture shall allow for two elliptical handholes with oil resistant gaskets, one at each end of the cylindrical section, as per drawing No. ME A4/1519 (see Clause “Standard Drawings”) and the handhole covers shall be spigotted to facilitate accurate positioning. Screwed inspection plugs will not be acceptable. A Government authorised inspection authority shall, in addition to the duties laid down in the relevant Code of Manufacture, inspect the design, construction and materials of all handhole covers and the clamping arrangement. These covers and clamps shall be stamped and certified and the maker's certificate shall be endorsed accordingly.

The vessels shall in all respects comply with the requirements of the applicable regulations of the Machinery and Occupational Safety Act of 1983 and each vessel shall include the following:

(a) A pressure gauge of not less than 150 mm diameter, calibrated in kPa and redlined at the maximum safe working pressure. The calibration scale shall not exceed twice the safe working pressure of the vessel or be less than the hydraulic test pressure of the vessel.

(b) Lockable safety valves complete with bronze padlocks and two keys.

(c) Automatic drain valve cock (the drain for condensate removal must be at the lowest point of the receiver, a syphon type drain is not acceptable). Particular attention must be paid to the contouring of the weld at the drain cock to ensure that no condensate can be trapped within the vessel. The draincock shall be piped to a drain.

(d) An isolating valve in each air supply line as close as possible to the air receiver which it

controls.

A maker's Test Certificate for the air receivers as required in terms of the Machinery and Occupational Safety Act, 1983 as amended, showing the hydraulic test pressure, must be supplied. This Test Certificate must be signed by a Government authorised inspection authority. The Contractor shall also arrange for the receivers to be tested and inspected in accordance with the above Act after installation and before being put into use for the first time. This test shall be witnessed by the Engineer or a competent person delegated by him.

All hot pipework which constitutes a hazard to operators shall be insulated.

The vessel shall be painted externally in accordance with System for non-Immersed Steel in Moderate Atmosphere and unpainted internally.

A56. PRESSURE VESSELS

All aspects of pressure vessels installations, including design, fabrication, installation, ancillary equipment, etc., shall comply in all respects with the appropriate parts of the Vessels Under Pressure Regulations, 1996 forming part of the OHS Act & Regulations. Pressure vessels shall be of welded construction and shall be manufactured to a code acceptable to the Department of Manpower Utilisation. Screwed inspection plugs will not be acceptable.

The vessels shall in all respects comply with the requirements of the applicable regulations of the Machinery and Occupational Safety Act of 1983 and each vessel shall include the following:

(a) A pressure gauge of not less than 150 mm diameter, calibrated in kPa and redlined at the maximum safe working pressure. The calibration scale shall not exceed twice the safe working pressure of the vessel or be less than the hydraulic test pressure of the vessel.

(b) Lockable safety valves complete with bronze padlocks and two keys.

(c) A maker's Test Certificate for the pressure vessels as required in terms of the Machinery and Occupational Safety Act, 1983 as amended, showing the hydraulic test pressure, must be supplied. This Test Certificate must be signed by a Government authorised inspection authority. The Contractor shall also arrange for the pressure vessel to be tested and inspected in accordance with the above Act after installation and before being put into use for the first time. This test shall be witnessed by the Engineer or a competent person delegated by him.

The required corrosion protection system shall be System for non-Immersed Steel in Moderate Atmosphere unless specified otherwise in the Detailed Mechanical Specification.

A57. POSITIVE DISPLACEMENT BLOWERS AND VACUUM PUMPS

A57.1 General

Each blower shall be provided with the following:

(a) Isolating valve.
(b) Pressure relief valve sized for full flow.
(c) Check valve.

(d) Inlet filtration with paper element.
(e) Inlet and outlet silencing.
(f) Discharge pressure gauge.
(g) Inlet pressure gauge (if not atmospheric).
(h) Anti-vibration mounts.

Roots type rotary lobe blowers shall be installed and configured so that the suction and discharge pulsing is minimised and shall not cause undue noise or damage to equipment.

The Detailed Mechanical Specification describes the requirements for the sealing water supply arrangement for liquid-ring units.

A57.2 Pressure Relief Valve

A lockable pressure relief valve shall be fitted to **each** unit, regardless of whether any electronic protection system has been provided.

The pressure relief valve shall be sized for full flow at blow-off pressure. It shall be mounted immediately downstream of the blower but upstream of any valve. Unless provided as part of a proprietary package, the valve shall be mounted on a flanged nozzle on the discharge pipe. A padlock, or equivalent locking mechanism, shall be provided.

The valve shall be provided with a test certificate indicating the blow-off pressure setting.

A57.3 Liquid-Ring Units for Wastewater Applications

Liquid-Ring Units for wastewater installations shall incorporate stainless steel impellers and bodies.

A58. COOLING TOWERS

Cooling towers shall be rated to suit the cooling duty calculated from or specified in the Detailed Mechanical Specification. Calculations shall be based on the maximum wet bulb temperature of 23 ºC.

Cooling towers shall be of the induced draught counter flow design. Construction shall be of corrosion free and UV resistant materials such as fibre glass, with all metal components including fasteners of 316 SS, or better.

The cooling towers will be exposed to the very strong winds common in this area and must be designed to eliminate spray drift.

A large water reservoir must be provided in the bottom of the tower which shall be provided with a float valve for make-up water, and connections for overflow, drains and take off.

A59. LIFTING EQUIPMENT

A59.1 General Requirements

Lifting equipment shall comply with the following general requirements:

(a) The design, fabrication and installation of lifting equipment shall be fully in accordance with the relevant aspects of the Occupational Health and Safety Act and Regulations.

(b) Lifting equipment shall be designed, constructed and installed in accordance with an internationally accepted technical design standard.

The guidelines given in the Southern African Steel Construction Handbook may be used where applicable and where these do not conflict with the internationally accepted technical design standard.

(c) Test certificates shall be provided for all items of lifting equipment.
(d) The safe working load (SWL) shall be permanently marked on all items of lifting equipment.
(e) Lifting equipment and installations shall be inspected and shall be tested over the complete lifting range using a test load.

Unless otherwise specified in the internationally accepted technical design standard, the test load shall be:
⊕ at least 125 % of the SWL for equipment with a SWL of up to 10 tonne SWL;
⊕ at least 110 % of the SWL for equipment with a SWL of 10 tonne and above.

(f) High-tensile and alloy steel chains shall have a factor of safety of at least four. Other chains shall have a factor of safety of at least five.

(g) Steel-wire ropes shall have a factor of safety of at least six. Man-made fibre ropes or woven webbing shall have a factor of safety of at least six. Natural fibre ropes shall have a factor of safety of at least ten.

(h) Anchor fasteners for securing steel structures to concrete shall have a diameter of not less than M16 and shall be of grade 316 SS, or better.

(i) Foot-plates for columns which form part of lifting gantries shall be secured with a minimum of four anchor bolts.

(j) Hollow steel sections such as pipes and tubing are not acceptable as structural members unless the section is fully closed by welding.

(k) Tenderers shall note that many aspects, such as fabrication, welding, corrosion protection and fasteners, shall be in accordance with the requirements of other clauses in this Standard
Specification for Mechanical Works.

A59.2 Steel Gantries

In addition to the general requirements for lifting equipment, steel gantries shall comply with the following:

(a) The same internationally accepted technical design standard used for the design of the crawl beam or crane shall be used for designing the gantry which supports the crane or crawl beam.

(b) Columns shall be cross-braced and/or “triangulated” in more than one plane. In other words, columns shall not be cantilevered in any vertical plane.

(c) Gantry steelwork shall be hot-dip galvanised. If this is not feasible, steelwork shall be hot-metal zinc-sprayed, sealed and coated in accordance with the clause “Corrosion

Protection : Metal Coatings".

A59.3 Overhead Travelling Cranes

In addition to the general requirements for lifting equipment, overhead travelling cranes shall comply with the requirements below.

A 59.3.1. General

Construction of the crane shall be in accordance with BS 466 and BS 2573 (or BS EN 13 001), as applicable. All welding of steelwork shall be carried out in accordance with BS EN 1011 by competent artisans meeting the requirements of BS 4872. (Suitable equivalent standards are acceptable).

Design requirements for the fixing and installation of the crane rails shall be provided by the Contractor to the Engineer for acceptance.

The Tenderer shall determine a suitable method of installation for the crane and the crane rails and shall manage all work accordingly.

The Contractor may use the crane during the installation of other parts of the Works on condition that all testing and certification for the complete lifting installation, including the supporting structure, has been successfully completed.

A59.3.2. Certificate

The Contractor shall supply to the Engineer a certificate from the crane manufacturer which:

(a) certifies that the crane has been manufactured in accordance with the requirements of the Driven Machinery Regulations of the Occupational Health and Safety Act;

(b) specifies the internationally accepted technical design standard used, and;
(c) states the SWL and the test load.

This certificate shall be provided to the Engineer prior to delivery of the crane to Site.

A 59.3.3. Configuration

The overall configuration shall be as follows:

(a) the crane hoist shall be supported on and travel along a steel crane beam structure.
(b) the crane beam shall be supported on end carriages which travel along crane rails.
(c) the crane rails shall be supported along their full length, either on a concrete beam or on a hot-dip galvanised steel beam structure.

The crane long travel, cross travel and hoist shall be electrically-powered or manually operated as stated in the Detailed Mechanical Specification.
Unless otherwise stated:

(a) the lowest hook level shall be floor level.
(b) electrical control pendants shall be arranged to move independently along the length of the crane beam and shall be situated at one metre above floor level.
(c) the operating chains of manually operated cranes shall fall to one metre above floor level.

A 59.3.4. Construction

All materials shall be new and unused and suited to the application. Structural steelwork shall comply with the requirements of SANS 1431 and the grade used for structural members shall be 300 WC.

