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ARAB ENGINEERING BUREAU

1 GENERAL

1.1 GENERAL MECHANICAL AND ELECTRICAL REQUIREMENTS

1.1.1 Scope

- 1 This section specifies the General Mechanical and Electrical Equipment Requirements, which apply to all mechanical, and electrical systems and equipment and are 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 and electrical equipment and related appurtenances for the works to the provisions in the Contract Documents and this Section and also to the extreme climatic conditions.
- 2 The purpose of QCS is to provide as a general technical guide for acceptable construction work practices in the State of Qatar, considering this; any addition for technology, material, specification, standard that are not mentioned in this section or their modification, shall be subject to approval as stated in the introduction of QCS (00-02).

1.1.2 Related Works

- Section 1, General
- Section 8, Drainage Works
- Section 10, Instrumentation, Control and Automation
- Section 16 Structural Metal work
- Section 17 Metal work
- Section 21, Electrical Works

1.1.3 References

- 1 The following standards or revised/updated versions are referred to in this Part:
 - AWS D1.1, Steel structure welding code
 - BS 88,..... Cartridge fuses for voltages up to and including 1000 V a.c. and 1500 V d.c (IEC 60269 - Low-voltage fuses)
 - BS 89,..... Direct acting indicating analogue electrical measuring instruments and their accessories (IEC 60051 - Direct acting indicating analogue electrical measuring instruments and their accessories)
 - BS 970..... Specification for wrought steels for mechanical and allied engineering purposes; (ISO 683-1 Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering; ISO 683-2 Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering; ISO 683-3 Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels; ISO 683-4 Heat-treatable steels, alloy steels and free-cutting steels — Part 4: Free-cutting steels; ISO 683-5 Heat treatable steels, alloy steels and free-cutting steels — Part 5: Nitriding steels; EN 10250-4: Open die steel forgings for general engineering purposes - Stainless steels; EN 10095 Heat resisting steels and nickel alloys; BS PD 970 Wrought steels for mechanical and allied engineering purposes. Requirements for carbon, carbon manganese and alloy hot worked or cold finished steels; EN 10089 Hot rolled steels for quenched and tempered springs. Technical delivery conditions; EN 10277 Bright steel products. Technical delivery conditions; EN 10278 Dimensions and tolerances of bright steel products; EN 10088-1 Stainless steels - List of stainless steels; EN 10088-3 Stainless steels - Technical delivery conditions for semi-finished products, bars, rods, wire, sections and bright products of corrosion resisting steels for general purposes)

- BS 142,..... Electrical protection relays (IEC 60255 - Electrical relays)
- BS 159,..... Specification for high-voltage busbars and busbar connections
- BS 162,..... Electrical power switchgear and associated apparatus (IEC 61439- Low-voltage switchgear and controlgear assemblies)
- BS 449,..... The use of structural steel in building (EN 1993- Eurocode 3: Design of steel structures)
- BS 729, Specification for hot dip galvanized coatings on iron and steel articles (ISO 1460 -Metallic coatings — Hot dip galvanized coatings on ferrous materials — Gravimetric determination of the mass per unit area ; ISO 1461 -Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods)
- BS 1224..... Specification for electroplated coatings of nickel and chromium (ISO 1456- Metallic and other inorganic coatings. Electrodeposited coatings of nickel, nickel plus chromium, copper plus nickel and of copper plus nickel plus chromium)
- BS 1780..... Specification for bourdon tube pressure and vacuum gauges (EN 837- Pressure gauges)
- BS 2048,.... Specification for dimensions of fractional horse-power motors
- BS 3100,.... Specification for steel castings for general engineering purposes (EN 10293 - Steel castings. Steel castings for general engineering uses)
- BS 3643,.... ISO metric screw threads
- BS 3790, ... Specification for belt drives. Endless wedge belts, endless V-belts, banded wedge belts, banded V-belts and their corresponding pulleys (ISO 155, ISO 254, ISO 1813, ISO 4183, ISO 4184)
- BS 381C SET, Specification for colours for identification, coding and special purposes
- BS 4142, ... Methods for rating and assessing industrial and commercial sound (ISO 1996 - Acoustics — Description, measurement and assessment of environmental noise)
- BS 4196, ... Sound power levels of noise sources (ISO 3740; ISO 3741; ISO 3743; ISO 3744; ISO 3745)
- BS 4794, ... Specification for control switches (switching devices, including contactor relays, for control and auxiliary circuits, for voltages up to and including 1000 V a.c. and 1200 V d.c.) (IEC 60947 - Low-voltage switchgear and controlgear)
- BS 4800, ... Schedule of paint colours for building purposes
- BS 4884,.... Technical manuals (IEC/IEEE 82079 - Preparation of information for use (instructions for use) of products)
- BS 4921,.... Specification for sherardized coatings on iron or steel
- BS 4999..... General requirements for rotating electrical machines; (IEC 60034 Rotating electrical machines- ; IEC 60072 Rotating electrical machines - Dimensions and output series -)
- BS 5000,.... Rotating electrical machines of particular types or for particular applications
- BS 5304,.... Code of practice for the safety of machinery (BSI PD 5304 -Guidance on safe use of machinery)
- BS 5472,.... Specification for low voltage switchgear and controlgear for industrial use. Terminal marking and distinctive number. General rules
- BS 5685,.... Electricity meters (IEC 62052 - Electricity metering equipment); (IEC 521),

- BS 5950,... Structural use of steel work in building (EN 1993- Eurocode 3: Design of steel structures; EN 1994 Eurocode 4. Design of composite steel and concrete structures - EN 1090-2 Execution of steel structures and aluminium structures - Technical requirements for steel structures)
- BS 6231,... Electric cables. Single core PVC insulated flexible cables of rated voltage 600/1000 V for switchgear and controlgear wiring
- BS 6739.....Code of practice for instrumentation in process control systems: installation design and practice
- BS 7626,... Specification for current transformers; (EN 61869 -Instrument transformers); (IEC 61869- Instrument transformers);
- BS 7671,... Requirements for Electrical Installations. IET Wiring Regulations
- BS 8233,... Guidance on sound insulation and noise reduction for buildings
- EN 1092 Flanges and their joints - Circular flanges for pipes, valves, fittings and accessories, PN designated
- EN 1561, .. Founding - Grey cast irons; (ISO 185 - Grey cast irons — Classification)
- EN 1563, .. Founding - Spheroidal graphite cast irons; (ISO 1083- Spheroidal graphite cast irons — Classification)
- EN 10084, Case hardening steels. Technical delivery conditions (ISO 683-3 - Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels)
- EN 10204 .. Metallic products - Types of inspection documents
- EN 60439, Low voltage switchgear and control gear assemblies (IEC 61439- Low-voltage switchgear and controlgear assemblies)
- EN 60947, Low voltage switchgear and controlgear
- IEC-278 Documentation to be supplied with electronic measuring apparatus (IEC 61187- Electrical and electronic measuring equipment - Documentation)
- ISO 9000, . Quality management systems — Fundamentals and vocabulary
- ISO 9001 ... Quality management systems — Requirements
- ISO 10816-1 Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 1: General guidelines; (ISO 20816-1 - Mechanical vibration — Measurement and evaluation of machine vibration — Part 1: General guidelines)
- ISO 10816-3 Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ; (ISO 20816-3 - Mechanical vibration — Measurement and evaluation of machine vibration — Part 3: Industrial machinery with a power rating above 15 kW and operating speeds between 120 r/min and 30 000 r/min)
- ISO 10816-7 Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts

