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TECHNICAL STANDARD SPECIFICATION MECHANICAL

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**OMAN WASTEWATER
SERVICES COMPANY S.A.O.C**



**الشركة العمانية
لخدمات الصرف الصحي ش.م.ع.م**

OMAN WASTEWATER SERVICES CO. S.A.O.C.

TECHNICAL STANDARD SPECIFICATION

GENERAL MECHANICAL REQUIREMENTS

SECTION 01

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1. General

1.01 Scope

This Part specifies the General Mechanical Equipment Requirements, which apply to all mechanical systems and equipment and is a part of each and all of the separate Sections of the Specification. The Contractor shall direct the attention of all manufacturers and suppliers of mechanical equipment and related appurtenances for the works to the provisions of the Contract Documents and this Section of the Oman Waste Water Services Company's Standard Specifications.

1.02 References

Due to the introduction of new European Standards, both British and European Standards may be in force at the time. In the case of conflict the European Standard shall apply.

All specifications referred to are the latest revisions, and include any subsequent amendments.

1.03 Manufacturer's Experience

Unless specifically named in the detailed specifications, a manufacturer shall have furnished equipment of the type and equal or larger size than specified, which has been installed, and demonstrated successful operation for at least 10 years and at least 5 installations in the Gulf countries, or in countries with similar weather conditions. User certificates will be required to be submitted.

1.04 Factory Inspection

The OWSC representative and a representative of the Engineer may inspect fabricated equipment at the factory and the cost of inspection shall be borne by the Contractor unless otherwise stipulated. Notify the Engineer in sufficient time so that factory inspection can be arranged. Factory inspection will be made after manufacturer has performed satisfactory checks, adjustments, tests and operations. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the site, and does not constitute final acceptance by the Engineer

The Contractor shall submit all necessary documents / drawings for the FAT to the Engineer well in advance prior to FAT.

1.05 Factory Tests and Test Certificates

- a. Factory tests shall be carried out as specified in the Project Specification, and as required by international standards and industry norms.
- b. The Contractor shall ensure that the manufacturer provides all labor, materials, electricity, fuel, stores, apparatus and all instruments as are requisite and as may reasonably be required to carry out the test efficiently. OWSC or his representative may witness the tests. Where specified, the Contractor shall include in the Contract Price for all the costs of OWSC or his representative.
- c. The Contractor shall submit from the equipment manufacturer, or his authorized representative, a certified written test certificate in accordance with the requirements of the relevant test procedure.
- d. If after examining or testing any equipment the OWSC, or his representative, shall decide that such equipment or any part thereof is defective or, not in accordance with the specification, he may reject the said equipment or part thereof. He shall notify the Contractor in writing within 7 calendar days of the rejection, stating the grounds on which the rejection is based.
- e. Wherever possible Site conditions shall be simulated or the tests shall be extended to allow for Site conditions.

1.06 Inspection and Testing - General

Tests shall be carried out by the Contractor on all equipment in accordance with the appropriate BS unless otherwise specified. All tests will be witnessed by OWSC and a representative of the Engineer.

The Contractor shall submit a detailed equipment plan indicating manufacturing process, FAT, Delivery and any other related activities necessary to complete such equipment.

The fulfillment of the guarantees given in the Schedule of Particulars and Guarantees shall be verified at the Works Test and at Site Tests in accordance with the procedure given in the latest editions of BS 5316 and BS 5000: Part 99 etc.

The Site Tests shall be carried out under the control of the Contractor's staff and the supervision of the Engineer and a representative of OWSC. The Contractor shall provide all of the necessary labor and instrumentation to conduct the test. Electric power will be provided by the OWSC if available otherwise the Contractor shall provide a temporary supply by mobile generator.

The discharge from the pumps during the site testing will be measured by the flow meter in addition to the draw-down method from the sump over timed intervals during a test run of several hours duration.

All equipment subject to water pressure shall be hydraulically tested to at least 1.5 times the maximum working pressure, 1.5 times the closed valve pressure or 1.5 times the surge pressure whichever is the greater in accordance with the latest Hydraulic Institute Standards.

The Contractor shall be responsible for the submission to the Engineer of all plant in his supply for site inspection and testing as required by the Engineer. During the course of erection, the Engineer shall have full access for inspecting the progress of the work and checking its accuracy or witnessing such checks as may be required by him.

All welding procedures, testing of welders and hydraulic pressure testing will be supervised and approved by the Engineer.

At least 24 hours notice will be given to the Engineer of the times at which such inspection and testing is to be carried out.

On completion of erection, all pressure parts shall be subject to a suitable hydraulic test and running tests on all plant shall be carried out by the Contractor and witnessed by the Engineer to demonstrate adequately that the equipment as erected on Site is entirely suitable for commercial operation.

Four months prior to pre-commissioning tests being commenced the Contractor shall supply test sheets for the Engineer's approval. These sheets shall provide for the following information to be set out in tabular form:

- Ø Name and number of item of plant or equipment.
- Ø Actual test or checks to be carried out.
- Ø Space for test results or data obtained during checks.
- Ø Date of test and names of persons conducting and witnessing tests.
- Ø Space for remarks.

Two copies of all test results and calculations shall be provided by the Contractor to the Engineer for his approval. The results shall be bound into the operating and maintenance instructions to form a permanent record of plant operation at the time of site testing.

1.07 Quality Standards

Items of equipment may be specified by the name of a manufacturer for the purpose of establishing a standard of quality and acceptable experience. Substitute equipment will be acceptable if it can be demonstrated to the Engineer that the substitute is in strict accordance with the Specifications and equal or better in quality to those models specifically named.

Manufacturers specified have been determined by the Engineer to meet or exceed the minimum acceptable standard for the designated equipment style and model.

All mechanical equipment furnished under this Specification shall be new and of current design and fit for the purpose.

1.08 Adaptation of Equipment

- a. No responsibility for alteration of a planned structure to accommodate substitute equipment will be assumed by OWSC. Equipment which requires alterations of the structures will be considered only if the Contractor assumes all responsibility for making and coordinating all necessary alterations. All revisions to structures, mechanical, electrical, or other work made necessary by such substitution shall require the Engineer's approval. All costs of said revisions, including cost of redesign, shall be borne by the Contractor.
- b. Equipment. Where equipment to be furnished is installed in an existing enclosure or adjacent to existing equipment, field check for the dimensions of existing equipment, location of conduits, etc., and ascertain all existing conditions and difficulties likely to be encountered in performing such work.

1.09 Guarantee and Warrantees

- a. Guarantee all equipment in accordance with the Conditions of the Contract. In addition to the general guarantee requirements, equipment guarantee shall cover (1) faulty or inadequate design; (2) improper assembly or

erection; (3) defective workmanship or materials; and (4) leakage, breakage, or other failure.

- b. Unless specified elsewhere, the nominal equipment guarantee period is two years from the date of the issue of the Substantial Completion Certificate of the whole works.
- c. The guarantee period for equipment shall commence upon the date of the Employer's written acceptance of the equipment as it is put into service for each stage of commissioning.
- d. The Contractor shall consider the staging requirements of the project when ordering equipment so that the manufacturer's warranties are not voided due to delay in equipment commissioning.

1.10 In-service Checks

During the guarantee period, an in-service check of each system required to be validation tested shall be performed twice by qualified technical representatives of the various system manufacturers, including manufacturers of equipment components within systems. Checks shall be detailed and complete, requiring not less than 8 hours at the site, and shall be performed under the observation and to the satisfaction of the Engineer or his designated representative. All costs for in-service checks shall be included in the Contract Price.

