

PART 3 – GENERAL AND TECHNICAL SPECIFICATIONS

PART 03 – TECHNICAL SPECIFICATIONS

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01 000 GENERAL REQUIREMENTS

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01 000 GENERAL REQUIREMENTS

1. GENERAL

1.1. REFERENCE TO OTHER CHAPTERS

Throughout the Specifications and Bill of Quantities, references are occasionally made to other Chapters. All such references are intended solely for the convenience of those using the documents, and the absence of a reference in no manner excludes the application of every other Chapter in the Specifications which may, in the opinion of the Engineer, have any bearing upon the point in question, the intention being that the Contract Documents shall be read and applied as a whole.

1.2. NON-DISCLOSURE OF INFORMATION

The Contractor shall not without the consent in writing of the Employer disclose particulars of the Contract to any person or furnish or publish or permit to be furnished or published any information with regard to the Employer's business to any person save in so far as may be necessary for the due performance of the Contract and shall preserve strict confidence with regard to any information of a confidential or secret nature received from the Employer or the Engineer.

1.3. CLAIMS FOR DAMAGES TO PERSONS OR PROPERTIES

Any claim received by the Employer in respect of matters in which the Contractor is required under the Contract to indemnify the Employer will be passed to the Contractor who shall likewise inform the Employer of any such claim which is submitted directly to him by a claimant. The Contractor shall do everything necessary, including notifying the insurers of claim received, to ensure that all claims are settled properly and expeditiously and shall keep the Employer informed as to the progress made towards settlement. If the Contractor receives a claim which he considers to be in respect of matters for which he is to be indemnified by the Employer under the Contract, he will immediately pass such claim to the Employer. All information as aforesaid shall be given in writing and shall be copied to the Engineer.

2. SPECIFIC INFORMATION RELATED TO THE PROJECT

2.1. PROJECT LOCATION

The construction site for the new and rehabilitated Aeratsia Waste Water Treatment Plant is located at the existing wastewater treatment site in the Shengavit District of the Yerevan Municipality.

2.2. SITE CONDITIONS

2.2.1. GENERAL

A site investigation has been carried out for the WWTP, a copy of the soil investigation works (Boreholes logs + laboratory tests) has been attached in the Tender (part 5 of Appendix 6).

The Contractor shall analyse these investigations and shall draw his own conclusion from the Site Investigation Report. The Client recognizes no responsibility of any conclusion the Contractor may draw thereof.

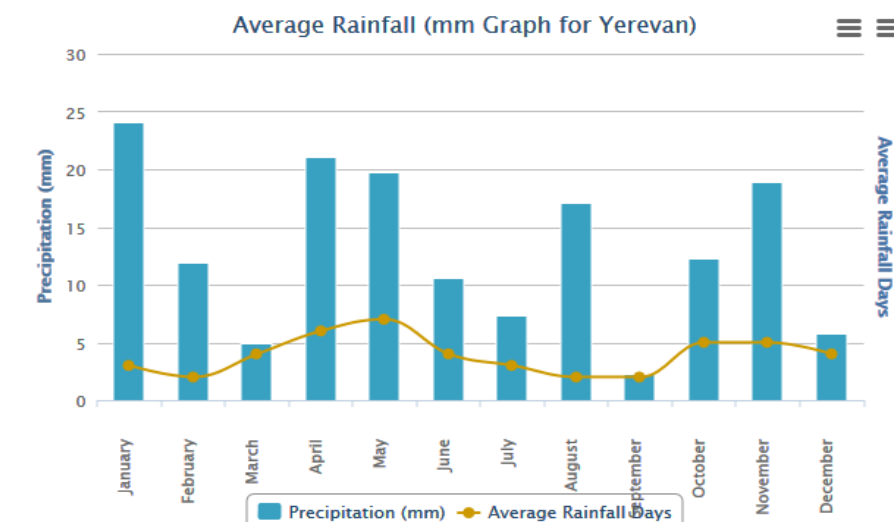
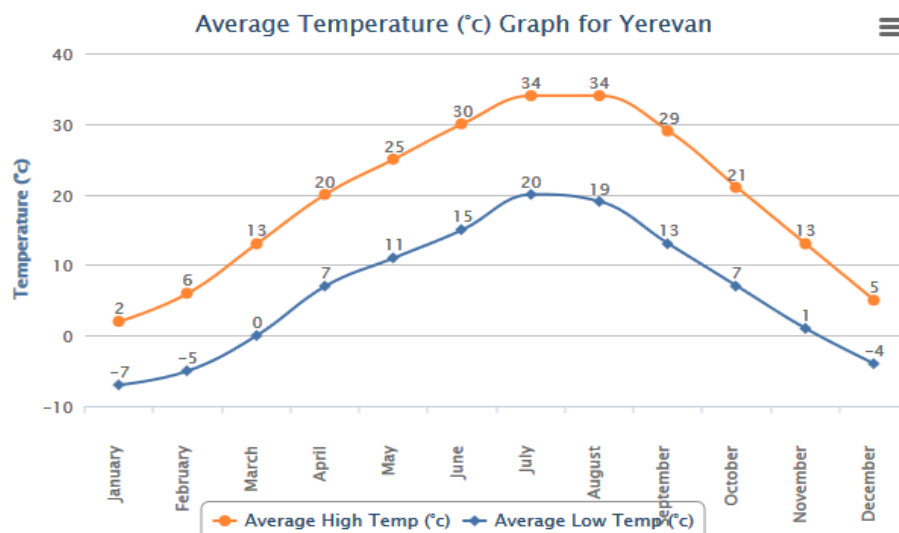
2.2.2. SEISMICITY

The evaluation of the ground acceleration to use for the structural calculations will be done in accordance with the National regulations.

2.2.3. CLIMATE

The climate is typically continental with hot summers and cold winters. The average monthly temperature varies between 34°C to -7°C. The temperature may be -20 °C for more than one week.