List of 'Approved Suppliers' prepared by the Public Works Authority

1.1.4 Submittals**1 General**

- (a) in addition to the requirements of Sections 1, 8, 10 and 21 the Contractor shall submit the following information as described in the below paragraphs
- (b) 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
- (c) all drawings shall be on ISO standard sized paper A1 unless specified otherwise. Each drawing shall be marked with the Contractor's and manufacturers names and references, project title drawing number, drawing title, scale, the date of completion and a full description and date of all amendments. A clear space 100mm x 160 mm shall be left at the bottom right hand corner of each drawing for the Engineer's approval and disclaim stamps
- (d) 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.
- (e) Data sheet forms shall be against latest Owner's specifications, must be stamped & any deviation shall have full supporting justifications.

2 Submittal Schedule

- (a) general. The Contractor shall submit a programme for all the submittals, with dates, for the Engineer's approval. Adequate time shall be left in this programme for approval
- (b) submittal times. Table 1.1 shows a Table of times for submittals and approvals. These times may be varied in the Project Specification depending on the scope and complexity of the Works. The Contractor should also note that the times for approval are dependent on the above, and drawings being submitted in an orderly fashion. Submittals of many drawings and information at any one time will delay the approval process. If the Engineer has to extend the approval time he will notify the Contractor within 7 calendar days of receipt of the submittal of the date on which he will grant approval or otherwise.
- (c) copies: numbers of submittals are as required in Table 1.1 below. In addition to the requirements of Table 1.1 the Contractor shall submit all record drawings, photographic records, test records and operation and maintenance manuals in electronic format on the latest form of digital record such as a CD.

Table 1.1
Submittals and Approvals

Submittal stage	Submittal type Number of copies in brackets	Time to be submitted (calendar days)	Time for comments/approval (calendar days)
Programme	(4)	14 days after Contract start	7 days
Design data	(4)	60 days after Contract start	21 days
Material and products data	Manufacturing programme (4)	30 days before start of manufacture	21 days
	Shipping and delivery schedules (4)	30 days before shipping	21 days
	Materials and product data (4)	60 days after Contract start	21 days
	Fabrication and assembly	90 days after Contract	21 days

Submittal stage	Submittal type Number of copies in brackets	Time to be submitted (calendar days)	Time for comments/approval (calendar days)
	drawings (4)	start	
Shop drawings	Working drawings (4)	30 days after approval of materials and product submittals	21 days
	Co-ordination drawings (4)	30 days after approval of working drawings	21 days
Records	Record drawings (4)	14 days after notification of change	21 days
	Photographic records (3)	7 days after date of photograph	14 days
Testing and commissioning	Plan and procedures (4)	30 days before commencement of testing	14 days
	Test records (4)	7 days after tests	21 days
Operation and maintenance	Operation and maintenance manuals and instructions (5)	60 days before * commencement of testing	30 days
	As-built drawings (5)	As erection progresses, but all drawings within 90 days of Practical Completion Certificate	40 days

* Draft only. Final version to be submitted before issue of Practical Completion Certificate (PCC) or similar.

3 Design Data

- (a) this shall include data and supporting calculations which is required for the following:
 - (i) justification for the overall design, sizing of process units, levels and layout
 - (ii) to show compliance with standards used. This may include quality manuals and procedures
 - (iii) as required in the particular and general project specification
- (b) design data shall be derived from standard methods of calculations. Computer generated data will only be accepted if it is produced by software with a proven record of use in the field in which it is supplied
- (c) any calculations which do not follow recognised standards or norms shall have full supporting justifications, with technical references.

4 Material and Product Data

- (a) programme. When required by the Engineer a critical path type programme shall be submitted showing all the manufacturing activities with the critical path clearly identified.
- (b) shipping and delivery schedules. These shall include the following:
 - (i) date of shipping, arrival at port and on site
 - (ii) details of packing methods. Any unique packing, shipping, handling and unloading requirements shall be stated.
- (c) materials and product data
 - (i) approval of materials and equipment shall be based on latest manufacturer's published data

- (ii) 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. Each item submitted shall be referenced to the applicable paragraph in the specification.
- (iii) materials of construction of materials, equipment or components shall be stated. At the request of the Engineer, a sample of these shall be submitted for further study before approval. Where samples are required by the Engineer, the period required to obtain the sample will be taken into account when scheduling approvals.
- (iv) If any additional testing is required and not performed by the Manufacturer as per their internal QA/QC procedures and approved ITP these Tests shall be done by third party body at the cost of the Manufacturer.
- (d) materials and product specification data forms shall be submitted for each item of equipment. These shall summarise the specification features as called for in these specifications, and including such other necessary data, as would provide a complete and adequate specification, for reordering an exact duplicate of the original item from the manufacturer at some future date. The assigned tag numbers and manufacturer's part numbers shall be included, but will not be considered as a substitute for any of the required statement of specifications. More than one tag numbered item may be included on a sheet.
- (e) 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 equipment such as pumps, clearly showing the materials and individual components.
- (f) test certificates. Manufacturer's test certificates, type test certificates, third party test certificates and quality control test certificates shall be submitted as required in the general and particular Project Specification. Certificates shall be originals or certificated copies.

5 Shop Drawings

These shall include the following:

- (a) working drawings. These shall include layout drawings. They are 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. Standard or specialised procedures for installation work recommended by the manufacturer's of materials or equipment and method statements for installation work shall be submitted. They shall include drawings of any templates required for the installation work.
- (b) co-ordination drawings. These shall be prepared by the Contractor to show how multiple system and interdisciplinary work will be co-ordinated. The location, size and details of fixings, box-outs, apertures, ducts, holes, cable routes, access doors/covers, Key plan and plinths shall be shown on detailed layout drawings which are coordinated with the building and civil structural drawings. Drawings shall illustrate clearances for lifting equipment, maintenance, access requirements and loadings due to equipment heights.
- (c) electrical drawings. These shall include single line diagrams, load schedules, cable schedules, cable schedules, loop diagrams, piping and instrumentation diagrams, panel layouts and circuit diagrams

6 Record Submittals

- (a) record drawings. These shall be prepared as work proceeds. They shall provide a record of any modifications to materials and equipment, and to the layout, arrangement and installation of the works.
- (b) photographic records shall also be made, as specified in Section 8, and as required in the Project Specification.