- a. Notification. Notify the Engineer in writing at least 10 days before the performance of each in-service check and obtain his approval of the proposed dates.
- b. Consultation. At the time of each in-service check, consult with the Engineer, review the O&M Manual and the pertinent operational and maintenance problems encountered, and furnish technical advice and recommendations to the Engineer.
- c. Schedule. Perform initial in-service checks approximately 6 months after final acceptance of the plant. The second in-service check shall be performed within 30 days of the end of the contractual guarantee period.
- d. Reports. Deliver a written report of each in-service check, signed by the appropriate manufacturer or his representative, to the Engineer within 10 days following the check. The report shall describe the checking procedure in detail, and shall state all advice and recommendations given to the Engineer.

1.11 Spare Parts

Where spare parts requirements are not listed in the individual Sections relating to the specifications for equipment, the contractor is to provide the manufacturers recommended spare parts for two years operation of the equipment which should be approved by the Engineer. The spare parts will be packaged and labeled for the specific items of equipment for which they are intended. Each individual part will also be appropriately labeled.

Spare parts will be supplied and delivered at the same time as the equipment to which they appertain.

1.12 Submittals

a. General:

- Ø The Contractor shall submit the following information as described in the below paragraphs.
- Ø The Contractor shall note that submittals will not be approved unless submitted in order. All submittals shall be clearly marked with the name of the manufacturers, sub-contractors and Contractor's contract number such that they can be clearly identified and are unique to the Contract.
- Ø Any work commenced or materials ordered before receipt of the Engineer's approval shall be entirely at the Contractor's risk. Modifications required to comply with approved submittals shall be at the Contractor's expense.

b. Submittals Schedule:

The Contractor shall submit a program for all the submittals, with dates, for the Engineer's approval. Adequate time shall be left in this program for approval

c. Design Data:

This shall include data and supporting calculations which is required for the following:

- Ø Justification for the overall design, sizing of process units, levels and layout

- Ø To show compliance with standards used. This may include quality manuals and procedures.
- Ø As required in the particular and general project specification

d. Material Data:

- § When required by the Engineer a critical path type program shall be submitted showing all the manufacturing activities with the critical path clearly identified.
- § Shipping and delivery schedules including the date of shipping, arrival at port and on site
- § Material and product data:
 1. Complete and detailed information of all materials and equipment to be incorporated in the Works shall be submitted. Detailed descriptions and specifications, catalogue cut outs, installation data, diagrams, dimensions, controls, and any other data required to demonstrate compliance with the Project Specification shall be submitted.
 2. Materials of construction, equipment or components shall be stated. At the request of the Engineer, a sample of these shall be submitted for further study before approval.
- § Material and products technical specifications data shall be submitted for each item of equipment.
- § Fabrication and assembly drawings. These shall be supplied for any fabrication or assembly of equipment which is to be carried out in the factory or on site. Sectional drawings shall be provided for all equipment, clearly showing the materials and individual components.
- § Test certificates. Manufacturer's test certificates, third party test certificates and quality control test certificates shall be submitted.

e. Installation Data:

- Shop Drawings:
These shall include the following:
 1. Working drawings: These shall include layout drawings, diagrams, illustrations and schedules specifically prepared by the Contractor for each part or area of the works. They shall include general

arrangements of the equipment and appurtenances in relation to the buildings and structures.

2. Co-ordination drawings: These shall be prepared by the Contractor to show how multiple system and interdisciplinary work will be coordinated. Drawings shall illustrate clearances for lifting equipment, maintenance, access requirements and loadings due to equipment heights.
 3. Installation Method Statements: Standard or specialized procedures for installation work recommended by the manufacturer's of materials or equipment shall be included in method statements for installation works and submitted. They shall include drawings of any templates required for the installation work. Any clearances or tolerances in erections should be included in that method statement
 4. Request for inspection (RFI): shall be submitted after finishing partially or completely a specific activity, for approved by the Engineer before starting the next dependant activity, inspection for installation will be done according to the manufacturer recommendations and the approved method statement.
 5. Progress Reports: the contractor shall be required to submit to the Engineer weekly and monthly progress reports on the first day of the week following and the first day of the month following respectively.
 6. Programming the progress of the works: A detailed computer based program using critical path method shall be submitted by the contractor. This shall include full details of resources and rates of progress.
- f. Instruction Manuals for Equipment Two copies of the draft manual shall be delivered not later than 30 days prior to operational demonstration and system validation tests. The balance of the copies shall be provided to the Engineer within two weeks of the commencement of the Maintenance Period and shall include all revisions necessary to correct for any changes made during installation or checkout.
- h. Manufacturers, Certified Reports. Submit a notarized written report from each equipment manufacturer, or his authorized representative, with respect to his equipment certifying that (1) the equipment has been properly installed and lubricated under his supervision, (2) the equipment is in

accurate alignment, (3) he was present when the equipment was placed in operation, (4) he has checked, inspected, and adjusted the equipment as necessary, (5) the equipment is free from any undue stress imposed by connecting piping or anchor bolts, (6) has been operated under full load conditions and operated satisfactorily, (7) he has inspected his equipment during the operational demonstrations and system validation tests to the extent specified, and (8) is fully covered under the terms of the guarantee.

i. Submittals for Operational Demonstration and System Validation Tests:

1. Operational Demonstration.

At least 60 days before the first operational demonstration is to be performed, submit a detailed and comprehensive procedure plan for performance of each operational demonstration required. Identical equipment items may be covered under one plan. Include an estimated date and duration for each procedure and the personnel required.

2. System Validation Tests.

At least 60 days before the first system validation test is to be performed, submit a detailed and comprehensive procedure plan for performance of each separate validation test and for each validation test that covers two or more systems. Each procedure plan shall describe and itemize the involved system including associated electrical equipment and instrumentation and control systems, and shall include evidence of an organized step-by-step procedure properly coordinating the efforts of the various trades and manufacturers' representatives involved and of the operations of the facilities. Procedures shall include an estimated duration and date for each procedure and the personnel required.

3. Procedure Plan Information.

In addition to the information specified above, each procedure plan shall include the following information, as applicable:

- Description of temporary procedure facilities, including drawings and sketches as required to fully illustrating the facilities.
- List of test materials and estimated quantities.
- List of instruments, measuring and recording devices, and other test equipment, whether a part of the plant or furnished separately for temporary use.
- Names of supervising and inspecting manufacturers.
- Complete listing of all functional parameters to be served and recorded.
- Recording intervals.

4. Records Materials.

Submit samples of the forms, charts, and other materials to be used in recording demonstration and validation test results.

5. Results.

Within 10 days after completion of each procedure plan submit 3 copies of all recordings and results of all operational demonstrations and system validation tests.

1.13 Material Delivery, Storage and Handling

- i. All plant and equipment as necessary shall be packed in first quality containers or packing; no second-hand timber shall be used. All packing must be suitable for several stages of handling via sea or air freight, inland transport and movement on site.
- ii. Flanged pipes are to have their open ends protected by adhesive tape or jointing and are then to be covered with a wooden blank flange secured by service bolts.
- iii. The sleeves and flanges of flexible couplings shall be bundled by wire ties. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500 kg gross.