The average rainfall in Yerevan has a maximum in January with 24 mm. The number of rainy days per month varies from 2 to 7 days per month. Intense rain event occur regularly.



Source: World Weather Online

2.2.4. EXISTING FACILITIES WITHIN THE SITE OF WORKS

There are many buildings from the old Aeratsia plant at the site. The following buildings are in good conditions and will be reused for this project:

- Office building for the plant director and his staff
- Laboratory
- Main Entrance gate with Guard house
- Storage building to be reconverted as a sludge handling building, including a guard house and a secondary entrance
- Substations and power supply
- Artesian well with its pump
- Small Building for electrical room
- Two Inlet Pipes (gravity flow): one ND 1600 gravity pipe and one ND 1200 gravity pipe.
- Plant Bypass (inlet structure and pipe)
- One Outlet Pipes (gravity flow): ND 2000 gravity pipe from the plant Bypass to the Hazdran river, located on the side of the road, outside of the WWTP site.

In addition the site has many building or works that are to be demolished by the Owner prior to the beginning of the Construction Works under this Contract. The demolition performed by the Owner is shown on the drawings.

2.2.5. CONSTRUCTION PHASING

The Contractor shall consider the following elements for the construction Phasing to be submitted to the Engineer:

- Connection to the two existing Inlet Pipes: The ND 1600 gravity pipe and the ND 1200 gravity pipe are connected approximately 100 m upstream of the inlet Chamber by a ND600 connecting pipe. The ND 1200 pipe drops approximately 1m vertically in a chamber at the location where the connection to the ND 1600 pipe is located. Therefore backflowing of the ND 1200 pipe is feasible. If all flow is diverted from one pipe to the other during the construction of the connection Works to the existing pipes, the contractor shall provide a temporary pump if needed, as the ND600 may not pass the entire flow. Backflow to the sewer Networks upstream of the WWTP entrance gate shall not be acceptable.
- Connection to the existing outlet Pipe: The ND 2000 gravity pipe is continuously used as it transports the bypass and existing treated wastewater to the Hazdran River. The ND 2000 gravity pipe discharges to an existing effluent chamber located outside of the WWTP site, and approximately 300 m downstream of the "Offsite Outlet Chamber". From this existing Chamber the ND2000 pipe goes to the Hazdran River.

2.3. SCOPE OF WORKS

2.3.1. DESCRIPTION

The services to be provided by the Contractor include, but are not limited to the following:

- A. Mobilization Period documents

- Foundation drawings and temporary works
- Additional soil investigations, as considered required by the Contractor
- Construction Phasing Plan for connecting to existing facilities, including a written description and drawings as needed.
- Shop drawings and working drawings with the corresponding calculation
- Submission to the Armenian Authorities of the appropriate above listed documents for the Expertise and Construction Permit obtention.

B. Implementation

Works to be carried out by the Contractor include the following in particular:

- a) Installation of the site and preparatory works, connection to telecoms, water and other networks.
- b) Implementation of works in accordance with the “The Design”, as specified in the General Conditions of Contract, including in particular:
 - Preliminary drillings and investigations, as deemed necessary by the Contractor,
 - Earthworks and final backfilling, drainage (including removal and storage of materials and earth),
 - Special foundations, if necessary
 - All shell construction (reinforced concrete, masonry, framework, roofing, sealing, cladding, etc.),
 - All finishing and fitting works for the plant,
 - All equipment installation,
 - Fences, roads and utilities networks,
 - demolition of existing structures to be removed, if any, including pipes and the reuse or removal and dumping of the corresponding materials in locations authorized by local legislation, and levelling of the land thus freed,
 - Connection of the new installations with existing structures (pipes).
 - All pipes, whatever the position, as described on the drawings
- c) Implementation of the “electricity and electromechanical and hydro mechanical equipment” section in conformity with the Design, including the supply, testing and transportation on site of all necessary materials and equipment and their implementation or erection and adjustment, namely:
 - Hydraulic, mechanical and electrical treatment equipment, including driving equipment and control, monitoring, measurement, protection and safety devices
 - Miscellaneous equipment required for the proper operation and maintenance of the installations, (lighting, ventilation, heating, telephone, etc.),
 - The remote surveillance system, if any

- All small equipment, pipes, and all adjustments required for a proper operation
- d) The installation of all necessary fire safety equipment in technical rooms of the facility, in accordance with Armenian regulations.
- e) The commissioning of the installation and performance of the tests.
- f) The provision of maintenance and operating manuals, as-built drawings of the structures and yard piping.
- g) Supply of spare parts.
- h) Services for the Employer, as defined below and/or in this tender documents.
- i) No interference with the existing operation of the plant during construction, except during the connections to the existing facilities and in accordance with the submitted Construction Phasing Plan.

C. Operation and Maintenance

No Operation and maintenance service shall be provided under this Contract.

2.3.2. PARTICULAR PROVISIONS

2.3.2.1. PRODUCTS AND COMPONENTS STORAGE

While establishing their bids' prices, the bidders should be aware of the specific situation of Armenia in regards to transport and availability of construction materials. Then, the Contractor shall organize the supply of the works in order to manage to have enough materials and equipment on site in case of transport issues.

2.3.2.2. MAINTAINING EXISTING PLANT OPERATION DURING CONSTRUCTION

The Existing plant (screening with manual cleaning and grit removal) shall continue to operate during the Construction works and until the flooding of the new treatment plant.

The Grit is removed by front loaders and trucks which will need to have access to the existing grit tanks during construction.

2.3.2.3. PROVISIONS FOR A FUTURE PHASE 2

The wastewater treatment plant may be expanded to accommodate larger flows. For this purpose several provisions shall be included, as. noted on the drawing

In addition, under a future Phase 2, the primary solids might be directed to an anaerobic digestion prior to dewatering. For this purpose provisions shall be included as shown on the drawings.

In the future a Coagulation and Flocculation (area 104) could be added between the grit tanks (area 103) and the lamellar sedimentation tanks (area 105). For this purpose provisions shall be included as shown on the drawings.