7 Testing and Commissioning Submittals

- (a) test procedures plan. At least 30 days before testing and commissioning is to be performed, a detailed and comprehensive procedure plan shall be submitted for the performance of each separate test. Each procedure plan shall describe and itemise the involved system including associated electrical equipment, and shall include evidence of an organised step-by-step procedure, properly co-ordinating 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 and equipment required.
- (b) procedure plan information. Each procedure plan shall include the following information, as applicable:
 - (i) description of temporary procedure facilities, including drawings and sketches as required to fully illustrate the facilities
 - (ii) list of test materials and estimated quantities
 - (iii) list of instruments, measuring and recording devices, and other test equipment, whether a part of the equipment or furnished separately for temporary use. Copies of calibration certificates shall be submitted for any test equipment.
 - (iv) names of supervising and inspecting manufacturers, where applicable
 - (v) complete listing of all functional parameters to be served and recorded
 - (vi) recording intervals.
 - (vii) "Tabular risk assessment analysis arranged as below:
 - Activity.
 - Risk rating.
 - Hazards Controls.
 - Responsible Person.
 - Residual risk rating
- (c) record materials. Samples shall be submitted of the forms, charts, and other materials to be used in recording demonstration and validation test results. Wherever possible, standard forms shall be used.
- (d) test recording. Neat and comprehensive records of each test shall be maintained by the Contractor. Each portion of the test procedure shall be described with all components itemised. Records shall be prepared on forms in a step-by-step fashion paralleling the approved procedure plans. Forms shall list for each test or check the following:
 - (i) check/list taken
 - (ii) result anticipated
 - (iii) result obtained
 - (iv) if incorrect, corrective action taken
 - (v) re-test/check result
 - (vi) step (iv) and (v) shall be repeated until all systems operate as required.

Instruments, gauges, and other sensors and display devices forming a part of the various systems shall be employed for data acquisition where applicable. The Contractor shall furnish all other instruments, gauges, recorders, and test devices as required, types conforming to the approved procedure plans. All applicable data such as, but not limited to, water and other liquid levels, flows, pressures, head differentials, duration of runs, instrument readings, voltage settings, drive speeds, motor running currents, torque, voltages and related information, as applicable, and in accordance with approved test procedures shall be recorded at the start and finish of each operational demonstration and at 30 minute intervals during system validation tests, unless other intervals are specified or agreed with the Engineer.

- (e) when a repeat of the same demonstration or validation test is required to verify the results, the repeat procedure shall be indicated on the recorded data by numerical indication, data and time.

8 Operation and Maintenance Manuals and Instructions - General

- (a) the Contractor shall provide fully detailed manuals covering all mechanical, electrical and electronic equipment. The manuals shall be in English
- (b) two copies of the draft manuals shall be submitted to the Engineer for review and approval, before the programmed commencement of commissioning works
- (c) the remaining three copies of the manuals shall be provided to the Engineer, before the commencement of the maintenance period. They shall include all revisions and comments made by the Engineer and any revisions or corrections necessitated by changes made during installation and testing
- (d) manuals shall be contract specific, and be fully indexed and sectioned, for allocation and distribution to the specialist staff involved on the particular plant and equipment
- (e) where several sub-contractors and manufacturers have supplied equipment the Contractor shall, if required by the Engineer provide a complete integrated manual which clearly demonstrates the inter-relation of the equipment
- (f) manuals shall be provided in durable hard cover backed A4 sized loose-leaf four ring binders. Lever arch binders are not acceptable. The full project title shall appear on the cover and spine
- (g) the manuals shall enable the client to safely operate, maintain, dismantle, reassemble and adjust all parts of the works
- (h) Original copies of leaflets and instructions provided by the specialist manufacturers shall be provided. Superfluous information shall be clearly deleted and relevant information referred to separately in the text
- (i) all instructions and manuals shall be written in accordance with BS 4884, IEC 278 (IEC 61187), and in accordance with other recognised guidelines on technical manual writing.

9 Operation and Maintenance Instructions and Manuals shall confirm to Section 1, Clause 7.12.2.

10 Operation and Maintenance Instructions and Manuals' Contents shall also confirm to the following listed items or otherwise agreed with the Engineer.

- (a) these shall comprise a number of volumes, dependent on the amount and technical content of the equipment installed. The operating instructions shall always form a separate volume. Manuals shall include sections containing information as described in the following paragraphs

- (b) introduction. The names, addresses, telephone and fax numbers of the Site, Employer, Consultant, Contractor, sub-contractors, manufacturers and agents. The date the Contract commenced, and the date of the Practical Completion Certificate. This item is to be completed when the date is established. A brief description of the equipment provided and the contractual scope of the work, with descriptions of any work subcontracted
- (c) general equipment description
 - (i) general process description. This shall provide a general description of the treatment processes based on process P&I drawings included with the manual
 - (ii) process design parameters. This shall provide information on the performance of the process systems
 - (iii) general description of the mechanical equipment. This shall provide a brief description of all mechanical equipment provided
 - (iv) general description of the electrical equipment. This shall provide a brief description of the equipment provided, listing individual control panel compartments and the remote controls
- (d) detailed equipment description
 - (i) mechanical equipment. This shall provide details of all the mechanical equipment including type, rating, duties, characteristic curves and manufacturers, and full component schedules, with serial numbers
 - (ii) electrical equipment. This shall provide details of all electrical equipment and cables including detailed information on the control panel(s), listing the display and controls available for each compartment and stating the rating, manufacturer and supplier of main components, and full component schedules with serial numbers. This section shall include a schedule of input and output signals, detailing number, signal type, polarity, digital open or closed state and analogue range, and detailed calibration routine
- (e) operating instructions. These shall provide details of how each component of equipment is controlled and operated in both automatic and hand modes, including the control philosophy and its interrelationship with other interdependent equipment. Details of equipment operation under non-routine conditions and details of start-up and shut-down procedures with any associated safety checks shall be provided. (see note below)
- (f) inspection and maintenance instructions. This shall provide schedules and time intervals for routine inspection, maintenance and lubrication tasks, referring to individual manufacturer's instruction manuals for full details. They shall describe briefly to more complex tasks that will be needed from time to time (see note below)
- (g) fault finding and correction. This shall provide a guide to first line checks that can be undertaken in the event of equipment failure, without the need for reference to the detailed instructions. A detailed guide of more complex checks shall be provided as below
 - (i) more complex tasks, involved with plant shut-downs, fault rectification to component level, fault diagnostics, overhauls, etc.
 - (ii) specific hazards associated with operating and maintaining the equipment, e.g. auto starting, high voltage, noise levels
 - (iii) highlight any particular complex or critical tasks over the above normal requirements

(iv) measurements and guidance on limits of acceptable wear for all items subject to wear.

(h) spare parts

(i) The Contractor shall assess and recommend the consumable and strategic spares requirements of all equipment supplied under the Contract. They shall be listed in the manuals. These and any other recommended spares shall also be identified in sufficient detail for the Employer to select and purchase spares, and shall be provided with drawings or annotated diagrams showing the spare parts

(ii) consumable spares are for those components which are scheduled for routine replacement during annual or more frequent service

(iii) strategic spares are for those components or items of equipment (e.g. gear box) not duplicated by standby equipment, which are expected to operate for not less than 5 years under normal operating conditions, but whose premature failure would cause the process to fail

(iv) the Contractor shall indicate which spares are available ex-stock.