- iv. Precautions are to be taken to protect shafts and journals where they rest on wooden or other supports likely to contain moisture. At such points wrappings impregnated with anti-rust composition or vapor phase inhibitors are to be used of sufficient strength to resist changing and indentation due to movement which is likely to occur in transit. The form of the protective wrappings and impregnation are to be suitable for a minimum period of twelve months.
- v. Lids and internal cross battens of all packing cases are to be fixed by screws and not nails.
- vi. Hoop metal bindings of cases are to be sealed where ends meet and if not of rustles material are to be painted.
- vii. Contents of cases are to be bolted securely or fastened in position with struts or cross battens and not with wood chocks, unless they are fastened firmly in place. All struts or cross battens are preferably to be supported by cleats fixed to the case above and below to form ledges on which the batten may rest. Cases are to be up-ended after packing to prove that there is no movement of contents.
- viii. Where parts are required to be bolted to the sides of the case, large washers are to be used to distribute the pressure and the timber is to be strengthened by means of a pad.
- ix. All stencil marks on the outside of the casings are to be either of a waterproof material or protected by Shellac or varnish to prevent obliteration in transit.
- x. Wood wool is to be avoided as far as possible.
- xi. Waterproof paper and felt linings are to overlap at seams at least 12mm and the seams secured together in an approved manner, but the enclosure is to be provided with screened openings to obtain ventilation.
 - a. Where applicable, indoor items such as electric motors, switch and control gear, instruments and panels, machine components, etc. are to be 'cocooned' or covered in polythene sheeting, sealed at the joints and the enclosures provided internally with an approved desiccators.
- xii. Bright metal parts are to be covered before shipment with an approved protective compound or coating and protected adequately during transport to site. After erection these parts are to be cleaned by the Contractor.

- xiii. Each crate or package is to contain a packing list in a waterproof envelope and copies in duplicate are to be forwarded to the Engineer; prior to dispatch. All items of material are to be clearly marked for ready identification against the packing list.
- xiv. All cases, packages, etc. are to be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and to indicate the correct positions for slings, and are to bear an indelible identification mark relating them to the appropriate shipping documents.
- xv. Structural steel work pipes valves encased fittings and metalwork shall be similarly marked. In addition one in every ten repeated articles shall bear the dispatch marks in suitable paint or other approved medium. When in the opinion of the Engineer the dispatch marks cannot be applied satisfactorily to any item they shall be stamped on a metal label attached to the item or part by means of a piece of wire passing through holes at either end of the label and secured so that it lies flat with the item.
- xvi. The Engineer may require inspecting and approving the packing before the items are dispatched but the Contractor is to be entirely responsible for ensuring that the packing is suitable for transit and such inspection will not relieve the Contractor for any loss or damage due to faulty packing.
- xvii. Lift large equipment items only at the points designated by manufacturer.
- xviii. Factory Painted Surfaces. Protect against impact-, abrasion, discoloration, and other damage. Repair damage as directed and approved.
- xix. Electrical Equipment. Maintain electrical equipment, controls, and insulation dry at all times. Keep heaters in equipment connected and operating until equipment is placed in operation.
- xx. Shaded or air conditioned storage where considered appropriate by the Engineer shall be provided.

1.14 Job Conditions

Drawings are diagrammatic and show the intended arrangement of principal apparatus, piping, and appurtenances. Conform to Drawings as closely as possible and exercise care to secure approved headroom and space conditions, neat arrangement of piping, valves, hangers, and like items, and to overcome structural interference's. Verify dimensions and conditions at the place of installation, and install materials and equipment in the available spaces. Submit written details and reasons for proposed deviations from Drawings and Specifications, and do not deviate there from

unless authorized by Field Order or Variation Order if approved changes require alteration of structures or related work, make such alterations as approved in advance by Engineer at no additional cost to OWSC.

1.15 Tropicalisation

Equipment is to be designed for Muscat coastal climate and the following shall apply:

- i. Tropical grade materials should be used wherever possible. Some relaxation of these provisions may be permitted where equipment is hermetically sealed.
- ii. Iron and steel are in general to be painted or galvanized as appropriate in accordance with the reference standard. Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the cores of electro-magnets and the metal parts of relays and mechanisms are to be treated in an approved manner to prevent rusting. Cores etc. which are built up of laminations or cannot for any other reasons be anti-rust treated, are to have all exposed parts thoroughly cleaned and heavily enameled, lacquered or compounded.
- iii. The use of iron and steel is to be avoided in instruments and electrical relays whenever possible. Steel screws, when used, are to be zinc, cadmium or chromium plated or, when plating is not possible owing to tolerance limitations, shall be corrosion resisting steel. Instrument screws (except those forming part of a magnetic circuit) are to be of brass or bronze. Springs are to be of brass, bronze or other non-rusting material. Pivots and other parts for which non-ferrous material is unsuitable are to be of an approved stainless steel.
- iv. Fabrics, cork, paper and similar materials, which are not subsequently to be treated by impregnation, are to be adequately treated with an approved fungicide. Sleeves and fabrics treated with linseed oil or linseed oil varnishes are not to be used.
- v. The use of wood in equipment is to be avoided as far as possible. When used, woodwork is to be thoroughly seasoned teak or other approved wood which is resistant to fungal decay and is to be free from shakes and warp, sap and wane, knots, faults, and other blemishes. All woodwork is to be suitably treated to protect it against the ingress of moisture and from the growth of fungus and termite attack. All joints in woodwork are to be dove-tailed or tongued and pinned as far as possible. Metal fittings where used are to be non-ferrous material.

- vi. Adhesives are to be specially selected to ensure the use of types which are impervious to moisture, resistance to mould growth, and not subject to the ravages of insects. Synthetic resin cement only is to be used for jointing wood. Casein cement is not to be used.
- vii. The use of hygroscopic insulating materials shall not be permitted except where immersed in oil or suitably sealed to prevent ingress of moisture.

1.16 Climate

- a. All materials used shall in all respects be suitable for the climatic conditions of the Sultanate of Oman as indicated below. The following maximum conditions shall be used for all design.

	Coastal	Inland
Maximum peak ambient Shade temperature :	50°C	55°C
Maximum daily average Ambient shade temperature :	45°C	50°C
Maximum yearly average Ambient shade temperature :	30°C	35°C
Maximum temperature of Metal surfaces in direct Sunlight :	80°C	85°C
Maximum Relative humidity :	100%	100%

- b. In damp situations and wherever exposed to the weather, precautions shall be taken against corrosion of metal work.

1.17 Welding

- a. All welding shall be carried out in accordance with the relevant British or other National Standard Specification as applicable. Where there is no such applicable standard the welding technique and procedure shall be carried out to standards approved by the Engineer.
- b. All welders employed on the Works shall be qualified and shall hold current certificates in accordance with the requirements of BS 4872 or equivalent. The Engineer may call for test welds to be carried out should he at any time consider that the welding is not being carried out in a

satisfactory manner, or if the welder's certificate does not conform to the British [American] Standard.

- c. Full information as regards weld sizes and details, plate preparation, assembly and fit up, welding procedure and sequence shall be submitted to the Engineer for approval before manufacture commences.

This is particularly applicable to highly stressed parts such as pressure vessels, shafts, mechanism parts, etc.