Fabrication shall comply with the following:

(a) Site welding will not be acceptable.
(b) Welding shall be continuous.
(c) Crevices will not be permitted.
(d) Weld slag and spatter shall be removed and welds shall be ground smooth prior to coating.
(e) Welds shall be free of blowholes and undercut.
(f) Edges shall be rounded to a radius of at least 3 mm.
(g) Open pockets which are inaccessible for preparation and coating will not be permitted.

The crane rails shall be standard rail sections. Rails manufactured from square section steel bar will not be acceptable. Rail lengths shall be joined using fish-plates, with at least four fasteners, to provide a continuous path for the travel of the crane wheels.

The crane beam and end carriages shall be designed with suitable dimensions, wheel spacings and gusset plates or diagonal bracing to prevent cross-whipping.

End stops with rubber buffers shall be fitted to prevent the hoist from moving off the travelling beam. Stops and buffers are also required to limit the long travel on the rails.

Lubrication systems shall be designed to exclude dirt and moisture and all gear wheels shall be fully enclosed.

Bearings shall be mounted in sealed, cast iron bearing housings or in totally enclosed and sealed housings, grease-lubricated and provided with grease nipples in both cases. The open type bearing units with exposed "lubricated for life" bearings will not be acceptable.

A59.3.5. Installation

The crane and rails, when erected and installed, shall be of neat and workmanlike appearance, solidly and evenly supported, true to line, level, plumb and in proper working order. The crane rails shall be straight to within the permissible deviations given in BS 466 over their entire length.

The distance between rail supports shall not exceed 1 000 mm. Every rail length shall be supported at both its ends.

Crane rail anchor fasteners shall be M16 or larger and shall be of grade 316 SS or better.

The full length of the rails shall be grouted in cases in which the rails rest on a concrete beam. A suitable gap between the rails and the beam shall be provided for application of the grout. The grout shall be applied strictly in accordance with the manufacturer's instructions. The grout shall be neatly finished with a 45º chamfer. The Engineer shall be notified prior to application of the grout.

In the alignment of equipment or structures, the use of multiple shims will not be permitted. Shimmed feet shall be fully grouted to provide corrosion protection of the shims.

Grouting shall be done using a non-shrink cementitious grout, ABE Duragrout 1000 or equivalent, to the approval of the Engineer and in accordance with the manufacturer’s instructions.

A59.3.6. Corrosion Protection

The Contractor shall arrange for the fabrication of the crane to be inspected by the Engineer at the fabricator's premises prior to preparation for corrosion protection.

The crane beam and end carriages shall be hot-metal zinc-sprayed, sealed and coated in accordance with the clause “Corrosion Protection: Metal Coatings”. Smaller items, such as cable brackets and protective covers, shall be hot-dip galvanized.

The crane rails shall be hot-dip galvanized after all fabrication work is complete.

A59.3.7. Maintenance Platform and Ladder

Where specified in the Detailed Mechanical Specification, a maintenance platform for two people shall be provided along the length of the crane beam.

The crane beam structure shall incorporate welded lugs onto which the platform shall be bolted; i.e. the platform shall be removable and shall not be welded to the crane beam. The complete platform and all guard-railing shall be hot-dip galvanised after fabrication. The platform floor shall have a minimum width of 500 mm.

Guard rails shall be provided on the maintenance platform and shall comply with the clause “Guard Railing”.

Where specified in the Detailed Mechanical Specification, a hot-dip galvanised fixed steel ladder shall be provided at a suitable position within the building for accessing the platform on the crane. This shall comply with Clause “Permanent Ladders and Stairs”.

A59.4 Hoists

In addition to the general requirements for lifting equipment, hoists shall comply with the following:

(a) Hoists shall be provided with an overload prevention device; e.g. a clutch which slips upon overloading. Powered hoists shall comply in all applicable respects with Driven Machinery Regulation 18 of the Occupational Health and Safety Act.

(b) Powered hoists shall hold the load stationary upon power failure.

(c) The bottom hook shall swivel on a ball or roller bearing through 360º and the bearing shall have a protective skirt. The hook shall be fitted with a safety latch.

(d) Lifting chain is preferred, but corrosion-protected steel wire rope is acceptable.

(e) Chain boxes shall be provided for holding unloaded lengths of lifting chain.

(f) Wire rope hoists shall comply with the following:
⊕ Drum diameter shall be at least 25 times the wire rope diameter.
⊕ Drums shall have no more than three layers of wire rope when fully wound up.
⊕ Drums shall have no fewer than three full turns of wire rope remaining when the hook is at the lowest design level.

A59.5 Hoist Trolleys

In addition to the general requirements for lifting equipment, hoist trolleys shall comply with the following:

(a) Hoist trolleys shall be designed so that the trolley will remain on the support beam if a wheel falls off or a wheel axle fails.

A59.6 Crawl Beams

In addition to the general requirements for lifting equipment, crawl beams shall comply with the following:

(a) Crawl beams shall be fabricated from standard I-Sections or standard H-Sections.

(b) Crawl beams shall be hot-dip galvanised after all fabrication is complete. If the zinc coating is removed or damaged by drilling or welding or any other activity, the complete beam shall have the zinc removed by abrasive blasting and it shall be returned to the galvanisers for hot-dip galvanising.

(c) Crawl beams anchored to concrete shall be secured using grade 316 SS, or better, anchor bolts. The anchor bolts shall, preferably, be through-bolted. If through bolting is not feasible and chemical anchor is used, every anchor shall be tested to the design load for the anchor prior to installation of the beam.

(d) Mechanical expanding anchors are not acceptable for anchoring crawl beams.

(e) Crawl beams fastened to steel support structures shall be secured using hot-dip galvanized fasteners.

A59.7 Davits

In addition to the general requirements for lifting equipment, davits shall comply with the following:

(a) Davits shall be column mounted with swivelling booms and shall be designed to suit the application. Where specified in the Detailed Mechanical Specification, each davit shall be provided with a winch rigidly fixed to the davit at a convenient height and position.

(b) The davit shall be designed for a SWL at least 50 % above the load requirements of the equipment installation.

(c) Guide pulleys shall be provided to suit the arrangement. These pulleys shall be machined with a groove having a radius 5 % to 7,5 % greater than the rope radius and with a flare angle of 52º. The pulley effective diameter shall be not less than 25 times the wire rope diameter. The groove depth shall be twice the rope diameter or greater.

(d) The davit shall either be manufactured of grade 316L SS, or better, or of carbon steel, hot-dip galvanized and painted. All fasteners, pins, shafts, shackles, hooks, etc., shall be of 316 SS, or better. Guide pulleys and shafts shall be made of 316 SS, or better, or other approved corrosion resistant material, and shall use suitable non-metallic bearings which do not require lubrication.

(e) The swivelling arrangement shall be properly designed for easy operation, shall be accurately fitted and shall not be subject to corrosion problems. Bushes made of nylon, "Vesconite" or other suitable non-metallic material shall be used and any metallic rubbing mating face shall be of 316 stainless steel.

(f) Operating cross bars, locking arrangements, fixing arrangements, etc., shall not represent a hazard to passers-by. If necessary, operating levers shall be hinged so that they can be swung out of the way when not in use.

A59.8 Hand Cranked Winches

In addition to the general requirements for lifting equipment, hand cranked winches shall comply with the following:

(a) Hand cranked winches shall be rated for a SWL of at least 50 % in excess of the expected working load. All gears, clutches, etc., shall be enclosed in a robust cast iron, cast steel or fabricated stainless steel casing which shall be grease filled and sealed against ingress of dirt and moisture. The winch shall be designed to hold the load stationary when the hand crank is released during raising and lowering. In addition, a locking arrangement to lock the position of the load at any point shall be provided.

(b) The force required to operate the winch at its maximum rated load shall not exceed 130 Newtons.

(c) The wire rope shall be of stainless steel. The wire rope shall be long enough to reach the lowest required position and still have at least 3 turns remaining on the drum. The drum size shall easily store the full rope length. The drum shall have a diameter of at least 25 times the diameter of the wire rope.

(d) The support brackets, all exposed fasteners, shafts, handles, pins, etc., shall be of 316 SS, or better, and the casing shall be hot-dip galvanized or hot-metal zinc-sprayed (to a thickness of 150 µm) and then painted.

(e)

D60. LINEAR SCREENS / BELT PRESSES

The General Specification covers equipment for sludge dewatering by linear screens and belt presses.

The requirements set out herewith are the minimum anticipated and the Contractor shall be responsible to ensure that the equipment proposed is suitable in all respects for the duties specified herein and in the Specific Requirements following.

A60.1. Type of Equipment

The equipment shall comprise of the following basic components:

a) Sludge pumping equipment.
b) Linear screen/s. (gravity sludge dewatering moving belt machine/s)
c) Filter belt presses.
d) Effluent wash water pumps.
e) Support and access structural steelwork.
f) Associated pipe work, valves, strainers and polymer injection device/s etc.
g) Ancillary equipment, (air compressor equipment or hydraulic equipment).
h) Sludge pumping equipment for dewatered sludge.
i) Electrical switch gear, cabling and instrumentation (if specified).

Coagulation chemical (polyelectrolyte) preparation and dosing equipment will be the subject of

another specification and is not covered in this specification. However the control of the dosing will be closely interfaced with the above equipment and the necessary instrumentation will be required to also measure, record and control the dosing equipment.