(v) the Contractor shall provide all the above necessary spares during the maintenance period and in addition shall provide sufficient spares for 2 years of operation on issue of the PCC.

(vi) It's up to the concerned Engineer to finalize the consumable spare parts based on the BOQ, Manufacturer's recommendations & has right to add any additional spares deemed pertinent.

(i) special tools. A list of the special tools supplied for the maintenance of all equipment included in the Contract shall be provided

(j) test certificates. Certificates and documents of equipment tests shall be provided (e.g. pressure vessels, lifting equipment, etc.). Performance test certificates and characteristic details shall be provided. Set points for timers, overloads, pressure switches, relief valves, etc. shall be provided

(k) inventory of as-fitted equipment. A schedule of this shall be provided

(l) drawings list. A list of the as-built drawings shall be provided

11 As built drawings

(a) after erection has been completed, the Contractor shall submit to the Engineer copies of the following "As-built" drawings for approval, including:-

(i) piping and instrumentation diagrams

(ii) Civil foundation drawing for pumps and valves

(iii) site layouts showing main works operational features

(iv) equipment layout

(v) general arrangement drawings

(vi) mechanical details

(vii) electrical power circuit diagrams

(viii) control schematic diagrams

(ix) HV and LV distribution single line diagrams

(x) HV and LV cable routes

- (xi) PLC or computer programs
 - one master copy of the proprietary software package shall be provided to the Engineer within one week of the issue of the PCC. All software licences and/or registration requirements must be forwarded promptly to the Engineer for subsequent registration with the manufacturer. Sole rights to all software developed and written on all schemes financed by Employer will be retained by the Employer
 - (xii) PLC Drawing and System architecture
 - (xiii) assembly drawings shall clearly show the construction details and be in sufficient detail to facilitate dismantling and re-assembly
 - (xiv) parts lists shall be included for identification of replacement items
 - (xv) cable schedules shall include cable reference numbers and core reference numbers relating to power circuit diagrams
 - (xvi) diagrams where necessary shall be in colour to identify different components, networks, systems etc.
- (b) the above are to be supplied to the approval of the Engineer. The Contractor shall provide the Employer prints of each on thick paper and one ISO size A1 (594 x 420) negative of each. All drawings shall be prepared on a CAD system and printed on ISO standard sized paper A3 unless specifically requested otherwise. One set of drawings shall also be submitted in Windows based AutoCAD System, software version and storage media shall be as approved by the Engineer. Each drawing shall be marked with the Employer's, Consultant's, Contractor's and manufacturer's names and references, drawing number, title, scales, date of completion and a full description and date of all amendments, and shall be certified 'as-built'. The project title shall be included in a box at the bottom right hand corner of each drawing.

1.1.5 Quality Standards

- 1 All equipment furnished shall be new, and where feasible, shall be a standard product of an approved or experienced manufacturer, and assembled from standard components readily available.
- 2 Equipment shall conform to the requirements of the Project Specifications and reference standards.
- 3 Manufacturers shall operate an ISO 9001 approved quality system, or equivalent in-house quality system. If requested, details of the quality system shall be submitted to the Engineer.

1.1.6 Manufacturer's Experience

- 1 Manufacturer's shall be from the approved list in the Project Specification and 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 5 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.

1.1.7 **Factory Inspection**

- 1 The Engineer or his representative may inspect the equipment at the factory. The Contractor shall notify the Engineer of the manufacturing schedule 30 days before commencement in order that the factory inspection can be arranged. Factory inspections will be made at any reasonable time during manufacturing, testing or after the completion of testing and prior to shipment. Approval of equipment at the factory only allows the manufacturer to ship the equipment to the Site and does not constitute final acceptance. Where specified, the Contractor shall include in the Contract Price for all the costs of the Engineer or his representative.

1.1.8 **Factory Tests and Test Certificates**

- 1 Factory tests shall be carried out as specified in the Project Specification at manufacturing facilities places, and as required by international standards and industry norms. Detailed factory test procedure shall be provided by the Contractor and submitted for Engineer's approval. FAT procedure shall be approved minimum 30 days before FAT date.
- 2 The Contractor shall notify the Engineer in writing of the Factory Acceptance Test (FAT) schedule dates, 30 calendar days before commencement date of Factory Acceptance Test. Witnessing of Factory Acceptance Test shall include the following equipment as minimum, pumps (above 50 KW), Macerators, Blowers, Process Compressors and, Centrifuges, Valves (above 600mm), Penstocks (above 600mm) and generators (above 200 kVA). These inspections, examinations and tests shall not relieve the Contractor, in any case, from the contractual responsibility and commitments.
- 3 The Contractor shall ensure that the manufacturer provides all labour, materials, electricity, fuel, stores, apparatus and all instruments as are requisite and as may reasonably be required to carry out the test efficiently. The Engineer or his representative may witness the tests. Where specified the Contractor shall include in the Contract Price for all the costs of the Engineer or his representative.
- 4 The Contractor shall submit from the equipment manufacturer, or his authorised representative, a certified written 3.1 type test certificate as a general for non-critical equipment and 3.2 type certificate for critical equipment required by the Engineer in accordance with EN 10204 and requirements of the relevant test procedure.
- 5 If after examining or testing any equipment the Engineer, 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.
- 6 Wherever possible Site conditions shall be simulated, or the tests shall be extended to allow for Site conditions.

1.1.9 **Shipment, Storage and Handling**

- 1 All equipment shall be boxed, crated or otherwise enclosed and protected for shipment, handling, and storage. Electrical materials shall be delivered in manufacturer's original cartons or containers with seals intact as applicable. Large multicomponent assemblies shall be delivered in sections that facilitate site handling and installation.

- 2 All equipment shall be kept dry, off the ground and covered from exposure to weather prior to installation. Pumps, motors, electrical equipment and equipment having anti-friction or sleeve bearings shall be stored in weather proof storage facilities. Where possible, heaters provided in equipment shall be connected and operated until the equipment is placed in operation. The Contractor shall prevent corrosion, contamination or deterioration of stored equipment. Storage shall be covered and the temperature and humidity maintained according to the manufacturer's requirements.
- 3 Equipment and materials shall be handled in accordance with manufacturer's recommendations. Large or heavy items shall only be lifted by the designated points. Padded slings and hooks shall be used for lifting to prevent damage.
- 4 All equipment shall be fully protected until final acceptance and all factory surfaces shall be protected from impact, abrasion, discoloration and other damage. All damaged equipment shall be repaired or replaced before final acceptance.