- d. In the case of large fabrications, after scrutinizing the general arrangement and welding detail drawings, the Engineer will inform the Contractor of the stages at which inspection will be required. It will be the Contractor's responsibility to notify the Engineer when one or more of the inspection stages will be reached and no further work is to be carried out until the specified stage has passed the Engineer's inspection.
- e. All tests are to be carried out in accordance with the relevant British [American] Standards or by agreement between the Engineer and the Contractor. All welding and tests on items of plant are to be carried out to the complete satisfaction of the Engineer. Mechanical tests are to be carried out in the presence of the Engineer, as required. Where required by the Specification non-destructive examination of the finished weld is to be made.
- f. If the examination be by radiographic means, then the recommendations of BS 2600 or 2910 where applicable are to be followed and the resulting negatives are to be made available to the Engineer. If the examination be by means other than radiographic, then such examinations are to be made in the presence of the Engineer.

2. Products

2.01 Materials

- a. The Plant design, workmanship and general finish shall be of sound quality in accordance with good engineering practice. Design shall be robust and rated for continuous service, at the specified duties, under the prevailing operational site conditions.

- b. The general design of mechanical Plant particularly that of wearing parts, shall be governed by the need for long periods of service without frequent attention but shall afford ready access for any necessary maintenance.
- c. Similar items of Plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same material specification as the originals.
- d. No welding, filling or plugging of defective work will be permitted without the written permission of the Engineer. All welding spatters shall be removed.
- e. It shall be the responsibility of the Contractor to ensure that all the equipment selected is fully compatible, mechanically, electrically and also with respect to instrumentation, control and automation.
- f. It shall be the responsibility of the Contractor to ensure his equipment interfaces with any existing equipment correctly.
 - a. Any interfaces must not affect the integrity of the equipment, or invalidate any warranties or guarantees.
- g. Each component or assembly shall have been proven in service in a similar application and under conditions no less than those specified therein.
- h. The equipment shall be compatible with the civil structure, when installed, with sufficient space for operator access and maintenance procedures.
- i. All materials shall be of the best commercial quality and free from any flaws, defects or imperfections.
- j. Materials shall be selected to eradicate or reduce corrosion to a minimum.
- k. All submerged parts of the Plant shall be of non-corrodible material. Plant in contact with chemicals shall be resistant to corrosion or abrasion by those chemicals and maintain their properties without deterioration by the passage of time, exposure to light or other cause. Sun shading shall be supplied where necessary.
- l. Materials and components shall be stored, handled and installed in such a manner as to preserve their quality and condition to the standards required by the Contract and in accordance with the manufacturer's recommendations.

- m. All equipment furnished shall be new and guaranteed free from defects in materials, design, and workmanship. It shall be the manufacturer's responsibility to ascertain the conditions and service under which the equipment will operate and to warrant that operation under those conditions shall be successful. All parts of the equipment shall be amply proportioned for all stresses that may occur during fabrication, erection, and intermittent or continuous operation.
- n. All equipment shall be designed, fabricated, and assembled in accordance with the best modern engineering and shop practice. Individual parts shall be manufactured to standard sizes and gauges so that repair parts, furnished at any time, can be installed in the field. Like parts of duplicate units shall be interchangeable. Equipment shall not have been in service at any time prior to delivery, except as required by tests. Materials shall be suitable for service conditions. Iron castings shall be tough, close-grained gray iron free from blowholes, flaws, or excessive shrinkage and shall conform to [BS3468] [BS6681]. Except where otherwise specified, structural and miscellaneous fabricated steel used in items of equipment shall conform to the British Standards Institution. All structural members shall be considered as subject to shock or vibratory loads. Unless otherwise specified, all steel which will be submerged, all or in part, during normal operation of the equipment shall have a minimum nominal thickness of 6 mm. Provide equipment and materials suitable for the service conditions and meeting British Standards specifications. The location of the fabricator and his shop schedule shall be furnished to the Engineer prior to the beginning of fabrication so that the Engineer can schedule shop inspection.

2.02 Building Attachments, Foundations, Supports and Fixings

- a. Where any Plant included in the Works is attached to civil or building structures, the magnitude of the applied loadings must be stated by the Contractor in his outline design drawings. Cutting of steelwork will not be allowed. Drilling, welding or stud fixing into tension flanges or other steelwork subjected to tensile loads, will not be permitted on plate girders or any principal steelwork member. Where attachments are allowed, proper clamps or straps shall be utilized and shall have prior approval of the Engineer.
- b. The Contractor shall supply all foundation bolts, packers, frames and grillages necessary for the Works. Where these and other items are required to be built in, the Contractor shall ensure that both details and materials are available in time to avoid delay to any part of the Works. In

default, any alterations or additions subsequently found necessary shall be at the expense of the Contractor.

- c. Before commencement of the installation of the Plant the Contractor shall satisfy himself, that the foundation levels, dimensions and alignment are correct and shall level and adjust the Plant on its foundations prior to suitable bedding of bases.
- d. Where fixings are used by the Contractor, he shall drill the holes, providing and fixing all parts, to the Engineer's approval. Fixings into concrete shall be of stainless steel.
- e. Materials and components shall be selected so that they can withstand minor accidental damage without affecting their function.
- f. Drilling into steel reinforced structures will not be permitted without the prior approval of the Engineer.

2.03 Lubrication

- a. Lubrication recommended by the manufacturer shall be provided to ensure smooth operation, heat removal and freedom from undue wear. Plant selected shall require minimum lubrication attendance and down time for lubricant change.
- b. The Contractor shall supply the first fill (after commissioning) of oil and grease from approved lubricants suppliers.
- c. The type and grade of lubricant shall be clearly marked on a label adjacent to the item of plant.
- d. All grease nipples, oil cups and dip sticks shall be readily accessible, being piped to a point as near as practicable to the lubrication point.
- e. Gearboxes and oil baths shall be provided with adequately sized filling and draining plugs and suitable means of oil level indication.
- f. Roller chain drives shall have a constant feed of lubricant, when in operation (via oil bath or auto lube system).
- g. Drain points shall be located or piped to a position such that an adequately sized container can be placed beneath them. Where a large quantity of oil is involved or drainage to a container difficult, a drain valve and plug shall be provided at the point of discharge.

- h. Bearings equipped with forced fed oil lubrication shall be automatically charged prior to machinery starting up and pressure monitoring during operation with automatic shutdown of machinery and alarm of low oil pressure.
- i. Access, without the use of portable ladders, to lubrication systems shall be such as to permit maintenance, draining and re-filling, without contamination of the charged lubricant.
- j. Grease application shall be by steel lubrication nipples manufactured in accordance with BS 1486.
- k. Anti friction bearings requiring frequent charging shall be fitted with hydraulic type nipples.
- l. A separate nipple shall be provided to serve each lubrication point. Where a number of nipples supply remote lubricating points they shall be grouped together on a conveniently placed battery plate with spacing in accordance with the recommendations of BS 1486, part I.
- m. Lubrication schedule to be supplied by the manufacturer.

2.04 Steel Works

- a. Conform to BS5950 part 1 Specification of the Design of Buildings, and part 2 Fabrication and Erection of Structural Steel Buildings. Design all fabrications for dynamic and vibratory loadings. Use structural steel shapes conforming to British Standards Institution or equal and approved, as applicable.
- b. Conform welding to BSEN288 Specifications and Approvals for Welding Procedures.
- c. Galvanize specified items in accordance with BS1706 and BS729 or equal and approved, as applicable; use galvanized bolts and fasteners with galvanized assemblies.
- d. All steelwork shall be detailed, fabricated and erected in accordance with BS 4, BS 449, BS 6323 or BS 4360 (Gr43). All steelwork shall be constructed in mild steel, hot dip galvanized after manufacture except where specified otherwise.