2.4. ADJOINING CONTRACTS

This contract is one of three contracts to be implemented separately under "the RPE Yerevan project". These contracts are

- 1- Contract 1: Aeratsia Waste Water Treatment Plant,
- 2- Contract 2 : Water Supply & Wastewater Network Works
- 3- Contract 3: SCADA Projects (for the Water Supply Network)

2.5. SERVICES TO PROVIDE

2.5.1. VEHICLES

No Vehicles shall be provided by the Contractor to the Employer or the Engineer.

2.6. COMMISSIONING

With reference to Section 17 of this Specification, the following duration shall be strictly applied:

Pre-commissioning period: minimum 14 days

Commissioning period: 2 months

These periods are considered as a minimum, included in the time of completion.

3. DAY WORK

3.1. GENERAL

The Contractor shall complete the Day work prices in the Bill of Quantity.

No increase or decrease in price will be made for labour and materials day work charges.

The day work prices are not subject to adjustment.

Day works shall be paid, if any, through the Provisional Sum amount.

Day works shall be used and implemented only if the Engineer requests to do so.

3.2. LABOUR CHARGES

The labour categories qualifying as reimbursable to the Contractor when employed on day work shall include the gangers and charge-hands working with their gangs but shall exclude supervision for foremen level and above.

The Contractor will be reimbursed for the actual gross remuneration at the current rate for each labourer, tradesman, artisan, etc., which shall be deemed to include the following, but not limited to:

- Basic wage

- Unemployment insurance
- Workmen's compensation
- Service bonus
- Foods and water
- Transportation if any

The rates provided by the Contractor shall cover all the following cost:

- Supervision
- Overheads
- Profit
- Time keeping
- Accommodation
- Insurances
- Holidays with pay
- Travelling
- Subsistence
- Other bonuses
- Allowance for paid sick leave
- Allowance for non-productive time
- Recruitment costs
- Pay packet costs
- Pension
- Allowance for paid public holidays
- Allowance for paid annual leave
- Any statutory charges due
- Any and all other relevant to the employment of such employees including all liabilities, obligations, risks and incidentals for all employees to execute work by day works.

In addition,

- Only gangers and charge-hand who are working with their gangs shall be paid for under day works. The composition of each working gang on day works shall be approved by the Engineer prior to the commencement of such day work. Any ganger or charge-hand who does not work with the gang shall be deemed to be in a supervisory category.
- Site Agents, Quantity Surveyors, Engineers, Foremen and the like shall be deemed to be covered in the rates and prices in the Bill of Quantities.

- Overtime hours on day work operations will be worked when expressly required by an instruction in writing from the Engineer. Overtime when required will be paid in the same proportions as actually paid to the employees.
- The day work hours that labour work will be calculated from the time of arrival of the labour at the site where the work is to be carried out to the time of departure from such site but excluding meal breaks and rest periods, etc., i.e. the net time expended for the work.

The combination of the gross remuneration as stated in the Bill of Quantities and the percentage allowance on labour for day work will be deemed to constitute the full inclusive charge to the Employer for each respective labourer, artisan, etc. Such combination shall include for all items of equipment and consumable which are normal to the particular labourer, tradesman or artisan in question including portable power tools, manual plant and tools, etc. which have not been listed in the Day work Equipment Schedule. It shall also include the use of water, lighting, power, the ventilation and sewerage facilities, the use and maintenance of staging, scaffolding, workshops, stores and the like.

3.3. CONTRACTOR'S EQUIPMENT CHARGES

The Bidder shall complete the Day work Equipment Schedule in the Bill of Quantities in order to provide prices for all items of equipment to be provided on Site which may be required to execute work under day work.

The schedule must indicate clearly the total hourly operating rate, such as at 28 days prior to the closing date of tender, for each item of equipment. Such rates shall constitute the net charge to the Employer for the equipment, in a state fit to perform its intended function, including operating labour required for the equipment.

The cost of operators shall be included under equipment charges.

Equipment rates for day work shall take account for the following:

- Small tools are not to be listed separately and the use of such tools will be deemed to be covered in the percentage allowance tendered for day work labour charges and shall not be the basis of claims for payment under day work charges.
- No addition shall be allowed on the quoted rate for the transport of the said equipment to and from the areas of work if the equipment is already on Site. If, however, the equipment is brought onto Site especially for the extra work ordered, then the transport shall be charged extra at cost, unless such equipment continues in operation for work of a normal nature under the Contract.
- The operating rates to be quoted are to include for items such as fuel, oils, power, consumable, ground-engaging tools, maintenance, repairs, etc. and other incidentals.
- Full payment of the bid rate will not be made for items not capable of operating properly or unable to perform any of their intended functions.

The day work operating for equipment will be calculated from the separate times of arrival of each item of equipment at the site where the work is to be carried out to each time of departure from such site but excluding meal breaks and rest periods, etc. as arranged by the Contractor for the respective equipment operators. The time for transport between Working Areas or from a Working Area to other Site areas as relevant will subject to prior agreement with the Engineer, be included for reimbursement at the applicable day work rates.

The minimum time paid for each item of equipment commencing work on each day work order will be one hour (operating or standby if applicable) and thereafter the times operating or on standby will be paid to the nearest 0.25 hour (15 minutes).

The combination of the net cost as stated in the Schedules and the percentage allowance on equipment for day work will be deemed to constitute the full inclusive charge to the Employer in respect of the incorporation of such materials in the Works except as allowed for in the Day work Labour and Equipment items in the Bill of Quantities.

3.4. MATERIALS CHARGES

Reimbursement for materials used in day work will be at the net current cost of such materials as delivered to the Site (including delivery to and handling at the usual points at which materials are received on the Site), which will be assumed to be the Contractor's Working Area closest to where the work is to be executed.