1.1.10 Adaptation of Equipment

- 1 Any alteration of the structure or building shown on the Contract Drawings to accommodate substitute equipment shall be the responsibility of the Contractor. Equipment which requires alteration of the structures or buildings will be considered only if the Contractor assumes all responsibility for making and co-ordinating all necessary alterations, at no additional cost to the Employer. All modifications to structures, mechanical, electrical, or other work made necessary by such substitution shall require the approval of the Engineer. The cost of this work shall be made at the Contractor's expense.
- 2 Following approval of the mechanical and electrical drawings the Contractor shall prepare and submit to the Engineer the revised drawings showing any necessary modifications to the proposed buildings and civil structures. The location, size and details of box-outs and fixings for mechanical and electrical and other equipment shall be shown on the revised Drawings and the Contractor shall be responsible for providing in the civil structures the correct location and size of the box-outs and fixings shown on the approved mechanical and electrical drawings. The Contractor shall prepare at his own cost the necessary revised civil drawings and detailed structural and other design calculations and submit them to the Engineer for approval. The Contractor shall not be entitled to an extension of time for completion for any delays from the preparation of such revised drawings.

1.1.11 Guarantee

- 1 The Contractor shall provide a guarantee during the maintenance period for all the equipment in accordance with the General Conditions of Contract. In addition to the general guarantee requirements, equipment warranty shall cover:
 - (a) faulty or inadequate design
 - (b) improper assembly or erection
 - (c) defective workmanship or materials

1.1.12 Job Conditions

- 1 The Contract Drawings indicate the general arrangement, layout and locations of equipment, valves, inserts, anchors, motors, panels, pull boxes, cables, conduits, stub-ups, lighting fixtures, power and convenience outlets, and exterior lighting units, and may not be exact. The Contractor shall conform to the Drawings as closely as possible, exercising care to secure approved headroom and clearances, to overcome structural interference and to verify scaled dimensions, field dimensions and conditions at the place of work.

1.1.13 Approved Manufacturers and Subcontractors

- 1 The Contractor shall ensure that all equipment shall be supplied, installed, tested and commissioned by subcontractors recommended by the equipment manufacturer and approved by Engineer. Large complex units, shall be installed, tested and commissioned by the manufacturers representatives as specified. Installation procedures shall be supplied and authorised by the equipment manufacturer.

1.1.14 Hydraulic Sump Model Testing

- 1 Unless otherwise specified in the Project Specification hydraulic sump model tests shall be performed by the pump manufacturer or an approved specialist hydraulic testing laboratory.
- 2 Physical hydraulic model tests shall be carried out to study the hydraulic performance of the sump and behaviour of flows in the wet well for all possible combinations of pump operation.
- 3 Models shall be designed and constructed to a scale approved by the Engineer as necessary to properly assess the wet well performance.
- 4 The model tests shall investigate the effects of the pump performance on sump operation and provide information on the following as a minimum:
 - (a) hydraulic conditions in the pumping station inlet and wet wells under varying flows and pump combinations
 - (b) formation of air entraining vortices in the sums
 - (c) formation of swirl at the suction pipework of the pumps
 - (d) velocity distribution in the suction pipework of each pump
 - (e) hydraulic surge effects in the pumping station inlet and wet wells caused by starting or stopping of one or more pumps
 - (f) start/stop levels for the pumps
 - (g) grit and solids deposition in the wet well.
 - (h) videos and coloured photographs with time and date stamping shall be produced to show the model test and important features. Commentaries shall be added to videos to describe the events recorded.
- 5 The model tests and study shall make recommendations on any modifications to the pumping station inlet and wet wells considered necessary to overcome adverse hydraulic conditions, and the provision of any flow splitters, diverters and benching required to improve the hydraulic conditions.
- 6 Model Requirements:
 - (a) the model shall be constructed to an approved scale based on an appropriate Froude number and the pumping station general arrangement drawings
 - (b) the walls of the wet well and inlet arrangement shall be constructed from transparent material to allow the flows to be viewed. The top of the model shall be open to allow viewing of the flows. A viewing platform above the model shall be provided for inspection and measurement
 - (c) the method of construction shall be such that the dimensions of the wet well may be adjusted to vary the hydraulic distribution and identify the optimum shape
 - (d) the Contractor shall submit four copies of drawings showing the general arrangement and details of the models for approval by the Engineer. The drawings shall also show details of all ancillary equipment forming part of the testing
 - (e) after completion of the testing the Contractor shall submit to the Engineer 4 copies of the Model Test report, including all documentation, photographs and videos.

1.1.15 Sewage Characteristics

- 1 Sewage characteristics are typical of an arid climate municipal area with a sewerage system comprising gravity sewers and rising mains. Hydrogen Sulphide is present in varying levels throughout the sewerage system and the levels given in the Project Specification must be used for materials selection.
- 2 Unless otherwise specified in the Contract documents, typical Qatar sewage characteristic shall be taken as:
 - (a) Temp °C 25 - 45
 - (b) PH 7.0 - 7.5
 - (c) BOD mg/l 200 - 220
 - (d) SS mg/l 150 - 200
 - (e) Alkalinity (CaCO₃) 225 - 245
 - (f) Chloride mg/l 400 - 500
 - (g) Sulphide mg/l 10 – 16
 - (h) TDS 1500 – 2000

1.2 PRODUCTS

1.2.1 Materials

- 1 All materials used in the manufacture of equipment shall be new, and guaranteed free from defects, and shall be capable of resisting corrosion from sewage. The Contractor shall ensure that the manufacturer ascertains the conditions and service under which materials and equipment are to operate and warrants that operation under those conditions shall be successful. Equipment and materials provided shall be suitable for the service conditions and for meeting the specifications. All structural members shall be considered as subject to shock or vibratory loads.
- 2 All equipment and materials shall be designed to sustain all stresses that are likely to occur during fabrication, handling, transportation, erection, and intermittent or continuous operation.
- 3 Iron castings shall be tough, close-grained grey iron free from blow-holes, flaws, or excessive shrinkage and shall conform to EN 1561 Grade 250 and to EN 1563 Grade 250 for ductile iron unless otherwise specified.
- 4 Structural steel shall be as specified in Section 8, 16 and 17.
- 5 Stainless steel shall be BS 970 Grade 316 S31 unless otherwise specified. All references to BS 970 Grade 316 shall include the statement '(partially replaced by EN 10084) after 'Grade 316'.
- 6 Bolts, nuts, washers and anchor plates, shall be of stainless steel Grade 316 S31, to BS 970-1, and shall remain unpainted. At least two washers shall be provided with each nut and bolt set. PTFE or nylon washers and spacers shall be fitted beneath stainless steel washers for both bolt head and nut when used to fix dissimilar metals.
- 7 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.

- 8 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 washers and tightened down, the threaded portion shall fill the nut and not protrude from the face thereof by more than half the diameter of the bolt. However, two complete threads must be visible as a minimum.

- 9 Safety guards shall be of stainless steel of Grade 316S31 to BS 970-1.

1.2.2 Workmanship

- 1 All equipment shall be designed, fabricated, and assembled in accordance with the best modern engineering practice. Individual parts shall be manufactured to standard sizes and gauges so that repair parts, are readily available and where practicable can be replaced on site. Corresponding parts of duplicate units shall be interchangeable.