A60.2. General Design Parameters

The following requirements shall be met:-

(a) The equipment shall be designed to facilitate efficient manufacture, inspection, transportation, installation, maintenance, cleaning and repairs.
(b) The equipment shall be designed to ensure safe and satisfactory operation for a life expectancy of at least 20 years under the conditions prevailing at the site.
(c) Belt life of more than 5000 hours should be achieved
(d) The equipment shall be designed to prevent undue stresses being produced by expansion and contraction due to temperature change, and other local natural and manmade conditions.
(e) The equipment shall be designed to keep maintenance cost to a minimum.
(f) The equipment shall comply with the legal requirements in respect of safety and the prevention of environmental pollution.
(g) The equipment shall satisfy any specific requirement contained in the relevant statutory codes and legislation.
(h) The equipment shall be suitable for operation 365 days per year, 24 hours per day under the specified design conditions.
(i) All equipment shall be provided to provide a fully operational plant within the scope of the contract.
(j) All materials from which the equipment is manufactured shall be compatible with the chemicals used and suitable for the intended duty and service conditions.
(k) All equipment shall be suitably treated and protected from corrosion and erosion.
(l) After approval by the engineer, at the time of the award of the Contract, the information stated in the Data Sheets shall be fully complied with, notwithstanding the specified scope of the Contract.
(m) All electrical equipment, forming part of the specified equipment, shall be sealed against penetration by the spray belt cleaning water in use, which may be in aerosol form, and be also accessible for repair and maintenance.

A60.3. <u>Sludge to be Dewatered</u>

The source and type of sludge/s to be dewatered, together with its / their dry solids concentration, shall be as indicated in the Specific requirements following.

A60.4. <u>Process Description and Design</u>

The following basic steps shall be followed for the dewatering of sludge using linear belt type dewatering screens.

1) Treat the sludge with a chemical to coagulate the sludge particles.
2) Handle the coagulated sludge gently to avoid breakup of the coagulated particles.
3) Dewater the sludge on a moving mesh belt under gravity.

Special attention shall be given to the mesh belts, the speed of the belts and the positioning of ploughs in the gravity dewatering zone.

The equipment shall be capable of dewatering the sludge/s specified in the scope of Works, and shall be designed and selected by the Contractor to achieve the dewatered sludge dry solids concentration, solids recovery and polyelectrolyte consumption as specified in the Scope of Work.

The dewatering installation is depicted on the process and instrumentation diagram and the Site layout Drawings provided. The installation comprises the following major units:

a) Sludge feed pumps.
b) Polyelectrolyte dosing equipment.(not part on this specification)
c) Linear dewatering screen machine/s.
d) Dewatered sludge pumps.
e) Service water tank and pumps for the supply of wash water.
f) Air compressing equipment (if applicable).

A60.5. Equipment Required

The equipment to be provided shall comprise the following, unless otherwise indicated in the Specific Requirements:

a) Sludge feed pumping equipment.
b) Linear dewatering screen machine/s.
c) Access platform steelwork.
d) Service water pumps and automatic backwash inline strainer.
e) Dewatered sludge pumps.
f) Associated piping, valves and fittings.
g) Air compressing equipment (or alternatively).
h) Hydraulic power pack equipment.
i) Electrical switchgear, cabling and instrumentation.
j) Laboratory equipment.
k) Ultrasonic level measuring and control equipment for the sludge storage tank/s.
l) Magnetic flow meter to measure the rate of flow of wash water to each dewatering unit.
m) Magnetic flow meter/s to measure the rate of flow of wash water and filtrate discharged from the dewatering equipment.
n) Solids density meter to measure the concentration of feed sludge to the dewatering equipment.
o) Solids density meter to measure the concentration of dewatered sludge from the dewatering equipment.
p) Solids density meter/s to measure the concentration of dewatered sludge from the dewatering equipment.

A61. CENTRIFUGES

A61.1. General

The centrifuge shall be of the horizontal solid bowl type with fully variable differential speed control of the scroll. The centrifuge shall be of a type with proven performance on the specified duty.

Particular care shall be taken to minimise corrosion and abrasion and generally a part life exceeding 100 000 hours before major overhaul or repair is required and shall be achieved by the appropriate selection of materials and sizing of parts.

Operational problems must be minimised. All openings, particularly in the sludge feed and cake discharge areas shall be of adequate size and design to prevent plugging or bridging. Sludge feed velocity into the centrifuge shall not exceed 2,5 m/s at design capacity.

The point of polymer addition shall be recommended by the Tenderer to suit the recommended type of polyelectrolyte but the option of polymer addition into the bowl of the centrifuge must be provided.

Provision shall be made for automatically flushing the centrifuge after operation. A manually operated flushing valve shall also be provided.

A61.2. Construction

A61.2.1. Casing

Casings shall be split and flanged down the centreline with adequate access covers for inspection of the dewatered solids discharge area and for easy access to the centrate discharge weirs for pool level adjustment. Sealing arrangements of all mating seal faces shall prevent any leakage. The casing shall be of rigid construction with baffles to ensure separation of the cake and centrate. Lifting lugs for the upper casing and handles for access covers shall be provided.

The casing, including all covers and fasteners, shall be manufactured of either grade 304 SS painted or of grade 316 SS, or better. The internal surface areas at the centrate and sludge discharge points must be suitably protected against abrasion using a lining material or approved thick coating.

A61.2.2. Bowl

The bowl assembly shall be of grade 316 SS, or better, construction with replaceable corrosion and abrasion resistant liners in the cylindrical and dewatering beach section and sintered tungsten carbide replaceable liners at the cake discharge ports.

Provision shall be made for measurement of the scroll flight wear via sealed ports provided in the bowl.

All fasteners shall be of grade 316 SS, or better, and so positioned as to avoid wear and shall be protected against plugging of clearances and holes for spanners and keys.

A61.2.3. Scroll

Scrolls shall be of grade 316 SS, or better, and protected against wear on the outer edges. This protection shall take the form of metal-backed, tungsten carbide components which are welded to the scroll and which can be replaced without causing structural damage to the scroll.

The feed sludge entry ports shall be fitted with replaceable abrasion resistant liners. The sludge feed pipe shall be easily replaceable and fabricated from an abrasion and corrosion resistant material or shall be suitably lined.

A61.2.4. Bearings

The main centrifuge bearings and scroll bearings shall preferably be grease lubricated and shall be adequately sealed to prevent moisture or solids entering the bearings and to prevent lubricant

entering the bowl. Details of the sealing arrangements shall be provided with the tender. Grease nipples which are easily accessible from outside the centrifuge shall be provided for all bearings.

Designs incorporating bearings which must be oil lubricated shall include for a system which will protect the bearings during the centrifuge run down period in the event of a power failure. Oil lubrication systems shall include all necessary ancillaries including oil pump, suction filter, discharge filter with blockage indicator, pressure relief valve, an adequate reservoir with drain, plugged drain valve, filler and breather cap, level indicator and temperature gauge, oil cooler with connecting pipework, protection switches, etc.

A61.3. Materials of Construction

The materials of construction shall be as follows:

(a) Structural steelwork shall be protected by a duplex system (HDG plus organic coating); or shall be hot-metal zinc-sprayed and sealed.

(b) Ducting shall be of grade 316 SS, or better.

(c) Hoppers shall be of grade 316 SS, or better.

(d) Screw Conveyors shall comply with Clause "Screw Conveyors".

(e) Baseplates shall be protected against corrosion. Acceptable systems are hot-dip galvanizing and paint or hot-metal zinc-spray (Zn 150) and sealed. The final colour shall be black.

(f) Coupling guards shall be of grade 316 stainless steel but, in hazardous areas, shall be of aluminium.

(g) Small items such as brackets, etc., shall be hot-dip galvanized and coated or shall be of grade 316 SS, or better.

(h) Fasteners - See Clause "Fasteners".

(i) Pipework and Valves

(j) Sludge pipework shall be of 316 SS, or better, HDPE or shall be of cast iron protected internally and externally with System for Large Immersed Steel Fabrications (not requiring decorative finish); i.e. polyamine/amide cured coal tar epoxy.

(k) Centrate pipework shall be of HDPE.

(l) Polyelectrolyte pipework shall be of grade 316 SS, or better.

(m) Water pipework up to 25 mm diameter shall be of copper. Water pipework above 25 mm shall be HDPE, PP or of carbon steel and protected with System “Fusion Bonded Epoxy”.

(n) Motors, pumps, gearbox, etc., shall be of cast iron suitably corrosion protected.
(o) Basket strainers - See Clause "Fluid Strainers".

A61.4. Alternative Materials of Construction

Tenderers may, as an additional and separately priced alternative, offer alternative materials of construction to those specified provided that both the short and long term economics of such

alternatives are detailed.

A61.5. Centrifuge Drive Arrangement

The centrifuge shall be vee-belt driven by an electric motor through a fluid coupling or by a frequency controlled variable speed motor, as recommended by the centrifuge manufacturer.

The motor and drive arrangement shall be adequately rated for the maximum load which can apply at any operating condition. In particular, the torque characteristics of a motor, fluid coupling and load under starting conditions shall ensure that the motor reaches full speed within 10 seconds and that the centrifuge reaches full speed with a substantial margin before causing overheating of the fluid coupling. Similar requirements apply to variable speed drives and their motors.

Contractors shall provide full details of torque characteristics and starting times for approval before commencing with manufacture.

The motor shall be mounted on slide rails incorporating stainless steel jacking screws.

Fluid couplings shall be suitably protected. This shall include protection from high temperature due to operation at high slip for extended periods.

A61.6. Centrifuge Mounting Arrangement

Each centrifuge and motor unit shall be mounted on a common fabricated steel baseplate generally complying with the Clause "Baseplates". A high mass, very rigid base arrangement is required with low deflection of the vibration isolation mounting system during operation.

Foundations will be constructed, usually by others under a separate building contract, in accordance with the details and requirements which shall be provided by the Contractor.