The net cost of materials shall mean the cost, after the deduction of any discounts on the materials, as substantiated by invoices or other such documentary evidence. The measurement of materials shall exclude all waste, i.e. the total to be paid shall be for the net quantity actually incorporated in the completed work. The materials charges shall include:

- All overheads and profit,
- All storage and handling of materials and for distribution to the individual area(a) where day work is in progress,
- All other charges relevant to the use of materials for day work.

The combination of the net cost as stated the Bill of Quantities and the percentage allowance on materials for day work will be deemed to constitute the full inclusive charge to the Employer in respect of the incorporation of such materials in the Works except as allowed for in the Day work Labour and Equipment items in the Bill of Quantities.

4. DOCUMENTS

4.1. TENDER DRAWINGS SUPPLIED TO THE CONTRACTOR

The only drawings provided by the Employer to the Contractor are the drawings included in the Tender Documents – Part 4, Appendix 6.

4.2. DOCUMENTS AND DRAWINGS TO BE CARRIED OUT BY THE CONTRACTOR

4.2.1. DESIGN DOCUMENTS:

No design documents are required.

4.2.2. SHOP DRAWINGS

A. General provisions for shop drawings

- a) Such drawings shall be deemed to be shop Drawings, part of the Contractor's Documents pursuant to Clause 4.1 of the General Conditions of Contract.
- b) The drawings issued by the Contractor for construction will include:
 - The foundation drawings, including if any temporary works such as excavation drawings, etc.

- Detailed drawings of installation of any steel works, wood works, including calculations notes if required.
- All additional electrical, automation, plumbing, HVAC, handling, etc. drawings to develop in greater detail, if necessary, and as required for the construction.
- The detailed drawings of concrete reinforcement and calculation works, as well as bar bending and cutting list, as installed.
- Reinforcing steel shop drawings, formwork drawings
- The additional drawings as required by the Engineer to develop in greater detail the construction required.
- Detail erection drawings, concrete placing (lift) drawings, shop drawings on mechanical and electrical drawings, wiring diagrams (electrical cabinet and structures) and cabling; other detail drawings shall be prepared by the Contractor on the basis of the Construction Drawings; they will be given for information to the Engineer before construction.
- All drawings shall be in the Contract's language, and all dimensions shall be in Metric system. Symbols shall be in accordance with approved Standards. All drawings submitted for approval shall conform to ISO paper sizes A1 to A3. Title block and numbering shall be approved by the Engineer.

These drawings will be submitted by the Contractor in accordance with the Documents' submittal program, to the approval of the Engineer.

The Permanent Works shall be executed in conformity with the Construction Drawings and other drawings approved by the Engineer.

- c) All the above listed drawings shall be referred to hereinafter as Shop Drawings.

B. Civil works

All particular arrangements on the civil structures (cranes, temporary loads, batching plant, additional or variant equipment...) shall comply with the following provisions.

- a) Design calculations

The design calculations may be presented in a computer format and shall include:

- A title page
- Design calculations conditions and criteria;
- The values of the maximum stresses under normal and exceptional operating conditions and during handling, transport and erection;
- The main dimensional characteristics:
- The properties of the materials used;
- Bibliographical references used for the calculations.
- The loads to which the supply is subjected and their origin;

- The forces transmitted to supplies and to the foundations;
- Stresses to which the equipment will be subjected under normal and exceptional operating conditions (including handling, transport and erection);
- The permitted safety factors;
- In general, any indications required for a proper understanding of the design of the supply;
- The output, power and characteristics of drive or control motors.
- All design calculations of the approved variant, if any.

The Engineer reserves the right to request the Contractor for any additional design calculations which he considers necessary. The above listed calculations shall be prepared during the mobilization period and submitted as part of the “Expertise” package for construction permit obtention.

The drawings prepared by the Contractor will be established for cases of maximum load likely to occur during operation of the Permanent Works, and exceptional load situations which may occur during construction in compliance with the method of works.

The Contractor shall be responsible for assuring the adequacy of all parts of the works with respect to loading which might occur during construction and shall supply calculation notes and drawings for any necessary false work, supports, strengthening as may be required by the Engineer.

b) Other drawings

In addition to the drawings listed above, the Contractor shall prepare and deliver to the Engineer prior to the start of construction the drawings for:

- the Temporary Works
- the performance of the Works as necessary for showing the construction methods
- Access roads;
- Contractor’s camp and facilities,
- The other drawings necessary for the performance of each part of the Works in accordance with the Contract.

The Contractor shall perform the necessary calculations in connection with the required drawings.

- c) The Contractor shall be responsible for the behaviour of the Permanent Works during the various phases of construction. He shall provide all equipment and accessories and all working arrangements necessary to limit stresses on the Works, so that stability of the structures is not threatened and so that stresses and deformation remain within acceptable limits.
- d) It is the responsibility of the Contractor to inform the Engineer in case of mistakes on the Tender Drawings.

C. Mechanical equipment included in the present contract

a) General

The Contractor is responsible for the execution of documents (drawings, diagrams, design calculations, erection, etc.) for the different supplies.

A list of all drawings, diagrams and design calculations to be submitted to the Engineer shall be drawn up at the start of the Works in agreement with the Engineer. However, the Engineer reserves the right to request further details at a later stage in order to facilitate understanding of equipment functions.

b) Overall and detail drawings of the equipment

The Contractor shall supply drawings for information of assemblies, parts of assemblies and large parts of the equipment to the Engineer for information.

These drawings, or where applicable their technical associated documents, shall include, in addition to production dimensions, flatness, straightness, horizontal and vertical tolerances, the values of assembly and operating clearance with the minimum and maximum acceptable deviations, the type and the properties of the materials used in the different parts, the weld categories and the types of non-destructive testing to be carried out on welds, the surface condition valued to be achieved for parts machined in accordance with ISO/R 468 standard or applicable Armenian standards, whichever is more stringent.

Drawings, or, where applicable, their technical associated documents shall also include the weights of assemblies, parts of assemblies and detailed parts as well as the surface areas to be painted for large structures.