- e. All steelwork in sewage wet wells, i.e. supports, brackets, cable tray, cable supports, etc. and all fixings and threaded rods shall be stainless steel to BS 970, 316 S31.
- f. No mild steel whatsoever shall be used in the wet well and wet well superstructure areas.
- g. The Contractor shall submit fabrication drawings for the approval of the Engineer before commencing manufacture.

2.05 Equipment Bases and Bedplates

Mount equipment assemblies on a single heavy cast iron or welded steel bedplate unless otherwise shown or specified. Provide bases and bedplates with machined support pads, tapered dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Continuously weld seams and contact edges between steel plates and shapes, and grind welds smooth. Do not support machinery or piping on bedplates other than that which is factory installed. Provide jacking screws in equipment bases and bedplates to aid in leveling prior to grouting. Provide plates of minimum thickness of 6 MM. Pump bedplates shall include a drip lip and provisions for directing gland leakage to a single disposal point.

2.06 Anchors, Sleeves and Fasteners

Arrange for each equipment manufacturer to furnish all required anchor bolts, nuts, washers, and sleeves of adequate design for securing bases and bedplates to concrete bases or concrete surface. Provide anchor bolts of sufficient length to allow for 50 mm of grout under base plates and adequate anchorage into structural concrete. Other specifically detailed lengths either shown or specified will supersede this requirement. Conform to designs for attachments to resist seismic forces. Provide sleeves with a diameter of at least 1-1/2 times anchor bolt diameter and of the same material as the anchor bolts. Grout all fixing holes with epoxy mortar and seal all exposed fixing material with a coal tar epoxy or GRP coating.

- a. All bolts, nuts, washers and anchor plates, except high tensile, for fastening ferrous parts for use in dry areas shall be galvanized steel to BS 729:1971
- b. All bolts, nuts, washers and anchor plates, for fastening galvanized components or aluminum alloy components and all fixings in wet wells and sumps shall be of stainless steel Grade 316 S31 to BS 970.

- c. All holding down and anchor bolts, nuts, washers and anchor bolts for use externally or in internal areas which are in 'wet' areas including above the top water level shall be stainless steel Grade 316 S31 to BS 970. All holding down and anchor bolts, nuts, washers and anchor plates for use internally in areas not subject to contact with 'wet' areas shall be galvanized steel to BS 729:1971(1986) and all exposed surfaces shall be painted after assembly and tightening. PTFE washers and spacers shall be fitted beneath stainless steel washers for both bolt head and nut when used to fix dissimilar metals.
- d. Fasteners shall be tightened with a specific torque as per the manufacturer's recommendations. Thread lubricants used shall be in line with the manufacturer's recommendations and the torque loadings shall take this into account.
- e. Where safety is dependent on correct torque loadings, the Contractor shall produce documentation to certify that these loadings have been imposed on the fasteners.
- f. Should it be necessary to use left handed fasteners, these shall be clearly marked up, by marking or engraving the fastener, and by means of a warning painted on the plant on which they are used.
- g. Fasteners used in areas where they are exposed to chemicals should be unaffected by the chemicals they are likely to be exposed to.
- h. Drilled anchor fixings for use on concrete structures shall normally be stainless steel and of a type approved by the Engineer. The positions of all drilled anchors shall be approved by the Engineer and any Contractor proposing to use such fixings shall be deemed to have undertaken to supply, mark off, drill and fit.
- i. Locking washers or locking nuts shall be used where necessary, and shall be of a type suitable for the duty to which they are subjected. The type used shall be approved by the Engineer.
- j. Where the use of chemical anchors is approved the Contractor must provide copies of the manufacturers installation instructions to the Engineer and must demonstrate that his operatives are following these instructions. A proof load must be applied to all bolts fixed in this manner by applying the required torque against nut or stud after curing. The Contractor must give the Engineer reasonable notice of when these tests are to be carried out in order that he can witness them.

- k. All nuts and bolts shall be threaded in accordance with BS 3643 "ISO metric screw threads" Part 2 "Specification for selected limits of size" and fitted with 3mm thick washers beneath bolt and nut.
- l. All exposed bolt heads and nuts shall be hexagonal and the length of all bolts shall be such, that when fitted with a nut and tightened down, the threaded portion shall fill the nut and not protrude from the face thereof by more than half diameter of the bolt.
- m. Where it is necessary for assembly reasons, or for jacking screws, to leave portions of exposed thread exposed, these shall be protected. Protection shall consist of a plastic tube filled with suitable anti-seize material.

2.07 Safety Guards

Cover belt or chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts on all sides with safety guards conforming to all applicable codes and regulations and the requirements contained herein. Safety guards shall be free of all sharp edges and corners. Use corrosion-resistant materials at least equivalent to hot-dip galvanized steel. Safety guards shall be fabricated from galvanized or aluminum-clad steel or 12 mm mesh galvanized expanded metal. Design guards for easy installation and removal. Provide necessary supports, accessories, and fasteners, of hot-dip galvanized steel or stainless steel. Design guards in outdoor locations to prevent entrance of rain and dripping water.

2.08 Drive Units

Provide drive units designed with a rating and service factor suitable for 24-hour continuous duty service under operating load, constructed to avoid oil leakage around shafts. Drive unit housings shall be constructed of high grade cast iron, welded steel, or other suitable material. Thermal rating of each unit shall exceed the design load or proper cooling devices shall be provided. All drives shall be designed especially for the service for which they are to operate.

- a. Motor Ratings. Provide drive motors having nameplate power rating at least equal 1.10 times the theoretical brake power required to drive equipment under full load for conditions specified, including all losses in speed reducers and power transmission.
- b. V-Belt Drives. Equip each V-belt with a sliding base or other suitable tension adjustment. Where motors are mounted above the driven machine

on a pedestal, the belt tensioning shall be accomplished by four studs which are tightened by two nuts to the motor plate to raise and lower the motor plate. Provide drives having a service factor of at least 1.5 at maximum torque using nameplate rating of driving motor.

2.09 Couplings and Coupling Alignment

- a. All couplings shall be fully checked for alignment and all necessary equipment for checking alignment shall be supplied by the Contractor.
- b. Particular attention shall be paid to achieving accurate alignment of solidly bolted couplings and the Contractor's proposed alignment procedure shall be to the approval of the Engineer. The coupling alignment procedure shall include a final check in the "bolted-up" condition for "cranking".
- c. Where flexible couplings are used the Contractor shall fully describe the arrangements proposed for ensuring that the desired freedom of relative movement between the shafts is obtained when transmitting a torque corresponding to the continuous maximum rating.
- d. Flexible couplings where supplied shall be generously rated to cover the full range of duty.
- e. Couplings in contact with or exposed to oil splashes shall be of metal flexible type.
- f. General Service couplings shall be of the flexible multi-pin and bush type having not less than six bushes and each bush shall have an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with the pin). All pins shall have shoulders to allow positive location and securing to the bosses.
- g. Bosses shall be a tight fit on the shafts and secured with hand fitted keys.
- h. Couplings shall be supplied by matching balanced sets and shall be machined balanced and marked before leaving manufacturer's works.
- i. Final alignment shall be checked by the Contractor in the presence of the Engineer.

2.10 Gears

- a. Gearboxes shall have a minimum design life of 200,000 hours, be selected in accordance with AGMA recommendations for horsepower calculation and service factor application and employ a standard reduction ratio.