Vibration isolation mountings which will eliminate not less than 90 % of the vibrations transmitted by the equipment shall be provided between the centrifuge baseplate and the concrete foundations. Full details shall be provided with the tender. When mounted on the vibration isolators, distortion of the baseplate shall be negligible in comparison with the permissible and acceptable misalignment of the equipment mounted thereon.

All cable, pipework and other connections to the machine shall be flexible and so fixed and mounted as to prevent wear and fatigue.

The baseplate and guards shall fully comply with the relevant clauses of this Specification.

A61.7. Centrifuge Scroll Differential Speed Control

Variable speed scroll drive systems utilising electronic frequency variation, preferably, or air cooledelectric braking systems may be used. Hydraulic drives will only be acceptable if electric/electronic systems are unavailable. If used, hydraulic power packs shall be properly designed and shall include all necessary ancillaries including oil pump, suction filter, discharge filter with blockage indicator, pressure relief valves, an adequate reservoir with drain, plugged drain valve, filler and breather cap, level indicator and temperature gauge, an oil cooler where necessary with connecting pipework, protection switches, etc. All systems shall be so designed that no

damage may result during the centrifuge run down period in the event of a power failure. Noise levels must also be kept low.

The scroll differential speed control shall be designed to provide a selectable option of either maintaining a selected differential speed or of maintaining a constant drive torque.

Provision must be made at the position of adjustment for indication of both differential speed and scroll torque.

The gearbox and differential speed control system shall be adequately rated for the duty using a service factor of at least 1,75. Gearboxes shall be oil lubricated and sealed.

Further requirements with regard to control and instrumentation are specified elsewhere in this Specification.

A61.8. Centrifuge Discharge Diverter

A means of diverting flushing water and thin sludge from the cake discharge opening shall be provided.

A61.9. Sludge and Centrate Discharge Ducting

Ducting and pipework shall be provided to guide the thickened or dewatered sludge and centrate without hangup, bridging, leakage, overflow or blockage. Consideration must be given in the design to the stickiness of sludge and all duct surfaces must be vertical or very steep.

The arrangement shall be such that no spillage or other mess occurs during start-up, normal operation or shut-down. All sections of the discharge ducting shall be individually flanged for separate removal.

A61.10. Sampling

Suitable sampling connections shall be provided for sludge, cake and centrate. These connections must be conveniently located and not less than DN 50.

A61.11. Centrifuge Maintenance

Tenderers shall provide, with their Tender, the anticipated short and long term maintenance schedules for the centrifuge. This schedule shall list the estimated maintenance which will be required at various stated intervals including lists of parts which will need to be reconditioned or replaced at each service and the present cost of the reconditioning and parts.

Separate schedules shall be provided for alternative materials or designs which may be offered.

A62. AUTOMATIC POLYELECTROLYTE PREPARATION SYSTEM

The system shall be of proprietary, unit design which has been tested in practice.

The system shall be chosen for the application and shall have volume flow capacity and polyelectrolyte dosing capacity of at least 20 % above the design ranges for the application.

The polyelectrolyte make-up and stock tanks shall be of GRP or stainless steel.

The polyelectrolyte stock tank shall be sized to provide at least six hours of polyelectrolyte dosing before refilling.

Polyelectrolyte dosing pumps shall be selected to avoid high shear on the liquid being pumped. Prepared types of pumps include progressing cavity and peristaltic pumps.

A63. ENGINE DRIVEN ELECTRICITY GENERATING SETS

A63.1. Equipment

This Clause deals chiefly with the overall requirements and the mechanical aspects of the equipment. The detail electrical requirements are specified in the Electrical Specification.

Engine-driven electricity generating set installations shall include an engine-driven alternator, shaft coupling, engine and alternator cooling system, starting system, double baseplate and anti-vibration mounting system, exhaust system, fuel tank, electrical control panel and specified spares.

Engines shall be diesel powered and ISO 9001 approved, unless otherwise stated in the detailed Particular Specification.

A63.2. Arrangement

The engine and generator shall be rigidly mounted on a steel baseframe. This baseframe shall be supported on anti-vibration mounts within a second steel baseframe.

The alternator shaft shall be supported separately from the engine shaft on a minimum of two bearings and the engine/alternator shaft coupling shall be of the flexible type.

Both baseframes shall be hot-dip galvanised after fabrication.

The outer baseframe of units to be installed on floors shall incorporate skids and shall be provided with four jacking points. After the genset is positioned correctly, suitably designed vibration pads (Tico, or equivalent) shall be placed between the skids and the concrete floor.

A63.3. Performance

The complete genset installation shall be capable of the kW and kVA output and any other performance requirement specified in the Detailed Mechanical Specification for continuous as well as for high current (motor starting) requirements. The genset rating shall provide for these performance requirements whilst maintaining the frequency and voltage within the ranges specified in the Electrical Specification.

A63.4. Engine

Unless otherwise specified in the Detailed Mechanical Specification, the engine shall be a multicylinder, diesel-fuelled compression ignition unit. It shall run at 1 500 rpm which shall not be

greater than 85 % of its rated full speed. The power rating shall be in accordance with an approved British Standard or other approved by the Engineer. Tenderers shall provide full details with their tender documents.

The net power output rating of the engine at 1 500 rpm with all driven accessories as installed and for continuous operation shall be **at least** 15 % greater than the full generator input power (kilowatt) required.

A63.5. Engine Environment

The engine cooling and ventilation system shall cater for all air needs such as combustion air, ventilation air and the cooling air requirements for the engine cooling system. Air for combustion, engine cooling and ambient cooling shall be drawn from an area free of the heated discharge(s)

and the exhaust emission.

If the engine is of the water-cooled type, the engine coolant shall be treated with the engine manufacturer's recommended anti-corrosive, water soluble coolant.

If the genset is to be installed in an enclosure or closed room, the allowable temperature rise to be used for the design of plant room ventilation shall be 5 ºC. Adequate ventilation shall be provided to remove from the enclosure the radiation and convection heat losses from the generating set (to be taken as a minimum of 33 % of the maximum engine shaft power plus the heat resulting from the inefficiency of the generator).

Filtration shall be provided on the inlet and outlet duct to prevent the ingress of wind-blown dirt.

A63.6. Engine Lubrication

Engine oil filters shall be mounted in an accessible position.

An extension pipe with square headed plug shall be provided to facilitate draining oil from the sump.

Certain control functions are specified for the monitoring and control of engine lubrication.

A63.7. Combustion Air Intake

A two-stage cyclonic dry type air cleaner shall be fitted and shall have water and dust evacuators. The air cleaner shall be amply rated for the application. There shall be no flow restrictions and the complete air induction system shall have the approval of the engine manufacturer.

The air filter shall be designed to reduce intake noise breakout.

A63.8. Exhaust and Silencing System

All piping for the exhaust system shall be of grade 409 stainless steel. The silencers and all pipe support brackets shall also be of stainless steel.

Where required to satisfy the OHS Act requirements, the exhaust system, including silencers, shall be acoustically insulated with a preformed mineral wool inner layer sealed with asbestos free finishing plaster.

Exhaust outlets shall be protected against the ingress of rain.

The silencing system for engines above 25 kW shall include a reactive silencer and an absorptive type silencer and all support brackets. A flexible connection of the bellows type shall be installed as close to the manifold(s) as possible to limit vibration transfer and to allow expansion under heating. The standard reactive (i.e. pulsation damper type) silencer shall be installed downstream of the flexible connection. The distance between the engine and the reactive silencer shall be designed to avoid resonance. An additional absorptive silencer, Burgess or equivalent, shall be installed downstream of the reactive silencer. The tail pipe shall have a length of at least 15 times the pipe diameter, measured downstream of the absorptive silencer.

Where the genset is installed inside an enclosure or room, both silencers shall be installed inside the enclosure. The exhaust outlet shall be led outside the genset enclosure to discharge at least three meters above ground level.

A63.9. Engine Fuel System

A primary and a secondary fuel filter of the replacement element type shall be provided. In addition, a water trap ("Otomatik" type, or equivalent) shall be provided. All three shall be installed between the fuel tank and the injector pump.

Piping between the fuel tank and the engine shall be of stainless steel and a flexible section for absorbing vibration shall be fitted, at the engine, to meet the requirements and approval of the engine manufacturer.

The flow velocity in the suction piping shall not exceed 0,8 metres per second (based on 3 times the fuel consumption at the rated load). The tank suction connection shall be at least 50 mm above the tank bottom.

A fuel return line from the engine shall be connected to the tank at the same level as the suction line and its diameter shall be the same as that of the suction line.

A fusible-link controlled, shut-off valve shall be mounted in the fuel supply line above the engine and this shall close in the event of fire. A manual shut-off valve shall be installed upstream of this valve.

A63.10. Starting

Refer to the detailed Particular Specification for the required starting details.

A63.11. Acoustically Enclosed Applications

Gensets which, in order to control noise, are installed in rooms shall have their air supply and discharge openings fitted with acoustic attenuators adequately designed to ensure a noise level at 1 metre from the openings outside the plant room of no more than 60 dBa impulse rating level. The attenuators shall incorporate sound absorbent elements (Donkin, Trox or equivalent).

Each opening shall be provided with a weather louvre and an internal mesh screen.

Silenced units shall be as specified in the Detailed Mechanical Specification.

A63.12. Operation and Control

The required method of starting and stopping is described in the Detailed Mechanical Specification.

All monitored items shall be displayed. Monitored and displayed items shall include the following:

(a) generator output power (kW).
(b) generator apparent power (kVA).
(c) generator power factor.
(d) generator voltage.
(e) generator current.
(f) generator speed.
(g) engine coolant inlet temperature.
(h) engine coolant outlet temperature.
(i) engine oil pressure.
(j) fuel tank level.