1.2.3 Tropicalisation

- 1 The equipment shall be suitable for installation in tropical areas. Tropical grade materials shall be used wherever practicable. Some relaxation of these provisions may be permitted where equipment is hermetically sealed.
- 2 Iron and steel are to be painted or galvanised unless specified otherwise. Indoor parts may alternatively be chromium or copper-nickel plated or other approved protective finish. 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 shall be treated in an approved manner to prevent rusting. Cores which are built up of laminations or cannot be anti-rust treated shall have all exposed parts thoroughly cleaned and heavily enamelled, lacquered or compounded.
- 3 Iron and steel shall not be used in instruments and relays. Where used, steel screws shall be zinc, cadmium or chrome plated or, where plating is not possible due to tolerance limitations, shall be dull nickel plated brass or be of other approved finish. Instrument screws except those forming part of a magnetic circuit shall be brass or bronze. Springs shall be of non-rusting material. Pivots and other parts for which non-ferrous material is unsuitable shall be of an approved stainless steel.
- 4 Fabrics, corks, paper and similar materials, which are not subsequently to be treated by impregnation, shall be adequately treated with an approved fungicide. Sleeving and fabrics treated with linseed oil varnishes shall not be used.
- 5 Wood shall not be used in equipment unless absolutely necessary. Where used, woodwork shall be of thoroughly seasoned teak or other approved wood which is resistant to fungal decay and free from shakes and warp, sap and wane, knots, faults and other blemishes. All woodwork shall be suitably treated to protect it from the ingress of moisture and the growth of fungus and termite attack. All joints in woodwork shall be dove-tailed or tongued and pinned. Where used, metal fittings shall be of non-ferrous material.
- 6 Adhesives shall be impervious to moisture, resistant to mould growth and not subject to the ravages of insects. For jointing woodwork only synthetic resin cement shall be used.

1.2.4 De-rating Due to Climate Conditions

- 1 The De-rating requirements for the climate conditions for all materials and equipments shall be in accordance with Section 21 unless otherwise agreed with the Engineer.

1.2.5 Steel

- 1 Fabrication of structural steel shall conform to BS 449 and BS 5950 AWS D1.1 unless otherwise indicated or specified. All fabrications shall be designed for dynamic and vibratory loadings. Welding shall conform to Sections 16 and 17. All steelworks shall be galvanised after fabrication unless otherwise specified. Galvanised bolts and fasteners shall be used with galvanised assemblies.
- 2 If practicable, steel plate and members shall have a minimum nominal thickness of 6 mm
- 3 Wrought steels shall be selected from the appropriate steel grade of BS 970 and shall be free from blemishes, shot or hammer marks. The steel grade used shall be subject to the Engineer's approval.
- 4 Cast molybdenum steel shall be to BS 3100 Grade B unless otherwise specified.

1.2.6 Equipment Bases and Bedplates

- 1 Equipment assemblies shall be mounted on a single heavy cast iron or welded steel bedplate unless otherwise shown or specified. Bases and bedplates shall be provided with machined support pads, tapered dowels for alignment or mating of adjacent items, adequate openings to facilitate grouting, and openings for electrical conduits. Seams and contact edges between steel plates and shapes shall be continuously welded, and welds ground smooth. Machinery or piping shall not be supported on bedplates other than that which is factory installed. Jacking screws shall be provided in equipment bases and bedplates to aid in levelling prior to grouting. Plates of minimum thickness of 6 mm shall be provided. Pump bedplates shall include a drip lip and provisions for directing gland leakage to a single disposal point.

1.2.7 Anchors and Sleeves

- 1 Each equipment manufacturer shall supply the required anchor bolts, nuts, washers, and sleeves of adequate design for securing the bases and bedplates to concrete plinths. They shall be stainless steel or, hot-dip galvanised as specified. Sleeves shall be at least 1.5 times anchor bolt diameter. Anchor bolts shall be provided of sufficient length to allow for maximum of 40 mm of grout under baseplates and adequate anchorage into structural concrete.
- 2 All anchors used in wet areas or areas containing sewage or sewage gases shall be resin anchors of BS 970 grade 316 S31 approved stainless steel. Fixing anchors shall be sealed with material appropriate to and recommended by the manufacturers of the concrete protection material.
- 3 Steel work shall normally be bolted to the concrete, with grout added as necessary. G.R.P. lamination or other lining material shall be terminated on the equipment secured. Consideration shall be given to subsequent removal of equipment, using additional brackets or bolts which can be demounted without affecting the lining material.

1.2.8 Safety Guards

- 1 Belt or chain drives, fan blades, couplings, exposed shafts and other moving or rotating parts shall be covered on all sides with safety guards to BS 5304. Safety guards shall be free of all sharp edges and corners. Safety guards shall be fabricated from a minimum of either 2 mm thick, galvanised or aluminium-clad steel, or 12 mm mesh galvanised expanded metal. Guards shall also be of sufficient strength to contain rotating parts in the event of a catastrophic failure. Guards shall be designed for easy installation and removal. Necessary supports, accessories, and fasteners shall be provided, of hot-dip galvanised steel or stainless steel. Guards in outdoor locations shall be designed to prevent entrance of sand. Hinged access doors shall be provided for routine maintenance. Microswitches shall be provided on guards to prevent the main drive from starting, if specified.

1.2.9 Drive Units

- 1 The requirements for the design, manufacture, construction installation, testing and commissioning of drive units shall be in accordance with Section 21 unless otherwise agreed with the Engineer.

1.2.10 Bearings

- 1 The Contractor shall select the most appropriate type of bearing for the equipment being supplied.
- 2 Equipment with vertical shafts shall have thrust and guide bearings.
- 3 Sealed for life units are to subject the Engineer's approval and shall have a minimum design life of 100,000 hours operation at maximum loading.
- 4 Bearings fitted to gearboxes shall have a minimum design life of 100,000 hours at maximum loading.
- 5 Plant which may be subject to vibration whilst stationary shall be provided with bearings designed to withstand damage from such a cause.
- 6 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 conditions can readily be inspected.
- 7 Plain type bearings shall be self-lubricating by either grease, forced oil or impregnation.
- 8 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 and water.
- 9 Bearings not integral with a casting shall be mounted in substantial Plummer blocks.
- 10 Bearings shall be sized and rated for the temperatures encountered in service conditions. Additional cooling shall be provided if necessary.

1.2.11 Lubrication

- 1 Suitable lubrication 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.
- 2 The Contractor shall supply the first fill of oil and grease from approved lubricant suppliers prior to completion, testing, and final acceptance. In addition sufficient approved lubricants for two years normal operation shall be provided.
- 3 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.
- 4 Gearboxes and oil baths shall be provided with adequately sized filling and draining plugs and suitable means of oil level indication.
- 5 Roller chain drives shall have a constant feed of lubricant, when in operation (viz oil bath or autolube system).
- 6 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.
- 7 Bearings equipped with forced fed oil lubrication shall be automatically charged prior to machinery starting up, and pressure monitored during operation, with automatic shutdown of machinery and alarm on low oil pressure.