- b. Gearboxes which have to be angle mounted shall have a rating, choice of bearings, seals and lubrication system which is suitable for such mounting. Dependence on splash lubrication alone is not acceptable but may be used in conjunction with a forced feed method to reach all bearings and gears.
- c. Calibration of the oil dipstick and its position, together with that of the sump drain plug, shall be suitable for the angle of inclination
- d. Service Ratings. Each gear shall have a nameplate service power rating equal to the nameplate rating of the driving motor. Each gear shall have mechanical and thermal capacity equal to or greater than an equivalent power determined by multiplying the service power rating by the specified service factor recommended by AGMA for heavy duty service, except each set of worm gears shall have a minimum service factor of 1.20 and all other gears shall have a minimum service factor of 1.50.
- e. Thermal Rating. Obtain thermal rating for the equivalent power without auxiliary cooling equipment such as heat exchangers. Design units to operate continuously for the conditions specified in a location where ambient temperatures vary from -5 to 550C. If a cooling coil is required, provide minimum 25 mm diameter tubing and a 25 mm solenoid supply water valve with the gear.
- f. Gear Nameplates. Equip each gear with an AGMA nameplate which shows service power, actual service factor for actual mechanical or thermal rating as applicable, and AGMA gear Class I rating.

2.11 Bearings

- a. The Contractor shall select the most appropriate type of bearing for the Plant being supplied.
- b. Bearings shall have a minimum design life time of 100,000 hours at maximum loading.
- c. Plant which may be subject to vibration whilst stationary shall be provided with bearings designed to withstand damage from such a cause.
- d. Single journal plain bearings shall have phosphor bronze or synthetic lubrication impregnated bushes with carbon or stainless steel journals respectively. Synthetic bearings shall only be used where bearing condition can readily be inspected.

- e. Plain type bearings shall be self-lubricating by grease, forced oil or impregnation.
- f. Ball and Roller type bearings shall be adequately lubricated by oil or grease and sealed to prevent leakage of lubricant along the shaft or the ingress of dust, water or sand.

2.12 Noise Levels and Vibration

Noise levels, with the envisaged maximum number of items of equipment operating 'on load' (including existing equipment), the sound level outside an envelope of 1 meter radius from any items of equipment, shall not exceed 85 dB (A). The Contractor shall include for suitable sound attenuation to achieve this level, generally in accordance with BS 8233. This will apply in the audible frequency range 20 Hz - 20k Hz. Above 20k Hz, the Contractor must state whether any fundamental frequencies are generated in the ultrasonic region. Noise levels shall be assessed in accordance with BS 4196, taking into account the actual or proposed site conditions. The Contractor shall ensure that the equipment installed within buildings and structures meets the requirements of vibration and resonance with respect to frequencies.

2.13 Gauges

Gauges shall be installed in the suction (where applicable) and discharge of each pump and blower. The gauges shall be 150 mm diameter and in accordance with other Divisions and shall include a stopcock between the pump/blower and the gauge. For solids bearing or corrosive fluids a diaphragm gauge isolator shall be provided. Gauge ranges shall be a standard commercially available range with the maximum reading not less than 1.5 times the working pressure. All Gauge mountings shall be free of vibration and the readings should be clearly visible and Accessible (i.e. mounted in place where operator can easily read from distance).

2.14 Nameplates and Data Plates

- a. The Contractor shall supply and fix name and rating plate(s) to each item of plant. The plates shall be engraved or stamped with the Manufacturer's name, the type and serial number of the Plant, details of the loading and duty at which the item has been designed to operate and sufficient detail to allow the assembly to be readily identified in correspondence and when ordering spare parts. Schedule of Plant nameplates shall be provided at the submittal stage, to enable these numbers to be allocated.

- b. The plates shall be robust, weatherproof, and resistant to cracking and fracture. Colorfast numbering and lettering, in block capitals and/or symbols shall not be less than 5mm high.
- c. The plates shall include a maintenance reference number obtainable from the Purchaser, for the item of Plant to which they are fixed.
- d. All plates shall, where practicable, be mechanically fixed to Plant. The use of other fixings shall be subject to specific written approval of the Engineer.

2.15 Instruction Notices

The Contractor shall provide and fix all necessary diagrams and/or instructions, notices for special systems. These shall be located adjacent to the appropriate items of Plant.

2.16 Labeling

Complete labeling system for all equipments on site and also for the main parts in the equipment to be created by the contractor and approved by the engineer. This suppose to respect the tag numbers given in the P& I drawings.

2.17 Safety and Warning Signs and Notices

- a. Signs and Notices specifically required for Safety and Warning purposes shall comply with the requirements of the Municipality.
- b. Any items of equipment which start automatically shall have permanent warning signs affixed to them with the legend in English and Arabic stating “Warning Equipment Automatic Starting, Isolate Elsewhere”.

2.18 Painting and Protective Coating

- a. Protection of Finish. The Contractor shall provide adequate means for fully protecting all finished parts of the materials and equipment against damage, from whatever cause, during the progress of the work, and until final completion. All materials and equipment in storage and during erection shall be protected in such a manner that no finished surfaces shall be damaged or marred, and all moving parts shall be kept perfectly clean

and dry. Painting and protective coatings shall conform to applicable requirements of colors. They shall be to the approval of the Engineer, and the following requirements, unless modified or otherwise specified elsewhere.

- b. **Factory Painting.** On mechanical equipment, drives, starters, control panels and other similar self-contained or enclosed components, a factory primer and high-quality oil-resistant baked industrial enamel finish shall be applied. Surfaces that are inaccessible after assembly shall be painted or otherwise protected by a method which provides protection for the life of the equipment.
- c. **Shop Priming.** Two shop coats of metal primer shall be applied on surfaces to be finish painted at the site, the coating thickness to protect surfaces until finished. The Contractor shall submit for approval the coating systems intended for use. Shop primers for affected items of equipment shall consist of only those approved for the intended protective coating system. Working drawings indicating compliance with this requirement shall be submitted.
- d. **Rust Prevention.** Machined, polished, other ferrous surfaces and non-ferrous surfaces which are not to be painted shall be coated with an approved rust preventive compound, and, in the case of aluminum be anodized. Structural galvanized steel and stainless steel need not be coated.

2.19 Color Coding for Water and Sewage Installations

Pipes, valves, pumps, compressors etc shall be colour coded in accordance with BS 1710 or equivalent. The coding shall indicate the content of the pipelines, purpose of the valves etc, and show whether or not the fluids being handled are dangerous.

Tape banding of pipes, of the appropriate colour, shall be spaced at 3m intervals and at every valve or junction. Direction of flows arrows shall be provided together with the process stream contents.

2.20 Glass Reinforced Plastic

- a. The Contractor shall submit the design of GRP components and full details of materials used and manufacturing process to the Engineer for approval.
- b. The following is a minimum standard:-
 - 1. A polyester resin shall be used to BS 3532, Chemical resistant.
 - 2. GRP shall be water resistant "E", chopped strand mat or woven glass fabric to BS 3496 and BS 3749.

3. All surfaces shall be gel coat / flow coat covered using resin to BS 3532.
4. All drilled, cut or otherwise exposed edges shall be sealed using polyester resin to BS 3532 to eliminate the ingress of moisture.
5. All materials used to stiffen the structure shall be completely encapsulated with GRP laminate.
6. The GRP product shall be stabilized to resist extremes of ultraviolet light and be satisfactory for use in its working environment.