The following alarms shall cause a system trip:

(k) high engine coolant temperature (if applicable).
(l) engine coolant low flow (if applicable).
(m) low engine oil pressure.
(n) high ambient temperature in enclosure (if applicable).

A63.13. <u>Acceptance Tests</u>

The tests which shall be carried out by the Contractor to certify that the equipment is operating in accordance with the performance requirements in this Specification shall include the following:

a) fuel lines shall be tested for airtightness prior to filling.
(b) a test shall be done to verify the guaranteed power output. The Contractor shall do preliminary tests and make adjustments as necessary. Once all adjustments have been carried out, the generating set shall operate for a period of not less than 15 minutes to permit conditions to settle down before proceeding with the acceptance test. The acceptance test shall be run for not less than 30 minutes at full specified continuous power output with electrical power output readings being taken every 5 minutes. The arithmetic average of these results will be taken as the official test result. All monitored parameters shall also be recorded.
(c) test that the genset is able to start the largest motor as specified.
(d) tests to show that each protection circuit is operational.
(e) pressure tests of all pipework.
(f) operation of all components of the system individually and as a system.
(g) where the genset is installed in an enclosure or room, the allowable temperature rise for plant room ambient is 5 ºC and this shall be confirmed during continuous operation for a period of at least two hours.

The Contractor shall make all arrangements and shall provide all equipment required to perform the above tests, including the provision of load resistor banks or equivalent.

A63.14. <u>Spares, Manual, etc.</u>

The following spares shall be provided if stated as a requirement in the Detailed Mechanical Specification:

(a) complete set of diesel injectors (1 off per genset).
(b) complete diesel injector pump (1 off per genset).
(c) complete engine gasket set (1 off per genset).
(d) complete engine fanbelt set (1 off per genset).
(e) complete air filter set (2 off per genset).

(f) complete fuel filter set (2 off per genset).
(g) complete oil filter set (2 off per genset).

Technical information to be provided for the operating staff shall be comprehensive and tailored to be specifically applicable to the installation. The detailed requirements for the Operation and Maintenance Manual is specified elsewhere in this Standard Specification for Mechanical Works.

Two fire extinguishers of a suitable size and type shall be provided and shall be mounted suitably for the application.

A64. DIESEL FUEL TANKS

A64.1. Requirements For All Tanks

The detailed design requirements, including capacity, are specified in the Detailed Mechanical Specification.

The complete tank, pumping system and piping arrangement shall comply with all applicable fire prevention regulations.

All fixed electrical equipment and wiring shall be installed in accordance with the recommendations of SANS 10108.

The tank shall be provided with an equalisation vent. A drain at the lowest point shall be provided and shall have a lockable isolating valve (with the exception of underground tanks). All pipe connections to the tank shall be provided with isolating valves.

Diesel tanks serving diesel engines shall be mounted on a stand at the correct level to provide the engine manufacturer's required gravity feed to the engine’s injection pump. The bottom of the tank shall not be more than 500 mm below the level of the diesel injectors.

A64.2. Requirements for Tanks Installed Above Ground

Apart from where they conflict with the specific details of this Specification, the complete design and installation shall be in accordance with SANS 10131.

In addition to any other measuring device, the tank shall be fitted with an indicating fuel level gauge of the rotating dial float level type for visual checking.

The filling arrangement shall be designed for use with conventional road tankers.

A64.3. Requirements for Underground Tanks

Tanks which are installed underground shall be in accordance with SANS 1535.

Provision shall be made for withdrawing sludge from the lowest part of the tank. Fuel in the tank shall be drawn from a position distant from this lowest point.

The filling arrangement shall be designed for use with conventional road tankers.

A64.4. Requirements For Tanks For Mobile Applications

Tanks for units which are transportable shall comply with the requirements of SANS 1518.

A65. 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-round the instrument.

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

Calibration certificates shall be included in the Manual.

A66. FLOW METERS

A66.1. Electromagnetic Flow Meters

A66.1.1. Meters

Electromagnetic flow meter sensors shall be full-bore, in-line, double-flanged units with remotely mounted transmitters. The transmitters shall provide local flow indication and 4-20 mA output. Sensors shall, unless otherwise specified, have IP 68 protection and transmitters shall have IP 67 protection.

Electromagnetic flow meters shall have polyurethane lined stainless steel tubes with either Titanium or Hastelloy C electrodes. Accuracy shall be + 1 % of flow or better. Rubber linings are acceptable for treated water applications.

Calibration shall be in litres per second unless otherwise specified.

For applications other than for treated water, flow meters shall be provided with an electronically operated electrode cleaning device. Automatic, timed cleaning shall be provided.

A66.1.2. Installation

The equipment shall be correctly installed, connected, adjusted and calibrated by competent persons. Calibration shall be done in the presence of the Engineer. The operation and signal transmission of meters against electromagnetic interference shall be provided.

The meter shall be installed with a straight pipe length of at least 10 pipe diameters upstream of the sensor and a straight pipe length of at least 5 pipe diameters downstream of the meter. If this is not possible, specific measures shall be taken to provide flow straightening. The complete meter installation shall comply with the manufacturer's instructions.
Grounding rings shall be supplied and installed if the application requires these.

A66.1.3. Testing

A factory test calibration certificate shall be provided for each flow meter.

The flow meter shall be provided with a simulation test unit for field verification of the measuring system without removal of the sensor. If more than one identical model flow meter is installed, two simulation test units shall be provided.

A63.2. Visual Flow Meters and Indicators

A66.2.1. General

Visual flow meters or flow indicators shall be provided if specified in the Detailed Mechanical Specification. These are normally used for auxiliary circuits such as cooling and lubrication circuits and for flushing of mechanical seals.

A66.2.2. Design and Materials

The units shall be of the double window type with a graduated indicating flap. Flow indicators which utilize a moving spinner or ball will be acceptable in some applications.

The body shall be double flanged and shall incorporate easy dismantling to allow cleaning of the windows.

Bodies shall be of stainless steel.

A67. GAUGES

A67.1. Gauges – General

Gauges shall comply with the following:

(a) Gauges shall be of durable, industrial construction. Case and bezel shall be of stainless steel unless this material is unsuitable.
(b) 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 % - 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.
(c) 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.
(d) 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.
(e) 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.** Such markings shall always be on the inner scale face and not on the glass face.
(f) The units of measurement shall be clearly marked on the dial. A printed label of approved non-corrosive material indicating the duty of the gauge shall be neatly fixed on or near the gauge.

A67.2. Gauge Installation and Mounting

Gauges shall be installed and mounted in accordance with the following:

(a) Gauges shall be mounted vertically and in such a position that they can be easily read from floor level.
(b) Flanged nozzles for gauge tappings shall be provided on the parent pipework. Nozzles shall comply with the requirements of the Clause "Pipework".
(c) Gauges for permanent equipment installations, such as for centrifugal and reciprocating pumps, shall not be mounted directly on pipework but shall be mounted on a wall or on a pedestal stand so as to minimise vibration. Gauge cocks shall be provided at each end of the connecting pipework.
(d) Pressure gauges shall be fitted with an isolating and air bleed cock.
(e) Pressure gauges used on sewage, sludge, powder, chemical 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 and, when solids are handled, shall have a large threaded socket connection not smaller than 1" BSP.
(f) Gauges for liquids containing solids shall have the nozzle on the side of the parent pipe and the configuration shall allow easy cleaning of the passageways.

A67.3. Pressure Gauges

Pressure gauges shall comply with the following:

(a) Pressure, vacuum or compound gauges shall comply with SANS 1062. Gauges shall be of Accuracy class 1.6 and Durability grade A unless otherwise specified. The gauges shall bear the Standards South Africa mark.
(b) Gauges shall have a scale diameter of not less than 100 mm.
(c) Calibration shall be in kiloPascals with the full scale reading between 1,5 and 2 times maximum actual operating pressure except where otherwise specified. The full scale reading for a gauge on the discharge leg of a centrifugal pump shall be higher than the pump shut-off head.
(d) All gauges shall be suitable for continuous operation and shall be liquid filled on all pump applications and where fluctuations in pressure may cause damage.
(e) Gauges shall not be mounted directly on equipment subject to vibration. Gauges in pump stations shall not be mounted directly on the pipework and shall be connected to the pressure tapping point by small diameter stainless steel pipework.
(f) For dry locations indoors, the casing may be reinforced plastic or epoxy coated aluminium and the elastic element and shank of stainless steel. For damp indoor locations, particularly in any location where sewage is flowing, and for all locations outdoors, the gauges shall be weatherproof and have the cases and other metal components of grade 316 stainless steel.
(g) When used on steam lines a siphon shall be fitted between the steam line and the gauge which shall be filled with water before putting the gauge into service

A67.4. Temperature Gauges

Temperature gauges shall comply with the following:

(a) Temperature gauges shall have dials not less than 120 mm diameter. Accuracy shall be + 1 % of reading or better.
(b) The gauges shall be fitted vertically into removable 316 stainless steel wells and the gauges shall be removable without leakage from the pipe or vessel. Protrusion into a pipeline shall be kept to a minimum. When handling sludge, sewage or other abrasive liquids the protrusion shall not exceed 15 mm and in this case the wells shall also be of a heavy duty abrasion resistant type.

A68. THERMOMETERS

Thermometers shall be of the liquid column type and the complete tube shall be protected by a sturdy pocket of stainless steel or brass.

A69. VENTILATION SYSTEMS

A69.1. Design

Performance requirements to be achieved by the Contractor's design are specified in the detailed Particular Specification.

Resistance to flow for all ductwork, pipework and associated equipment shall be calculated by the Contractor prior to equipment selection. At least 250 Pa shall be allowed for resistance losses in filters unless the Contractor can confirm a lower figure. Reasonable modification to ductwork and pipework during installation shall be provided for in the design; i.e. a suitable safety factor shall be incorporated in the design.