- 8 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.
- 9 The design of breathers shall take into account the humidity and atmospheric contamination at the vent point and measures shall be incorporated to prevent contamination of the lubricant.
- 10 Grease application shall be by steel lubrication nipples manufactured in accordance with B.S. 1486, Part 1 and 4.
- 11 Anti-friction bearings requiring infrequent charging shall be fitted with hydraulic type nipples.
- 12 Plain bearings requiring frequent charging shall be fitted with button head pattern nipples.
- 13 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 B.S. 1486, Part I, Table 9 and 10.
- 14 The type, grade and amount of lubricant shall be clearly marked on a label adjacent to the equipment.
- 15 Lubricants shall be suitable for the temperatures encountered in service conditions. Additional cooling of lubricant shall be provided if necessary.
- 16 Lubrication of equipment shall ensure constant presence of lubricant on all wearing surfaces. Lubricant fill and drain openings shall be readily accessible. Easy means for checking the lubricant level shall be provided. Prior to testing and/or operation, the equipment shall receive the prescribed amount and type of lubricant as required by the equipment manufacturer. Equipment lubrication systems shall require no more than weekly attention during continuous operation, shall not require attention during start-up or shut down, and shall not waste lubricants.

1.2.12 Electric Motors

- 1 The requirements for the design, manufacture, construction installation, testing and commissioning of motors shall be in accordance with Section 21 unless otherwise agreed with the Engineer.

1.2.13 Pressure Gauges

- 1 Gauges shall be connected to the suction (where applicable) and discharge pipework of each pump, compressor and blower. The gauges shall be 150 mm diameter and in accordance with BS 1780 and Section 10 and shall include a petcock between the pump/blower and the gauge. A non-corrosive diaphragm gauge isolator shall be provided for solids-bearing or corrosive fluids. Suction gauges shall be of the compound type and shall have a range of ± 1 bar. Discharge gauge ranges shall be a standard commercially available range with the maximum reading 1.2 times greater than the pump's rated shut-off pressure. Discharge gauges shall also read to -1.0 bar. All gauge mountings shall be free of vibration.
- 2 The pressure readings shall be recorded on the MCC/SCADA system using pressure transmitters.
- 3 Pressure gauges shall be always kept calibrated as QCS Section 10 requirements.
- 4 All pressure gauges should have an option to fill fluids or liquid glycerin

1.2.14 Nameplates and Data Plates

- 1 Nameplates and data plates shall be stainless steel of ample size with embossed, stamped or etched lettering in English, fastened to the equipment in a prominent place with corrosion-resisting pins. The manufacturer, serial number, date of manufacture, model number and essential operating characteristics shall be displayed on nameplates, which shall be to the approval of the Engineer. Data plates shall be inscribed with specific or directed information.

1.2.15 Painting and Protective Coatings

- 1 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 colours. They shall be to the approval of the Engineer, and the following requirements, unless modified or otherwise specified elsewhere. Painting systems shall be as specified in Section 8 Part 8.
- 2 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.
- 3 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. Primers specified for the required field applied paint systems as in Section 8 shall be used. 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.
- 4 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 aluminium be anodised. Structural galvanised steel and stainless steel need not be coated.

1.2.16 Noise Levels and Vibration

- 1 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 metre 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. Noise levels shall be limited to the values specified for designated equipment.
- 2 Vibration Levels : The Contractor shall ensure that the stiffness of the floors/buildings and supporting structures must be meet the requirements of vibration and resonance respect to frequencies. Vibration levels shall be within the limits and comply with ISO 10816 (ISO 20816), Parts 1, 3 , and ISO 10816-7.

1.2.17 Metal Plating

- 1 Chromium plating shall be to BS 1224 (ISO 1456).

2 Sheradising shall only be used in internal air conditioned environments, and shall be to BS 4921.

3 Galvanising shall be hot-dip, to BS 729. Whenever possible steel in a wet or external environment shall be galvanised.

1.2.18 MV Factory Built Assemblies (FBA's)

1 The requirements for the design, manufacture, construction, installation testing and commissioning of all labour, materials and accessories for the MV Cubicle Switchboards, Main Switchboards, Submain Switchboards, Motor Control Centres, MCCB panel boards, distribution boards etc shall be in accordance with Section 21 unless otherwise agreed with the Engineer.

1.2.19 Control Panels (PLC/SCADA/HMI)

1 The requirements for the design, construction, installation, testing and commissioning of all automation works such as PLC, SCADA & related instrument works shall be in accordance with Section 10 unless otherwise agreed with Engineer.

1.3 INSTALLATION AND COMMISSIONING

1.3.1 Co-ordination

1 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 judgement 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.

2 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.

1.3.2 Inspection During Installation

1 For the tests on the Site the Contractor shall provide at his own expense unless specified otherwise, such labour, materials, electricity, fuel, stores and apparatus and instruments as may be requisite and as may be reasonably demanded to carry out such tests efficiently.

2 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.

1.3.3 Preparation of Installation Areas

1 Prior to installing the equipment, the Contractor shall ensure that installation areas are clean, free of dust intrusion and that concrete or masonry operations are completed. The installation areas shall be maintained in broom-clean condition during installation operations. All buildings where permanent doors and windows have not been installed shall be provided with temporary protection to prevent dust ingress and any other damage to equipment, all to the approval of the Engineer.

1.3.4 Manufacturers' Installation Supervision

- 1 Where specified in the Project Specification, the Contractor shall ensure that each equipment manufacturer furnishes the services of an authorised representative especially trained and experienced in the installation of his equipment to:
 - (a) supervise the equipment installation in accordance with the approved instruction manual
 - (b) be present when the equipment is first put into operation
 - (c) inspect, check and adjust until all trouble or defects are corrected and the equipment installation and operation are acceptable
 - (d) witness and supervise operational demonstrations and system validation tests to the extent specified.
 - (e) prepare and submit certified test report.
- 2 All costs for manufacturers' representatives services shall be included in the Contract Price.

1.3.5 Installation

- 1 General. Prior to installation the equipment shall be cleaned, conditioned, and serviced in accordance with the approved instruction manuals.
- 2 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 specialised tools and equipment, such as precision machinist levels, dial indicators, gauges, and micrometers, as applicable.
- 3 Anchor Bolts. The Contractor shall provide bolts with templates or setting drawings and verify that bolts are correctly located before structural concrete is placed.
- 4 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 bevelled 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.