2.21 Special Tools

The Contractor shall provide one set of new and unused special tools (i.e. not obtainable from retail outlets) for the maintenance of all Plant included in the Contract. They shall be contained in a clearly labeled hardwood box.

2.22 Pressure and Vacuum Vessels

Pressure or vacuum vessels shall be designed, constructed, inspected and tested, to BS 5500:1991. The Inspecting Authority will be to the approval of the Engineer but all costs involved in testing and inspecting shall be borne by the Contractor. Vessels of a large enough size to allow man access for inspection shall have a suitable man access hatch.

2.23 Rivets

- a. Rivets are to conform to the appropriate British or American Standard and for general use pan heads are preferred. Rivets on bearing surfaces are to be flat counter-sunk, driven flush. Whenever practicable, rivetting is to be done by hydraulic tools and the rivets must completely fill the holes when closed. If loose, or if the heads are badly formed, cracked or eccentric to the shank or do not bear truly on the plate or bar, rivets are to be cut out and replaced. All surfaces to be riveted must be in close contact throughout.
- b. Rivets shall conform to BS 641 and tested in accordance with BS 1109.

2.24 Forgings

- a. Particulars of the heat treatment proposed for large forgings and the name of the proposed maker are to be submitted to the Engineer for approval.
- b. Records of the heat treatment of all forgings are to be made and certified copies shall be submitted to the Engineer.

- c. After heat treatment large forgings are to be subjected to examination by approved non-destructive methods such as ultrasonic or radiography.
- d. In the case of other forgings approved test pieces from areas selected with the agreement of the Engineer shall be submitted to mechanical and chemical tests.

2.25 Castings

All castings are to be free from blowholes, flaws and cracks. No welding, filling or plugging of castings is to be carried out.

2.26 Chromium Plating

Chromium plating shall comply with BS 1224:1970.

2.27 Wrought Steels

Unless specified otherwise, wrought steel selected from the appropriate EN series of BS 970 shall be used free from blemishes, shot, or hammer marks.

2.28 Cast Iron

All castings supplied shall be to the appropriate grade in BS 1452 Grade 220. The Contractor shall replace any casting which the Engineer considers is not of first class appearance or in any way is not the best which can be produced although such a casting may have passed the necessary hydraulic or other tests.

2.29 Seals

- a. The Contractor shall provide seals, preferably of the mechanical type, compatible with his Plant and best suited for the worst conditions likely to be met when the Plant is in operation.
- b. All seal materials shall be compatible with and resistant to the fluid or gas being handled

3 Installation, Testing and Commissioning

3.01 Coordination

- a. The Contract Drawings show in a general arrangement form the arrangements desired for the principal equipment, piping, and similar appurtenances, and shall be followed as closely as possible. Proper judgment shall be exercised in carrying out the work to secure the best possible headroom and space conditions throughout, to secure neat arrangement of all equipment, and accessories, and to overcome local difficulties and interference of structural conditions wherever encountered.
- b. The Contractor shall take all measurements for his work at the installation sites, verify all dimensions and conditions at the place of installation, verify the Sub-contractor's drawings and be responsible for the proper installation, within the available space of the equipment specified and shown on the Drawings. Written details and reasons for proposed deviations from Drawing and Specifications shall be submitted. The Engineer's approval for any variations shall be obtained before making any changes.
- c. Unit Responsibility, Refer to pertinent Sections for items of component equipment to be assembled under the unit responsibility of one manufacturer. Monitor and verify the work of the responsible manufacturer and submit the following information to the Engineer in writing on a monthly basis:
 1. Shipment dates of the various components to the responsible manufacturer.
 2. Scheduled dates of factory tests by responsible manufacturer.
 3. Scheduled shipment dates of assembled items to site by responsible manufacturer.
 4. Scheduled arrival, installation, and start-up dates of assembled items.

3.02 Inspection

- a. For the tests on the Site the Contractor shall provide at his own expense unless specified otherwise, such labor, materials, electricity, fuel, stores and apparatus and instruments as may be requisite and as may be reasonably demanded to carry out such tests efficiently.
- b. If after inspecting, examining, or testing any equipment the Engineer shall decide that such equipment or any part thereof is defective, or not in accordance with the Contract, he may reject the said equipment or part thereof, by giving the Contractor written notice within 7 calendar days of such rejection, stating therein the grounds upon which the decision is based.

3.03 Preparation

Prior to installing equipment, ensure that installation areas are clean and that concrete or masonry operations are completed. Maintain the areas in a broom-clean condition during installation operations. Clean, condition, and service equipment in accordance with the approved Instruction Manuals and requirements in other Sections of these Specifications before installing.

3.04 Manufacturers' Supervision and Installation Check

Arrange for each equipment manufacturer to furnish the services of an authorized representative especially trained and experienced to (a) see that the equipment is installed in accordance with the approved Instruction Manual, (b) be present when the equipment is first put into operation, (c) inspect, check, adjust as necessary, and approve the installation, (d) repeat the inspection, checking, and adjusting until all trouble or defects are corrected and the equipment installation and operation are acceptable, (e) witness operational demonstrations and system validation tests to the extent specified, and (f) prepare and submit the specified Manufacturers' Certified Report.

All costs for manufacturer's representative services shall be included in the contract price.

3.05 Installation

- a. General. Prior to installation the equipment shall be cleaned, conditioned, and serviced in accordance with the approved instruction manuals.
- b. Equipment. Equipment shall be installed in accordance with approved instruction manuals by an approved specialist sub-contractor. The Contractor shall employ skilled craftsmen experienced in installation of the types of equipment specified, and shall use special tools and equipment, such as precision machinist levels, dial indicators, gauges, and micrometers, as applicable.
- c. Anchor Bolts. The Contractor shall provide bolts with templates or setting drawings and verify that bolts are correctly located before structural concrete is placed.
- d. Base and Bedplate Grouting. Grouting shall not be carried out until initial fitting and alignment of connected piping is completed and approved by the Engineer. The Contractor shall level and align equipment on concrete foundations using suitable steel and brass shimming, then entirely fill the

space under base or bedplates with non shrink grout. Exposed grout shall be beveled at a 45° angle, except that exposed grout at horizontal surfaces shall be rounded for drainage. Exposed grout shall be trowelled or pointed to a smooth dense finish and damp cured with burlap for three days. After the grout has fully hardened, the Contractor shall remove jacking screws and tighten nuts on anchor bolts. The Contractor shall check the installation for alignment and level, and perform approved corrective work as required to conform to the tolerances given in the instruction manual.

3.06 Testing and commissioning

I. Include all costs of performing operational demonstrations and system validation tests in the Contract Price.

No extra payment will be made on account of overtime, weekend or holiday labor costs required to perform and complete the demonstrations and validation tests. Requirements specified in this Article are in addition to the demonstration and test requirements specified under other Sections of these Specifications.

a. Operational Demonstration and Systems Validation Testing shall be performed in accordance with the approved procedure plans to demonstrate to the Engineer's satisfaction that:

§ All specified components and the complete systems have been installed satisfactorily.

§ All specified component units and complete systems operate with the efficiency, reliability, and accuracy indicated and specified.

§ All component units and complete systems conform to the requirements specified in the Contract Documents and the approved shop drawings, samples, construction manuals, materials lists, and other approved submittals.

b. Scope of Demonstrations and Validation Testing, Operational demonstrations and system validation tests required for all work, equipment, and systems in the project including all associated and related electrical systems and control devices.