A69.2. Fans

Direct-drive, axial-flow fans shall incorporate manually adjustable pitch, cast aluminium, aerofoil section blades, clamped in split, metallic hubs. Terminal boxes shall be mounted on the fan unit. Fan casings shall cover the overall length of the fan and motor assembly or shall feature a plate mount which incorporates a bell mouth inlet. Suspended fans shall be restrained to prevent excessive torsional and axial movement during start-up.

Axial flow fans installed in corrosive flows shall be either belt-driven or shall have their motors protected by bifurcated airstreams.

Centrifugal fans shall be constructed of galvanized sheet steel with spun steel inlet cones and machined shafting supported on rolling bearings mounted in sealed bearing housings provided with grease nipples. The open type bearing units with exposed "lubricated for life" bearings will not be acceptable. Fans shall be mounted on steel channel base frames sized to accommodate drive motors.

Fan motors shall be protected to IP 55 or higher. Fans and motors shall preferably have a nominal speed of 1 500 rpm or lower and motors shall have a nominal voltage of 400 Volts.

Fans shall be dynamically balanced to ISO 1940, grade G6,3. Fans shall be flexibly connected to ducting.

Fan/motor housings shall, as a minimum, be provided with rubber mountings. Where flexible mounting is specified, fans shall be flexibly supported off the structure using spring or rubber-in-shear mountings having a minimum static deflection of 20 mm. Suction and discharge areas shall be effectively guarded with hot-dip galvanized (or better) wire screens of 12 mm maximum mesh and 1,6 mm minimum gauge. Belt drives shall be accurately aligned axially and angularly and shall be to the Engineer's approval. Guarding shall totally enclose drives, shall be rigidly mounted off base plates and shall be to the Engineer's approval.

Drive motors shall comply generally with the clause "Electric Motors".

A69.3. Ducting and Sheet Metalwork

All ducting for air conditioning and ventilation purposes shall be manufactured in accordance with SANS 1238.

Volume control dampers shall be installed where required or where called for in the Detailed Mechanical Specification and shall be of the opposed blade type.

Unless otherwise specified, materials used in the fabrication of air conditioning and ventilation ductwork shall be of hot-dip galvanized, low carbon steel and sheet steel material thicknesses shall be in accordance with SANS 1238.

Flexible connections between ducting and moving equipment shall be by means of approved coated fabric collars with sewn and cemented seams. Flexible collars shall have sufficient free movement to take up the deflection of the connected moving equipment and shall not be used as a means of accommodating misalignment. When installed, collars shall not restrict the free area the ducting and particular care shall be taken to avoid mounting flexible collars at fan intakes and discharges.

Take off sockets shall be provided where grilles or louvres are mounted in distribution ducting. Sockets shall be long enough to ensure that no part of the grille or its associated control mechanism projects into the duct cross-section. All such duct-mounted grilles shall be provided with opposed-blade, volume control dampers or flap-type volume controls with straightening blades.

Rectangular ducting shall be supported on trapeze type hangers constructed from hot-dip galvanized, low carbon steel angle with ∅10 stainless steel hanger rods. Rod diameter shall be not less than 10 mm and support spacing shall be less than 2 000 mm.

Circular ducting shall be supported in hoops constructed from 40 mm X 5 mm hot-dip galvanized low carbon steel flat bar suspended from ∅10 mm stainless steel rod at 3 000 mm maximum centres.

Where ductwork penetrates brickwork, a wrot timber frame shall be built in to locate and mount the ductwork or air terminal as the case may be.

Where ductwork penetrates concrete slabs or walls, flanges shall be provided on one side to stabilize the duct and weak grout or fire stopping shall be applied to the spaces between the ducting and the structure to effectively seal the clearance. Where ducting penetrates between areas having differing fire risk or mandatory fire separation, fire dampers to the latest amendment of SANS 193 shall be installed to the Engineer’s approval.

A69.4. Filters

Filter cells shall be mounted in proprietary frames and clip-fixed to achieve zero discernible by-pass. Slide frame mounted filters shall have wing nut fixed airtight cover plates.

Filter banks shall have a differential manometer connected across them. Manometers shall be correctly set up and levelled and shall be provided with red gauge oil of the correct specific gravity.

The filter frame shall be fabricated from hot-dip galvanised steel (minimum thickness of 0,5 mm) unless otherwise specified in the Detailed Mechanical Specification.

Flow speed through the filter opening shall be not greater than 2 m/s.

D69.5. Sound Attenuators

Circular attenuators shall be directly connected to axial flow fan flanges. Where diameters differ by more than 20 mm, hot-dip galvanized low carbon steel connecting cones shall be bolted between the fan and the attenuator to adapt the respective diameters. Attenuators containing an acoustic pod shall have leading and trailing fairings in moulded grp or spun hot-dip galvanized steel. Pods shall be securely and concentrically fitted in the casings to the Engineer's approval.

Splitter attenuators shall be fabricated of galvanized sheet steel with mating flanges. Splitters shall comprise acoustic lining material mounted on galvanized sheet steel and shall be securely supported within the attenuator casing. Leading and trailing ends of splitters shall have fairings in moulded grp or hot-dip galvanized steel sheet.

Attenuators shall be constructed to achieve the overall acoustic performance specified. Acoustic infill material shall be "Eurolon" by Donkin or equivalent. Where air passageway velocities exceed 20 m/s, the infill material shall be supported by pre-galvanised perforated sheet steel having a thickness of at least 0,8 mm.

Where attenuators are to be used in grease or oil-laden atmospheres or where called for in the Detailed Particular Specification, a polyester membrane shall be interposed between the infill material and the perforated sheet.

Attenuators shall not impose a resistance of more than 50 Pa at rated air-flow.
External surfaces of the attenuators shall be painted as for the general ductwork.

A69.6. Equipment Bases for Equipment in Acoustically Sensitive Areas

The detailed Particular Specification specifies whether the ventilation equipment system design must comply with the requirements of this Clause.

Inertia bases for centrifugal fans, chillers, refrigerant compressors, air cooled condensers, air compressors, pumpsets, motors and the like shall consist of reinforced concrete cast into sheet metal formers and shall be at least 150 mm deep.

Bases shall be reinforced with, at least, ∅13 mm reinforcing bars located at 150 mm centres each way.

The mass ratio between bases and equipment shall be at least 1:1 for fans and 1,5:1 for pumps. Concrete bases for pumpsets shall be large enough to support pipes and fittings between the pumps and flexible connections and shall also be generally large enough to accommodate the motors and driven equipment. Equipment shall be bolted onto concrete inertia bases.

Structural steel bases shall be provided for cooling towers and evaporative condensers.

Spring isolators shall be installed between concrete inertia bases and floor plinths and between cooling towers or evaporative condensers and floor plinths. Either free standing stable spring units or caged spring units with snubbers may be used. Spring isolators shall be installed with levelling bolts and shall incorporate 6 mm thick ribbed neoprene acoustic pads bonded to the base. Spring diameters shall be large enough to prevent excessive rocking of equipment during start-up as well as normal operation.

Isolators shall be chosen to give a static deflection corresponding to a ratio of 3:1 of the lowest disturbing frequency to the natural frequency of the mounting.

Bases and spring isolators shall be arranged to give a clearance of approximately 25 mm between the underside of the bases and floor plinths.
Floor plinths shall be provided for all equipment bases. Plinths shall be large enough to accommodate the concrete inertia bases and spring isolators. Floor plinths shall also be provided under items of equipment, such as cooling towers, air plena etc., which do not require concrete inertia bases. Plinths under air plena shall be at least 100 mm higher than finished floor level.

A69.7. Equipment Noise Control

Refer to clause “Noise Control”.

A69.8. Machine Vibration

Refer clause “Machine Vibration Levels”.

A70. CHLORINATION SYSTEMS

The design of plant installations for chlorination shall suit the application concerned but shall comply, as a minimum, with SANS 10298.

A71. CONTROL SYSTEMS

A71.1. General

Control systems shall comply with the following:

(a) Control shall function as an integrated, coherent system.
(b) Protection systems shall be designed to prevent damage to equipment. Failing to start, tripping or stopping of any item of equipment shall prevent the start-up or shall initiate the appropriate shut-down procedure of related equipment in cases where damage could occur.
(c) Emergency stop stations shall be provided near to each motor driven unit.
(d) Digital indicators shall provide no fewer than three significant places (and, preferably, no more than three).

A71.2. Design

The design of the control system, including drawings, functional specification, control panel layout, circuit diagrams and protection systems, shall be submitted to the Engineer for acceptance.

A71.3. Testing and Commissioning of Control Systems

Setpoints for equipment and process parameters which are required for the operation of control systems shall be obtained once the equipment is operational.

The Contractor shall submit a schedule of all control functions to be checked on Site during testing and commissioning. This shall be submitted for acceptance by the Engineer. The format shall be as follows, or similar:

COMMISSIONING – CONTROL SYSTEM TESTS				
Date	Test Function	Test Method	Result (e.g. SCADA message, etc	Proposed Corrective Action

A71.4. Technical Details

A71.4.1. Control Panels

Where the details of motor starter panels have not been specified in the electrical specifications, every 400 V starter panel shall include the following standard equipment:

(a) Circuit breaker (complete with auxiliary contacts for control circuits).
(b) Contactor.
(c) Overload relay with manual reset
(d) Ammeter (CT based, if above 40A).
(e) Starter alive indicating light (Red).
(f) Motor running indicating light (Green).
(g) Running hour meter.
(h) Selector switch.
(i) Stop push button.
(j) Start push button.

A71.4.2. PLC/SCADA Systems

Control systems utilising PLC/SCADA systems shall incorporate the following:

(a) The PLC/SCADA system shall be configured for equipment to be PLC controlled such that the installation will be able to operate following a failure of the SCADA system.