D. Submission and approval

- a) The Contractor shall submit in three (3) hard copies to the Engineer, for review, information or approval, all documents and drawings which he prepares under this Clause. The Engineer will analyse all such designs and drawings, will appraise them as to whether they are reasonable and consistent with the Construction Drawings, will approve if requested and will order changes when deemed necessary.

The Contractor's documents and drawings shall be submitted in a sequence to facilitate the Engineer's study and scrutiny of the same, shall be completed in regard to all computations and data, and shall be traced on size 840 mm x 594 mm (A1-size) or 297 mm x 420 mm (A3-size) paper. The title of the drawings, the signature of the Contractor's representative, the date of preparation and the reference to Construction Drawings, if any, shall appear in the bottom right hand corner of the drawing. Within twenty-one (21) days after submission of the drawings, the Engineer will advise the Contractor of his conclusions regarding the drawings.

- b) When approval is requested, the Engineer's conclusions may be one of the following:

- "APPROVED"
- "DISAPPROVED" (with relevant reasons determining rejection duly indicated).

Within seven (7) days of the return of documents and drawings marked "APPROVED" the Contractor shall present to the Engineer one reproducible copy of the drawings traced in ink and two (2) prints of the same with an new index x+1 stated "approved by the Engineer by decision of date"

No drawing shall be considered valid unless signed by the Engineer. The approval by the Engineer of such drawings shall not relieve the Contractor of his obligations and responsibilities under the Contract.

Those marked "DISAPPROVED" shall be redone or/and modify and submitted once again to the Engineer. The above process will then be followed again.

The Contractor shall not be entitled to a time extension based upon the rejection of designs or detail drawings, because such designs or detail drawings fail to conform to sound engineering principles, or to the Specifications.

All Works should be executed with the relevant approved drawings. All materials ordered or Works performed prior to approval of the relevant designs, shall be at the Contractor's risk.

The Contractor shall bring to the attention of the Engineer any variation to the Contract in the document submitted for approval.

c) When no approval is requested within twenty-one (21) days after submission of the drawings, the Engineer will notify his comments or requests. All materials ordered, or work performed, prior this notification shall be at the Contractor's risk.

E. Ownership of drawings and data

All the drawings, details, bill of materials and any other information or documents furnished by the Contractor shall become the property of the Employer and shall be non-returnable. The Employer will have the right to use this property.

Such information shall be given in paper copy and in digital format.

F. Design criteria

Unless otherwise specified, the following figures will be used as design criteria.

Acceleration due to gravity: for any relevant calculation or evaluation will be: $g = 9.81 \text{ m/s}^2$.

Unit weight:

- Waste water: 11KN/m³
- Clarified water: 10KN/m³
- Sludge and floating waste: 11KN/m³

4.2.3. AS BUILT DRAWINGS

At the date of the Taking-Over Certificate, the Contractor should have submitted the full set of "As built" Drawings, (2 copies) in A3 format.

Drawings shall be filed and printed, within different books, each of them being organized as follows:

- Formworks,
- Reinforcements,
- Pipes,
- Electrical,
- Instrumentation,
- Mechanical,
- Roads and utilities.

The lack of submission of such drawings will automatically postpone the Taking-Over Certificate, and such delay will be the responsibility of the Contractor.

4.3. STANDARDS, CODES AND REGULATIONS

4.3.1. GENERAL

A. General Standard specifications and codes of the following listed authorities wherever cited herein are referred to by use of the abbreviations shown below. All materials and workmanship shall comply with requirements of applicable codes.

In case of discrepancies between these standards, the order of priority shall be as detailed here after:

		Abbreviation
1	Armenian codes	SNIP
2	European Committee for Standardization 36 rue de Strassart 1050 Brussels, Belgium	EN
3	British Standards Institution Linford Wood, Milton Keynes MK14 6LE - UK	BS
4	AWWA 6666 W. Quincy Ave., Denver, CO 80235 - USA	AWWA
5	Deutsches Institute fuer Normung e.v D-1000 BERLIN 30, Burggrafen Str. 6 Germany	DIN
6	Fédération Européenne de la Manutention 80 boulevard A. Reyers B-1030 BRUXELLES – Belgique	FEM
7	Commission Electrotechnique Internationale 1 rue de Varembe Case Postale 56	CEI
8	International Standard Organisation 1, rue de Varembe Case Postale 56 CH1211 GENEVE 20 - Suisse	ISO
9	American Society for Testing and Materials 1916 Race Street PHILADELPHIA, PA 19103 – USA	ASTM
10	American Association of State Highway and Transportation Officials 444 North Capitol Street, NW WASHINGTON, DC 20001 – USA	AASHTO
11	American Concrete Institute	ASI

	Box 19150 - Belford Station DETROIT, MI 48219 - USA	
12	Bundesanstalt fuer Wasserbau D-7500 KARLSRUHE, Kussmaulstr. 17 Germany	BAW
13	Association Française de Normalisation Tour Europe - Cedex 7 92080 PARIS LA DEFENSE – France	AFNOR
14	American National Standards Institute, Inc. 10 East 40th Street NEW YORK, NY 10016 - USA	ANSI
15	American Petroleum Institute	API
16	American Welding Society 205 MW 7th Street MIAMI FLO 33125 - USA	AWS
17	United States Bureau of Reclamation Engineering and Research Center Code 922 Post Office Box 25007 Denver Federal Center DENVER, Colorado 80225 - USA	USBR
18	The Institution of Civil Engineers Publication Thomas Telford Ltd. 1 Heron Quay LONDON E148XF - UK	ICE
19	Eurocode 2, rue Bréderole B-1000 BRUXELLES – Belgique	

B. The following particular Standards will be used for items not covered under the Armenian code:

EN 12255, part 1 to 16: Wastewater treatment plants

EN 752, part 1 to 7: Drain and sewer systems outside buildings

EN 809: Pumps and pump unit for liquids- Common safety requirements

EN: 1085: Wastewater treatment- Vocabulary

C. Copies of Specifications, codes or standards of the above organizations may be obtained at the addresses shown.

4.3.2. STANDARDS TO BE ON SITE

The Contractor shall obtain and keep on Site at least one copy of each standard which is referred to in the Specifications. One copy shall be at the disposal of the Engineer's Representative.