§ Perform operational demonstrations on all individual equipment items such as pumps, compressors, fans, screening mechanisms, and like equipment items. Demonstrations shall be performed simultaneously on groups of identical equipment items and groups of items supplied by one manufacturer to the extent feasible.

§ Perform validation tests on all complete systems that perform a discrete process function of the plant such as pumping systems, screening systems, odor control systems and similar systems. Each system shall include associated structures, tanks, piping, utilities, instrumentation and controls, and like related items. Two or more separate systems shall be validation tested simultaneously when necessary to validate an entire discrete plant function.

- c. Prerequisite Conditions. Operational demonstrations and validation testing shall not commence for any equipment item or system until all related structures, piping, electrical, instrumentation, control, and like work has been installed, tested, and connected in compliance with the pertaining requirements specified elsewhere in the Specifications.
- d. Demonstration and Testing Materials Furnish materials and electrical power for operational demonstrations and validation tests. Use fresh potable water to fill tanks, wells, piping, and systems that contain water, wastewater or sewage in normal operation. Use the specified chemicals for chemical systems but do not exceed in service concentrations. Furnish temporary facilities as required such as bypass or recirculation piping, diversions, storage, and similar facilities. Use procedures that conserve testing materials and avoid wastage, especially with respect to large quantities of fresh potable water and electrical power.
- e. Inspection and Supervision by Manufacturers. Perform operational demonstrations and system validation testing under continuous inspection by the Engineer. Arrange for technical representatives of the various equipment manufacturers to be present at the start of the operational demonstrations, to examine their equipment at least twice near the beginning and end of the validation tests, to supervise the start-up and adjustment procedures, and to perform all other services necessary for the manufacturer's certified reports required herein.
- f. Correction of Defects. Immediately correct all defects and malfunctions disclosed by demonstrations and validation tests using approved methods and new materials for repairs as required. Interruption time necessary for corrective work shall be added to the specified total demonstration and validation test periods.
- g. Acceptance. Satisfactory completion and approval or required operational demonstrations and system validation testing is one of the

conditions precedent to the Engineer's acceptance of the work and does not constitute final acceptance.

II. Operational Demonstrations.

Demonstrate that the performance of installed equipment complies with all requirements indicated and specified. Operate each equipment item through entire no-load to full-load range in accordance with the approved procedure plan for not less than 24 consecutive hours, unless a longer period is specified under other Sections.

III. Commissioning and System Validation Tests.

Commissioning and setting to work of the Plant may be dependent on the completion of other contracts, operation of existing works, or planned commissioning Schedule. At a date to be agreed with the Engineer the Plant shall be commissioned with sewage or effluent as applicable and the Contractor shall supervise the working of all necessary engineering and technical supervision continuously to effect any adjustment that may be necessary. All equipment components of each system shall have been successfully completed the required operational demonstration before the system is validation tested. Perform validation testing in accordance with the approved procedure plan.

- a. Test Period. Unless specified otherwise in other Sections test each system, including standby systems, by continuous operation in "in-service" condition for not less than 7 consecutive days, with no interruptions.
- b. Testing Methods. Operate systems continuously 24 hours a day under constant inspection of trained operators. Cycle system operation from full load to light load and back to full load each 24 hours; cause variable speed equipment to cycle through the applicable speed range at a steady rate of change. Induce simulated alarm and distressed operating conditions, and test controls and protective devices for correct operation in adjusting system functions or causing system shutdown.
- c. Simulation of Conditions. Under special circumstances, subject to the Contractor's request, the Engineer may approve the simulation of certain operating conditions relating to flow rates, water levels, and malfunctions. Permission for simulations will be granted only where it is unwise or impossible to obtain the conditions covered by the capability of ranges or equipment under test conditions. The

simulations shall reasonably reflect the design operating conditions to the Engineer's satisfaction.

c. Ranges for Testing.

§ Flow Metering Systems shall be tested at not less than, 3 values corresponding approximately to minimum, average and maximum capacity, respectively.

§ Liquid Level Indicating Systems shall be tested at not less than 5 levels corresponding approximately to low-low, low, normal, high and high-high alarm levels respectively.

§ Remotely Controlled Valves shall demonstrate suitable operation both from local controls and remote controls. As a minimum, these procedures shall include full-open and full-close positioning. Each test shall be repeated not less than 2 times for non-throttling and non-modulating valves. In addition to these minimum requirements, and subject to approval, all throttling valves and modulating valves shall be operated at not less than 3 intermediate positions and shall demonstrate the ability of each valve to hold the set position under operating conditions.

§ Variable Speed Equipment shall demonstrate accurate response to speed controlling devices and controls within the required operating ranges. Actual output shaft speeds of manually adjustable speed equipment shall be validated by measurement of shaft speeds versus speeds shown by equipment instruments.

§ Automatic Response of Equipment. Response of equipment to appropriate manual or automatic controls, or combinations of both automatic and manual controls, shall be demonstrated to be correct and accurate. Where applicable, all components shall be tested for both manual and automatic operation. Where a component performs more than one function, every function shall be validated.

§ Pumping Equipment shall respond accurately and reliably to liquid level and flow rate signals from appurtenant basins, sumps, or wet wells. Automatic alternation and backup pump functions shall also be validated.

§ Chemical Feed Systems shall respond accurately to flow signals and feed proportionally over the ranges of process flows to be validated.

§ Air Compressors shall respond accurately, smoothly and reliably to control signals.

§ Auxiliary Equipment Items such as automatic samplers, enunciators, alarms, and like items shall respond accurately and reliably to every condition to which they are programmed, in the manner specified.

IV. Recording of Data: Maintain neat and comprehensive records of each operational demonstration and system validation test.

Each portion of the demonstration or validation procedure shall be described with all components itemized. Records shall be prepared on forms in a step-by-step fashion paralleling the approved procedure plans. Forms shall list for each condition:

- § Step taken;
- § Result anticipated.
- § Result obtained.
- § If incorrect, corrective action taken.
- § Retest results
- § Last two Steps shall be repeated until all systems operate as required.

- a. Recording Devices, Instruments, gages and other sensors and display devices forming a part of the various systems shall be employed for data acquisition to the extent applicable. Furnish all other instruments, gages, recorders, and test devices as required, types conforming to the approved procedure plans.
- b. Information and Intervals, All applicable data such as but not limited to water and other liquid levels, flows, pressures, head differentials, duration of runs, instrument readings, chemical feed rates, voltage settings, drive speeds, motor running currents, torque, voltages, flows, pressures, turbidity, residual chlorine and related information, as applicable, and in accordance with the approved procedure plans, shall be recorded at the start and finish of each operational demonstration and at maximum 2-hour intervals during system validation tests, unless shorter intervals are specified elsewhere.
- c. Repetitions. When a demonstration or validation test is repeated to verify the results, indicate the repeat procedure on the recorded data by numerical indication, date and time.

4 Instruction for OWSC'S Personnel

Conduct an instruction program for plant operators designated by OWSC. Furnish the services of qualified instructors from the various system supplier/equipment manufacturers. Include instruction covering basic system operation theory, routine maintenance and repair, and "hands on" operation of equipment. Base duration of the program on the complexity of equipment involved, and obtains the Engineer's approval of instruction adequacy before terminating the program. Schedule instruction periods in consultation with the Engineer.