(b) Mimic screens provided for SCADA systems shall include the following (unless inapplicable):
- ⊕ Overview of scheme; including the process flow diagram and indicating all electronically monitored parameters which are not included in a sub-system.
- ⊕ Overview of each plant grouping.
- ⊕ Individual unit (Centrifuge, compressor, pumpset, etc.).
- ⊕ Equipment sequence selection.
- ⊕ Equipment start interlocks.
- ⊕ For each motor larger than 55 kW, motor status and, where applicable, motor protection relay diagnostic.
- ⊕ Electrical reticulation schematic.
- ⊕ Hardware diagnostic.
- ⊕ Alarms.
- ⊕ Set-points for alarm, trip and control loop functions (including password protected alteration facility).
- ⊕ Record of equipment and process parameters at instant of equipment trip and station trip (see also below).
- ⊕ Event log.
- ⊕ Trending of monitored system parameters (see also below).

- ⊕ Communication status of control system hardware.
- ⊕ SCADA security system current settings, including personnel names.
- ⊕ Ancillary equipment status; e.g. security, fire detection, UPS.
- ⊕ Printing.

(c) Trend screens shall be as follows:
- ⊕ Screens may include logical operational groupings.
- ⊕ Points of inflection of measured parameters shall be recorded.
- ⊕ Trend screens shall be provided for 3 hours, for 7 days and for 3 months (unless the nature of the parameter demands different scales).

(d) At least one colour printer (for graphs, mimics, etc.) and one line printer (for alarms) shall be provided in accordance with the detailed specifications.

(e) The control system shall provide an alarm on the SCADA screen if an instruction to an item of equipment to start or stop does not cause that item to start or stop.

- ⊕ Alarm conditions which lead to the control system executing an equipment trip shall be logged. Subsequent alarms which occur as a result of the tripping action shall be logged as subordinate alarms. The condition **which caused the trip** shall be described with respect to the:
  Item of equipment.
- ⊕ Trip setpoint reached.
- ⊕ Description of parameter; i.e. flow, temperature, etc.
- ⊕ Time of event.

(f) A time delay following an alarm condition leading to a control system trip shall be incorporated in order to prevent tripping actions caused by electrical disturbances or similar occurrences. The time delay chosen shall match the functional needs and shall be decided in conjunction with the Engineer.

(f) Three significant places shall be used for representation of values on SCADA systems.

A72. CONTRACTOR'S DRAWINGS

The Contractor's drawings shall comply with the following:

(a) Drawings shall be provided in electronic data of AutoCAD format or compactable version indicating the true reflection of as built design.
(b) Drawings shall be prepared in accordance with the latest issue of SANS 10111. The equivalent BS code of engineering drawing practice will also be acceptable.
(c) Drawings shall be to A1 or A0 size.
(d) Drawings shall be to scale, with both the scale and the drawing being large enough to clearly show all relevant components of the plant and equipment.
(e) In addition to the usual plan and two side elevations, sufficient additional sections shall be included to clearly show the arrangement of all plant and equipment.
(f) Item lists shall be provided on the drawing or on a separate parts list.
(g) Item descriptions shall include the material of construction, quantity and full identification information, including, as applicable, brand name, manufacturer's reference number, model number, size, rating, source, duty, quantity, etc.

A73. CONTRACTOR'S RESPONSIBILITY WITH REGARD TO CIVIL WORKS

Buildings and concrete structures will form part of a separate civil contract which will include all plinths, foundation blocks, rebates, pockets, holes, thrust blocks and so forth to accommodate the installation of the plant as must be detailed on the drawings and other information to be submitted by the Contractor in terms of the Contract.

While the building and civil work will be done by others under a separate contract, the Contractor shall, prior to taking possession of the Site and before delivering any equipment to site, inspect and check the related building and civil works for accuracy and suitability of construction and for conformance with the Contractor's drawings. No payments shall be allowed for additional costs to the Contractor resulting from a failure to check such works timeously.

Ensuring that holes through walls and floors have been done correctly will be the responsibility of the Civil Contractor however the supply and installation of all foundation bolts and grouting of bases, supports or any other mechanical equipment shall be the responsibility of the Mechanical Contractor.

A74. TRAINING

A74.1. General

During the Trial Operation Period, the eThekwini Municipality's site staff will assist the Contractor in operating the plant and the Contractor shall train these staff in the starting, operating and stopping of the plant and shall train the eThekwini Municipality's maintenance staff on the maintenance requirements and procedures. Unless otherwise called for in the detailed Particular Specification, the Tenderer shall price for the on-Site personal tuition of 10 operational staff members and 5 engineering staff members depending on the nature of the project.

The Contractor shall also provide the trainees with printed copies of the Operating and Training Manual which forms part of the Operation and Maintenance Manual.

A74.2. Operational Staff Tuition

The Contractor shall provide the following tuition as applicable to the Contract:

(a) Start-up, shut-down and operating instruction for all operational modes for the Works shall be provided. This shall be comprehensive and shall include actions to be taken in the case of all alarm conditions and basic fault finding.
(b) A layout drawing of the installation, a process flow diagram, and a P&ID shall be provided for each Operator. The instructions described in (a) above shall also be provided in printed form for each Operator.
(c) If the specified control system is SCADA based, the tuition shall include instruction on the SCADA system.

A74.3. Electrical Engineering Staff Tuition

The Contractor shall provide the following tuition as applicable to the Contract:

(a) Control system software instruction.
(b) Detailed overview of 11 kV protection and settings.
(c) Tuition on setting of 11 kV protection.
(d) Motor protection relay and settings.

(e) Overview of PLC programming for the purposes of making changes and re-loading programs if PLCs are replaced.
(f) Overview of SCADA system.

A75. SPARES

Spares which are specified in the Detailed Mechanical Specification 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 approved the spares and the packaging.

A76. OPERATING INSTRUCTIONS AND SIGNAGE

Operating instructions and signage, if specified in the Detailed Mechanical Specification, shall comply with the requirements below.

A76.1. Operating Instructions

Wall mounted operating instructions shall comply with the following:

(a) Start-up, Shut-down and Operating instructions shall be provided. These 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, a process flow diagram, and a P&ID shall be provided.
(c) Instructions shall be laminated with hardboard backing. All instructions shall be included in Safe Operating Procedure format and form part of the O&M Manuals.

A76.2. Signage

Signs, photo-luminescent, 3mm white Perspex UV resistant, shall be provided by the Contractor in appropriate places on the walls of the plant room and 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.

Symbolic signs shall comply with SANS 1186.

The wording of the signs shall be approved by the Engineer prior to final printing. All signs shall cross refer, where applicable, to the relevant portion of the Manual.

All signs shall be installed prior to commissioning.

All signs 200mm x 200mm or larger in a wash down area shall be mounted on the wall using chemical mortar and secured with stainless steel ready bar and stainless steel nuts.

Non-wash down areas and signs smaller than 200mm x 200mm shall be secured using PVC fisher plugs with stainless steel coach screws.

For correct selection of mounting fasteners, preventing Bimetallic Reaction/Galvanic Corrosion, refer to: Design and Contracts – Quality Control Procedure 15: Bimetallic Corrosion Prevention.

A77. OPERATION AND MAINTENANCE MANUALS

A77.1. Submission of Manual

Three draft copies of the Manual shall be submitted to the Engineer prior to commissioning the Works. One copy will be returned to the Contractor with comments. The second copy will be used by the operational staff on Site.

Six copies of the final version of the Manual, as accepted by the Engineer, shall be provided prior to the start of the Defects Notification Period.

A77.2. General Requirements

The Manual shall comply with the following:

(a) The Manual shall be for the complete Works and shall be of a standard acceptable to the Engineer. It shall be in English and shall be practically and neatly presented.
(b) One Manual shall contain original documents and this set shall be marked "Original". The other 5 Manuals shall contain all the information in the original and shall be marked "Copy 2" to "Copy 6".
(c) Binders shall have hard, plastic protected covers utilising four-ring, spring-clip holders. Binders shall not be overloaded. One spare, empty binder shall be provided for every three used. A title label shall be affixed to the spine of all binders. This shall indicate Contract number, title, Contractor's name, Site/Plant name, volume number and contents.
(d) Sections and sub-sections shall be titled, uniquely numbered and provided with separator sheets.
(e) Printed matter which is inserted in the Manual shall be arrowed (indelibly) to indicate the equipment installed.
(f) Drawings shall be to a scale which makes details clear. Large drawings shall be held in plastic envelopes in the Manual. A4 and A3 drawings may be bound as normal pages. Drawings shall also be provided on electronic data storage in AutoCAD, or equivalent, format.
(g) Location map, street address as well as GPS co-ordinates to be provided.
(h) **Cross-referencing within the Manual is acceptable where duplication occurs.**

A77.3. Format and Contents

The Manual shall be in accordance with the following (the Contractor shall modify, elaborate and repeat this format as required):

Electronic Format

All information in the hard copy O&M manuals to be provided in soft copy on a USB flash discs (x6) with separate folders for each section including all material related to the particular section.

Each section shall be saved as a separate PDF file, with a hyperlinked index sheet for subsections. This shall include drawings and maintenance schedules as separate files. In addition, the "Summary equipment and maintenance template" shall be saved in Excel format under Section 1. Contractor to ensure the latest Excel template is requested, used and completed.

All necessary software programs and passwords to be provided.