1.3.6 Testing and Commissioning

- 1 General
 - (a) operational demonstrations and system validation tests are required for all mechanical and electrical equipment, and systems specified including all associated and related electrical systems and control devices specified in this Section, Sections 10 and 21, and the Project Specification
 - (b) all costs for these shall be included in the Contract Price

- (c) materials, potable water, chemicals and electrical power for testing and commissioning and validation shall be supplied by the Contractor. Temporary facilities, storage, and similar facilities necessary for these shall be supplied by the Contractor. Testing and commissioning shall be performed under continuous inspection by the Engineer. The Contractor shall provide sufficient experienced skilled staff to carry out the testing and commissioning. Various equipment manufacturers shall be present, if specified.
- (d) all defects and malfunctions found by testing and commissioning shall be corrected immediately, using approved methods and new materials for repairs as required. Interruption time necessary for corrective work may, at the Engineer's discretion, be added to the specified testing and commissioning periods
- (e) satisfactory completion and approval of required commissioning and testing is one of the conditions precedent to the Engineer's acceptance of the work, but does not constitute final acceptance
- (f) testing and commissioning shall be in accordance with the Project Specification, the QCS, the relevant International Standards, QGEWC requirements, industry norms and to the Engineer's approval.

2 Test Procedures

- (a) testing shall be carried out in stages as follows:-
 - (i) primary tests and checks
 - (ii) unit testing
 - (iii) system validation tests
 - (iv) commissioning and setting to work
- (b) the Contractor shall not proceed from one stage to the next without the Engineer's written approval
- (c) consolidation of demonstration, testing, and instruction requirements. Unit and system validation testing, commissioning and instruction of the Employer's personnel may be performed simultaneously.

3 Primary Checks and Tests

- (a) all component units and complete systems shall conform to the Specifications, Drawings and the approved working drawings, samples, construction manuals, material lists, and other approved submittals
- (b) all specified components and complete systems shall have been installed satisfactorily and are operable
- (c) all installations shall be safe to use. Temporary access, covers etc. will only be permitted if approved by the Engineer
- (d) all cleaning work shall be completed
- (e) equipment shall be free from physical damage due to mechanical force, exposure to the elements, incorrect connection, etc.

4 Unit Testing

- (a) unit testing is defined as tests on individual equipment such as pumps, compressors, blowers, fans conveyors and all similar equipment item. Tests may be performed simultaneously on groups of identical equipment, items, and groups of items supplied by one manufacturer, if practicable
- (b) potable water shall be used to fill tanks, wells piping and systems that contain water, sewage, or sludge in normal operation. Where necessary specified chemicals shall be used for chemical systems but shall not exceed in-service concentrations

- (c) tests shall show that all component units operate with the quantities, efficiency, repeatability, and accuracy specified
- (d) tests shall be carried out continuously for a minimum period of 8 hours, unless other periods are specified.

5 System validation tests

- (a) system validation tests shall not commence until unit tests have been satisfactorily completed
- (b) this is defined as testing of complete systems that perform a discrete process function such as pumping systems, emergency power 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 specific function
- (c) potable water shall be used for system validation tests if it is possible to carry them out satisfactorily with this medium. If the tests require use of the medium used in service, then this shall be used
- (d) each system validation tests shall be carried out for minimum of 24 hours, unless longer is needed to prove the performance of the system.

6 Commissioning and Setting to Work

- (a) commissioning is defined as testing all the equipment and systems together under actual operating conditions using all the mediums used in actual operating conditions. Setting to work follows consecutively from this. Once the equipment and systems are operating satisfactory they are left to work
- (b) each system shall be tested, including standby equipment, by continuous operation under the “in-service” condition for not less than 7 consecutive days unless required otherwise by the Engineer, with no interruptions except for normal maintenance or corrective work. Where the in-service condition is an automatically controlled repeat cycle with on/off intervals, it shall be so operated
- (c) systems shall be operated continuously under constant inspection of trained operators. System operation shall be cycled from full load to light load and back to full load each 24 h. Variable speed equipment shall cycle through the applicable speed range at a steady rate of change. Simulated alarm and failure operating conditions shall be induced. Test controls and protective devices shall be tested for correct operation in adjusting system functions or causing system shutdown
- (d) failure of an item of equipment or a system during the stated periods will result in termination of the test. The test will only recommence when the Engineer is satisfied with the remedial work. The test shall then recommence for a further 24 hours
- (e) subject to Contractor’s request and Engineer’s approval in each specific case, the Contractor may be permitted to simulate 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. The simulation methods shall reflect reasonable anticipated operating conditions.

1.3.7 Instruction and Training of the Employer's Personnel

- 1 After the equipment has been installed, tested, adjusted and placed in satisfactory operation the Contractor shall provide the services of qualified staff approved by the Engineer, or if specified in the Project Specification, of the manufacturer's representatives, to instruct and train the Employer's operating personnel in the use and maintenance of the key items of equipment as specified. An instruction and training programme shall be conducted for up to six operators designated by the Employer. The Contractor shall give the Employer at least one month's written notice of the proposed instruction and training programme. Instruction and training covering basic system operation theory, routine maintenance and repair, and "hands on" operation of equipment shall be included. The duration of the programme shall be based on the complexity of equipment involved, and the Engineer's approval of instruction adequacy obtained before terminating the programme. Instruction and training periods shall be acceptable to the Engineer and Employer.

1.3.8 In-Service Checks

- 1 General. In-service checks of all systems and equipment shall be carried out by the Contractor twice during the Contract maintenance period by the Contractor with qualified technical representatives of the various system manufacturers, including manufacturers of equipment components within systems, if specified. Checks shall be detailed and complete and shall be performed under the observation and to the satisfaction of the Employer. All costs for in-service checks shall be included in the Contract Price.
- 2 Notification. The Employer shall be notified in writing at least 10 days before carrying out of in-service checks and the Employer's approval shall be obtained prior to commencing work.
- 3 Consultation. During the in-service checks, the manufacturer's technical representatives shall consult with the Employer to review the instruction manuals and the pertinent operational and maintenance problems encountered, and shall furnish technical advice and recommendations to the Employer.
- 4 Programme. Initial in-service checks shall be performed approximately 6 months after final acceptance. The last in-service checks shall be performed 30 days prior to the end of the Contract maintenance period.
- 5 Reports. A written report on each in-service check, signed by the appropriate manufacturer or his representative, shall be delivered to the Employer within 10 days following the checks. The report shall describe the checking procedures in detail, and shall state all advice and recommendations given to the Employer.
- 6 Operation and Maintenance Manuals. These shall be altered to take into account any modifications to equipment, drawings or operating procedures. Replacement drawings and pages, marked as revisions, shall be supplied with sufficient copies to allow all the operation and maintenance manuals to be updated.

1.3.9 Specialised Training Programme for Employer's Personnel

- 1 Where designated in the Project Specification the Contractor shall provide a specialised training programme and manual for the Employer's key personnel in the equipment, electrical systems and instrumentation systems, to be conducted by the supplier/manufacturer and held at locations outside Qatar. The training programme and manual shall be submitted to the Employer for approval and shall be designed to:
 - (a) provide in depth information and familiarisation of the equipment installed in the Project
 - (b) receive specialised training in the design, proper operation, maintenance and replacement of the equipment and components

- 2 The Contractor shall provide whatever assistance is requested by the Employer to develop meaningful itineraries for the training programme. The Contractor shall provide hotel accommodation, travelling expenses by air, land transport and per diem allowance as per the Ministry of Education guidelines.

END OF PART

ARAB ENGINEERING BUREAU