4.3.3. SPECIFIC APPLICABLE STANDARDS

A. In particular, unless otherwise specified, the Standard to apply will be as follows:

- Civil works and process: Armenian Standards, SNIP
- Mechanical works: DIN
- Electrical works: IEC (in addition to EAC requirements)
- Handling equipment: FEM
- Road: AASHTO

B. Except if otherwise specified, where such standards are mentioned, the latest revision or edition on the Reference Date shall apply.

C. When the Contract Documents contain particular specification or more restrictive specification than required in Standards and Codes listed above, the Contract Documents will always prevail.

D. In case of lack of precise requirements in the Specifications and even if no reference to any standard listed in Sub-Clause hereof, these standards shall be used as a reference.

4.3.4. STANDARDS OTHER THAN THOSE SPECIFIED

Where requirements are specified by reference to a standard which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. The Contractor may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standard and all other information required by Section 6 (Approval of Materials and Equipment), and shall submit written proof that his proposed standard is equivalent in all significant respects to the standard specified. All submissions shall be made in English language.

5. SPECIFIC SERVICES TO BE PROVIDED BY THE CONTRACTOR

5.1. COORDINATION

The contractor shall co-ordinate his work with that of his sub-contractors and, if any of the other contractors at the site to whatever extent may be necessary to complete the project in accordance with the program of works, the drawings and specifications and the requirements of the engineer.

5.2. EMPLOYER'S USE OF CONTRACTOR'S TEMPORARY WORKS

The Contractor shall during the progress of the Works allow the Employer, the Engineer and other contractors employed by the Employer in connection with the Works the use of his roads, scaffolding, constructional plant, other temporary works or services such as described in the present Section. The Contractor shall at every place of working provide proper drainage, lighting and ventilation for other contractors' erection work and for the Engineer's inspection of the Works. Except for those items entered in the Bill of Quantities, such assistance shall be included in the rates.

5.3. ASSISTANCE TO THE ENGINEER'S STAFF AND TO OTHER CONTRACTORS

The Contractor shall provide labour for attendance on the Engineer for operations connected with supervision of the Works in particular for topographical survey. The attendance and assistance to the Engineer and his staff shall be included in the rates or lump sums.

5.4. DISPOSAL OF SURPLUS EXCAVATED MATERIALS

Surplus excavated material and debris arising from the Works shall be dumped on unused space at the WWTP site as agreed to by the Employer or on agreed disposal sites, within a distance of 20km, at the expenses of the Contractor. In order to avoid unauthorized disposal the Contractor shall arrange that each cartage contractor and lorry driver employed for the disposal of such materials is given written instructions as to the approved place where each load is to be tipped. The Contractor shall retain in his office copies of such instructions, together with a list of approved places to be used, for inspection at any time by the Engineer.

The Contractor shall indemnify the Employer against any claims arising from unauthorized disposal of such materials.

Surplus excavated materials may be re-used on the site for the landscaping development; in this case, the Contractor Proposal shall justify the characteristics and volume of materials; should the Contractor Proposal not include such arrangements, the re-use shall not be allowed.

5.5. VEHICLES

No Vehicles shall be provided to the Employer or to the Engineer.

5.6. SITE OFFICES

A. The Contractor shall supply fully furnished and equipped site offices for the sole use of the Employer and Engineer as follows:

- 4 x 15 m² offices
- 2 x 20 m² offices
- 1 x meeting room for 20 persons (at least 30 m²)

B. The Contractor shall supply the offices for the Engineer's and Employer's use along with the required connections for electricity, phone, water and sanitation. He shall be responsible for adequate regular maintenance and repairs of structures, furniture, equipment and appliances therein.

C. Each office shall be fitted with electric lighting and wall mounted socket outlets: water heater, hot plate, an air-conditioner, fan, one 0.8 m x 1.5 m table with drawers, one fixed 0.9 m x 1.8 m desk with shelves above to take fold drawings, one stool, four chairs, wash basin and stand, one cupboard fitted with shelves, hat and coat hooks, one bed 0.9 m x 2.00 m.

D. The offices compound shall be provided with simple toilet facilities, chemical type or similar, located in a covered and enclosed privy separated from the field office, provided with lock and key. The type of toilet facilities, method of waste disposal, location and type of construction therefore shall be submitted to the Engineer for approval.

E. The complete offices shall have to be supplied with all utilities and facilities not more than 28 days after the Engineer's notice to commence the Works and be maintained until the Performance Certificate.

5.7. TELEPHONE AND COMMUNICATIONS

5.7.1. TELEPHONE FOR ENGINEER'S REPRESENTATIVE

A. The Contractor shall, subject to the Engineer's approval, design, supply, install, operate and maintain during the execution of the Works a telephone exchange which shall revert to the Employer at the completion of the Works. The minimum number of telephones and their locations shall be as follows:

Location	No. of lines (Telephones)
Engineer's site office	2 permanent line

B. These external telephone lines shall be suitable for making calls in National area with extensions connected to the public telephone system. The telephones shall be connected to central PABX switchboard which is capable of handling up to ten extensions. One line in each office shall be connected to the international network.

C. These telephone lines shall be for the sole and exclusive use of the Employer or the Engineer's Representative and his staff.

D. The Contractor shall pay for the installation and rental of such equipment and for local calls made by the Employer or the Engineer's Representative and his staff.

Site radio or telephone system

In the event of the Contractor being unable to provide a telephone system he shall arrange, install and maintain a private radio or telephone system for use by the Engineer's Representative and his staff and to his requirements.

Where the Contractor has installed a site radio or telephone system for communication he shall allow permanently the Engineer's Representative and his staff free use of such equipment for their own equipment.