No.	HEADING	CONTENT
1.	**GENERAL**	
1.1	Contents List	Contents List for complete Manual
1.2	Description of the Works	The description of the Works shall include a description of; firstly, the process; secondly, the design parameters and; thirdly, a detailed description of the equipment installation supported by drawings and process flow diagrams.
1.3	Equipment List	Equipment list containing each item of mechanical, electrical, instrumentation and control equipment. The equipment list shall include the make, model, serial number, description, size, range, performance data, motor and drive details, supplier's name, address and phone numbers, all as applicable. The design duty, the position of each unit's installation and its purpose in the system shall be given. Additional information which shall be provided for instruments includes the normal operating reading, maximum or minimum permissible readings, set-points (activation, warning and trip), etc. A separate list of all spares provided in terms of this Contract shall also be provided.
1.4	Drawing List	Drawing list of all the Contractor's drawings and the Tender drawings.
1.5	Cable Schedule	Cable schedule for power, data, control and instrumentation cables. This shall include the cable construction, conductor material, insulation, protection, voltage rating, start and finish points, route length, duty, load, voltage drop, core area, no. of cores, no. of cores used and gland size. For cable voltages above 400 Volts, the schedule shall also include the purchase details, specification and date of manufacture.
1.6	Documents	Documents As-built system, layout and GA drawings. Plant circuit, flow diagrams and/or P&IDs. Control panel layouts. I/O list, program listing, loop and logic diagrams for each PLC. Colour prints of SCADA mimic screens, control faceplates and sequences. System control diagram and logic sequence chart. Copy of certificate of electrical compliance.

2	**OPERATION**	
2.1	Control System	Description of control system; including all manual and automatic controls. This shall include controls, instruments, protection list, settings, indications, alarms, trips, etc.
2.2	Commissioning	Commissioning Instructions. Commissioning report.
2.3	Operating and Training Manual	Operating and training manual. This shall include normal start-up, adjustment, operating and shut-down procedures and any emergency operating procedures. All specific safety aspects as well as settings, adjustments, observation, etc. shall be provided.
3	**MAINTENANCE SCHEDULES**	
	Maintenance and Lubrication	Schedule of routine maintenance, by time period, for all mechanical, electrical, instrumentation and control equipment. This shall be all-inclusive but reference to manufacturer's standard manuals in other parts of the Manual is acceptable. The schedule shall incorporate a lubrication schedule of recommended lubricants, capacity, lubrication periods, etc.
4	**MECHANICAL EQUIPMENT** *(This section shall be repeated for each item of equipment)*	
4.1	Identifying Information	Identifying information for the item; copied from the Equipment List.
4.2	Nameplate	A photograph of the nameplate and a table containing the unit's nameplate information
4.3	Design and Operation	Details of operating principles, construction and operating instructions.
4.4	Maintenance Information	Technical and maintenance information including instructions for installation, assembly, disassembly, lubrication, adjustment, calibration, reconditioning, repair, etc.
4.5	Spares	A spares list giving the item number, part number, description, quantity and materials. A list of spares recommended to be held on Site.
4.6	Test Results	Factory and Site test results
4.7	Corrosion Protection	Corrosion protection systems used, coating supplier's data sheets and coating repair procedures.
4.8	Documents	Performance curves. Large scale, dimensioned, cross sectional and arrangement drawings of the item for assembly and spares recognition purposes, cross-referenced to the spares list. Dimensioned drawings of fabricated equipment. Circuit layout of any auxiliary systems
5	**ELECTRICAL EQUIPMENT** *(This section shall be repeated for each item of equipment)*	

5.1 to 5.6	As for 4.1 to 4.6 for Mechanical Equipment (see above).	
5.7	Control Details	Control and electrical diagrams, including logic sequence, circuit diagrams and software, as applicable.
5.8	Documents	Electrical reticulation drawings. Equipment overall dimensions. Wiring diagrams. Switchboard layout drawings and SLDs. Electrical panel construction drawings.
6	**INSTRUMENT EQUIP** *(This section shall be repeated for each item of equipment)*	
6.1to 6.6	As for 4.1 to 4.6 for Mechanical Equipment (see above)	
6.7	Documents	Circuit diagrams of instrumentation systems and of individual instruments. Installation arrangement
7	**CONTROL EQUIP.; ETC.**	
7.1	Identifying Information	Identifying information for PLCs, transmitters, HMIs, computers, etc.; copied from the Equipment List.
7.2	I/O List	Cross-referenced listing of all I/O used
7.3	SCADA	Colour prints of SCADA mimic screens, control faceplates, sequences and trend screens. Schedule of alarm messages and TAG lists. File structures. Lists and naming conventions.
7.4	Program	Flash disk containing all software. An annotated program listing
7.5	Documents	Schedule of cable terminals. Copy of SCADA hardware diagnostic mimic.
8	**DRAWINGS**	
	Drawings	All drawings not filed elsewhere shall be filed in this section.

A78. STARTING, SITE TESTING AND COMMISSIONING OF PLANT

A78.1. General

The Contractor shall advise the Engineer when instructions may be given to the Building Contractor to execute any necessary screeding and finishings around the Works. Tenderers shall allow a reasonable period in their installation programme for this work to be done and no compensation for delay in the commencement of testing and commissioning shall accrue to the Contractor during such period.

A78.2. Preparation

Installation work shall be complete and accepted by the Engineer prior to commissioning.

Before starting up any section of the Works, the Contractor shall make all necessary checks to ensure that the installation has been correctly carried out, that all ducts, pipework, tanks, etc., are clean, that all equipment is correctly aligned, lubricated and connected up, and is in all respects ready to start with safety. The Contractor shall provide initial fill requirements, such as lubricating oil.

A78.3. Starting-Up and Testing

The Contractor shall arrange for the Engineer to be present at initial start-up and also for any electrical and control instrumentation sub-contractors to be present.

The Contractor shall start up and test each section of the Works. These tests shall be carried out to certify that the Works is operating in accordance with the requirements specified and must be witnessed by the Engineer. All necessary modifications and rectifications shall be carried out during this period.

Set points for equipment and process parameters which are required for the operation of control systems shall be confirmed and recorded.

A79. SCADA SYSTEM

During commissioning of a new installation which incorporates SCADA as part of the control system, each control system alarm and interlock shall be tested and the resulting alarm messages shall be modified by the Contractor to be acceptable to the Engineer.

A schedule of alarm messages and their full explanations shall be inserted in the Manual.

A79.1. Commissioning

When all tests have been completed to the satisfaction of the Engineer, the Works shall be commissioned. Unless the Engineer states otherwise, the complete plant, including all control functions and control systems shall be commissioned as a unit and the process performance requirements shall be achieved during normal operation.

Once the Works has been commissioned to the satisfaction of the Engineer, the operational acceptance period shall start and shall consist of a continuous period of operation free from trouble. Unless otherwise stated, this period shall be four weeks. During the operational acceptance period, the Contractor shall carry out all necessary servicing and any adjustments required. The plant staff will assist the Contractor in operating the Works during this period. The Contractor shall train the operational staff in the starting, operating and stopping of the Works, and shall train the maintenance staff on the routine maintenance requirements.

A79.2. Commissioning Report

A comprehensive commissioning test report, including the SCADA system commissioning procedure and schedule of alarm messages, shall be submitted by the Contractor prior to issue of the Certificate of Completion and shall be inserted in the Manual.

The contractor shall provide the following performance reports: for commissioning and tests as said above, a report after month of commissioning, report after three, six and 12 months of commissioning.

A79.3. Inspection

At the end of the Trial Operation Period, an inspection shall be done by the Contractor and the

Engineer for the purpose of taking over the Works in terms of Clause 10 of the General Conditions of Contract.

A79.4. Defects Notification Period

Refer to Clause 11 of the General Conditions of Contract and the Detailed Mechanical Specification for requirements regarding maintenance during the 365 day Defects Notification Period.

Reactive and proactive maintenance performed shall be captured by the Contractor and confirmed by the Senior Engineer. This communication shall be done in the following format:

Date:
Plant name:
Location and GPS:
Equipment reference / what failed:
What is the damage:
Causes of the damage:
Repair time:

A80. STANDARD DRAWINGS

Standard drawings are available on request.

A81. QUALITY CONTROL PROCEDURES

QCP's available on request:

* All completed QCP's to be included in the final copies of the O&M manuals.

* Ensure that the latest available version is used.

A82. FACTORY TESTS ON PUMPS

A hydrostatic test shall be performed for pressure-containing parts of a pump at a test pressure of at least 1.5 times the basic design pressure. This pressure shall be maintained for a period of at least 10 minutes.

Three (EWS representatives: Lead Mechanical , Electrical and Area M&E Engineer) shall be entitled to witness the pressure tests (as required and indicated on the data sheets provided with this tender) and at least two (2) weeks' notice shall be provided before such testing takes place. A test certificate shall be issued after the successful completion of such tests, in an approved format.

Each pump shall be subject to a hydraulic performance and NPSH test in accordance with ISO 9906, Class I or II, at an approved test facility. The Purchaser or his representative shall reserve the right to witness all tests (as required and indicated on the data sheets provided with this tender) and shall be granted full and complete access to all test data taken during the course of the test. They shall furthermore, be provided with copies of all test sheets, calibration certificates etc. upon completion of the tests. At least two (2) weeks' notice shall be provided before such tests are undertaken.

Where pumps are supplied as complete pumpsets, these shall preferably be tested as such and shall be complete with own job motors.

It should be particularly noted that all test data and performance curves produced shall be presented in the units as described in the variation above.

In addition to the test point required to establish the guaranteed performance, a sufficient number of test points shall be measured so as to establish the shape of the full performance curve as presented in the Tender.

During the execution of the performance test, the mechanical operation of the pump shall be monitored with particular reference to abnormal temperature, noise, vibration and leaks.

Failure to achieve the rated (guarantee) point may render the equipment liable for rejection. Should this occur the manufacturer/supplier shall then be responsible to rectify the equipment to achieve such guarantees at own expense.