5.7.2. HIGH RATE INTERNET CONNECTION

A. The Contractor shall, subject to the Engineer's approval, design, supply, install, operate and maintain during the execution of the Works a high rate internet connection to the Engineer's site office, which shall revert to the Employer at the completion of the Works.

6. MATERIAL AND EQUIPMENT

6.1. MATERIALS

6.1.1. NATURAL MATERIALS

A. All materials, fixtures, fittings, and supplies furnished under the Contract shall be new and unused, of standard first-grade quality and of the best workmanship and design. No inferior or low grade materials, supplies or articles will be either approved or accepted, and all work of assembly and construction shall be done in a first-class and workmanlike manner.

B. In asking for prices on materials intended for delivery to the site and incorporation in the Works under any portion of these Specifications, the Contractor shall provide the manufacturer or supplier with complete information as may, in any case, be necessary to secure compliance with this Clause and, in every case, he shall quote this Clause in full to each such manufacturer or supplier.

6.1.2. QUARRIED MATERIALS

The Contractor shall be responsible for investigating and obtaining clayed materials, rip-rap stones, rock-fills, granulates, filters and transitions and aggregates for concrete and other purposes. The Contractor shall develop such investigations that he may require to meet the Contract requirements.

6.1.3. CEMENT

The Contractor shall, within 28 calendar days after the Commencement Date, submit i) all the chemical and physical characteristics of the cement in compliance with the specifications and ii) a forecast on a monthly basis detailing his local cement requirements for the duration of the Contract in a form approved by the Engineer. Throughout the Contract period, the Contractor shall review this forecast at quarterly or more frequent intervals as may seem to him necessary or as may be required by the Engineer. Prior to commencing the Works, the Contractor shall establish a stockpile of cement based on his forecast of cement requirements and sufficient for maintaining his operations during the first three months of construction.

6.1.4. ENGINEER'S RIGHT TO TEST

The Engineer could make tests on concrete, concrete aggregates, embankment materials, filter materials and other materials as he may from time to time elect, and the Contractor shall provide such samples or assistance in sampling materials at the Site as the Engineer may reasonably require. Testing by the Engineer shall in no way relieve the Contractor of his responsibility to test materials to ensure that they meet all the specified requirements and to control their quality.

6.2. MANUFACTURED EQUIPMENT

6.2.1. SUBMISSION OF SAMPLES AND DATA

A. The Contractor shall submit for the approval of the Engineer samples, drawings, catalogues, cuts, diagrams and other descriptive data for all mechanical, electrical, architectural and such other materials and equipment as may be designated by the Engineer and which the Contractor proposed to incorporate in the Works. For certain materials and equipment data may be required to be submitted in accordance with a detail form furnished by the Engineer.

B. Items submitted shall be properly labelled to indicate the Project Contract number, Contractor, source of supply, manufacturer Contract Item number, and other data required by the Specifications.

C. All items shall be submitted in sufficient time, but not later than 90 calendar days prior to purchase, to allow proper consideration and action thereon without delaying the construction schedule.

D. Items sent for approval shall be shipped prepaid by the Contractor and the Contractor shall give the Engineer advance notice in writing of all items shipped.

6.2.2. INSPECTION AT THE PLACE OF MANUFACTURE

A. To allow possible inspection of materials and equipment in the course of or on completion of preparation or manufacture, the Contractor shall give the Engineer written notice of the workshops and places where the materials and equipment are manufactured or stored and advise him of the state of progress, so that the inspection may take place at appropriate times and without delaying the dispatch of materials and equipment to the Site. In particular, the Contractor will inform the Engineer of the date of final erection tests or inspection test prior shipping.

B. If the Engineer decides to attend these tests (or any representatives duly nominated, and accompanied by the Employer), the cost of flights tickets and accommodation shall be paid by the Contractor (for 3 persons maximum).

6.2.3. MANUFACTURER'S CERTIFICATE OF COMPLIANCE

In the case of standard labelled stock products of standard manufacture which have a record of satisfactory performance in similar work over a period of not less than 2 years, the Engineer may accept a statement from the Manufacturer attested by a notary public certifying that the product conforms to the applicable Specifications.

6.2.4. MILL CERTIFICATES

In the case of materials for which such practice is usual, the Engineer may accept the manufacturer's certified mill and laboratory certificate.

6.2.5. SERVICE RECORD

If a demonstrable satisfactory service record is available for a material, certain specified tests may be waived by the Engineer.

6.2.6. TESTING LABORATORY CERTIFICATES

The Engineer may accept at his own decision a certificate from an independent commercial testing laboratory, satisfactory to him, certifying that the product has been tested within a period acceptable to the Engineer and that it conforms to the requirements of the Specifications.

6.2.7. ASSEMBLY MARKING

All parts, or units of shop assemblies, shall be marked, or tagged with piece marks. Marks shall be in accordance with approved erection drawings, shall be clearly legible and so placed as to be readily visible when the part is being erected in the field. Before dismantling for shipment, connecting parts assembled in the shop shall be match marked to facilitate erection in the field and marked so as to identify each part with the assembly to which it belongs. The location of the match marks shall be clearly indicated on erection drawings. All parts or assembly of parts shall also be so marked as to identify them with this Contract.

6.2.8. SHOP CLEANING AND PAINTING

After shop assembly and inspection all parts of the Plant and Erection Equipment shall be cleaned and painted in accordance with the Specifications.

6.2.9. NAMEPLATES

A. Each major and auxiliary items of equipment shall have a nameplate permanently affixed thereto, or as directed, showing in a legible and durable manner the serial number, name and

address of the manufacturer, rating data, electrical and mechanical characteristics, and other significant information, as applicable. Nameplate of distributing agents only will not be acceptable.

B. Nameplates shall also be provided where required for panel-mounted devices. Dials, gauges, and nameplates shall be marked with the nomenclature and units of measure in the metric system, and a schedule of such makings shall be submitted for review and approval by the Engineer.

C. All nameplates shall be in the English language.

D. Nameplates for Plant Identification and record purposes shall be manufactured from stainless steel with satin finish and engraved with black lettering of a size which is legible from the working level.

E. Warning plate shall be manufactured from stainless steel with satin finish and engraved with red lettering and sited in a position affords maximum personnel safety.

6.3. APPROVAL OF MATERIAL AND EQUIPMENT

6.3.1. GENERAL

A. All materials and equipment intended to be incorporated in the Permanent Works shall be subject to information given by the Contractor to the Engineer. The Engineer shall give approval for the materials incorporated in the civil works (including architectural materials), and the Contractor shall wait for this approval prior to ordering. For the mechanical and electrical equipment, the Engineer shall give only comments or refusals if necessary.

B. Unless otherwise authorized by the Engineer no material or equipment shall be shipped from its point of original manufacture or final shop assembly to the work site before it has been inspected in accordance with Clause 6.2.2.

C. Except otherwise stated by the Engineer, all materials and equipment intended to be incorporated in the Permanent Works shall be subject to the Engineer's approval.

6.4. CONTRACTOR'S TESTING LABORATORY

6.4.1. GENERAL

The Contractor's laboratory shall be equipped to perform the following main tests:

A. Soils

- Identification.
- Compaction tests.
- Relative density determination.
- Permeability (laboratory).
- Particle size determination.

B. Concrete

- Fresh concrete analysis.
- Concrete workability.

- Concrete strength (compression, tensile strength by Brazilian test).
- Ultrasonic pulse velocity.
- Permeability.
- Concrete and grout modulus determination
- Temperature
- C. Rock and aggregate
 - Dynamic crushing tests.
 - Particle size determination.
- D. Cement
 - Setting time.
 - Blaine fineness.
 - Heat of hydration.
 - Mechanical characteristics (Strength, Young Modulus, Poisson Ratio).
- E. Grout for injections
 - Design and control.
- F. Bituminous materials
 - Design and control.
- G. Laboratory computer equipment

The Contractor's Laboratory shall be equipped with one PC Computer from a well-known manufacturer accompanied by printing facilities.

H. Laboratory Alternative

If the Contractor wishes to not install a laboratory on site, he could propose to the Engineer the use of some others laboratories; based on the technology and staff and references of these laboratories the Engineer is not committed to accept.

I. The sheets recording test results shall be of a type approved by the Engineer. The Records Book of tests and results shall be kept by the Contractor.

J. A copy of the Records Book shall be supplied once a month to the Engineer's Representative.

6.4.2. SPECIFIC EQUIPMENT

In addition the Contractor shall provide other Laboratory equipment or/and field testing equipment as specified in the different Sections for the purpose of controlling particular works or/and determining in-site parameters. This equipment shall be available as necessary during the execution of such activities and could be removed from the Site as and when approved by the Engineer.

6.4.3. METEOROLOGICAL EQUIPMENT

The Contractor shall supply and install at site or where instructed by the Engineer the following supplementary meteorological equipment:

- 2 recorder thermometers;
- 1 pluvio-meter (rain gauge)
- 1 hygrometer;
- 1 anemometer;
- 1 Simplified Piche meteorological shelter

6.5. ACCEPTANCE OF MATERIALS

The approval by the Engineer of any material or equipment shall in no way relieve the Contractor of any of his responsibilities for meeting all of the requirements of the Specifications and shall not prevent subsequent rejection if such material or equipment is later found to be defective or not conforming to the Specifications.

7. QUALITY ASSURANCE AND QUALITY CONTROL SYSTEM

Quality Assurance (QA) Quality Control (QC) System covering all aspects of the Contract and the Works must be implemented, documented and maintained by the Contractor during the period of the Contract. The system shall comply with a recognised international Quality Assurance Standard. The System shall as a minimum consist of the following items.

A. General

The Quality Assurance System for the Company shall show the overall QA Organisation and the lines of responsibility, monitoring and action. Furthermore, the overall principles and procedures for establishing Quality Assurance Plans, Control Plans, QA Organisation, etc. for specific projects and contracts, sub-contractors and suppliers shall be provided.

B. Quality Assurance System

As a minimum the Contractor shall, as part of his tender, submit the QA System for the Company, and QA organisation, providing all important and critical activities for controls, inspections and tests to fulfil the specifications.

It is a general requirement that works are only sub-contracted to companies with an effective QA System.

The other following documents shall be submitted within 1 month after the Commencement Letter.

C. Quality Assurance Plan (QAP)

The QAP shall as a minimum cover the following issues:

- The Contractor's staff and management organization for the project, management plan, and the quality assurance organization.

The person responsible for the Contractor's QAS shall be authorized and qualified to take decisions on quality assurance issues, and his reference and communication lines to the Company's overall quality assurance organization and its responsible management shall be clearly

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shown. Persons performing quality control and testing shall be independent of those executing or supervising the Works.

- Management of documents.
- Management of procurement.
- Management of sub-contractors and suppliers, and requirements of their QAS's.
- Control of materials and workmanship, defects and material reconciliation, procedures for corrective actions, etc.
- Handling of deviations, additions or variations to the Contract Documents.

The Contractor's system of management of current documentation for the execution of the Works shall include his sub-contractors and suppliers. It shall show:

- how it is ensured that only valid and approved documents are used for the execution of the Works and
- The method of recording variations and amendments to the documentation.

D. Control Plans (CP)

The Contractor shall present for the Engineer's approval his detailed CP for all quality assurance efforts or measures for the Works or sections thereof. Such CP shall be presented to the Engineer not later than one month before the commencement of the Works or an approved section of the Works.

The plan shall include the quality control of all aspects of on-site construction, laboratory tests and on-site tests. It will include a quality inspection plan which will cover all items intended for inspection at the Contractor, Sub-contractors and Supplier's works and premises, as specified in the Contract.

The CP shall for each control activity describe type, method, criteria for approval and documentation and who is responsible for performing the activity.

The plan shall contain but will not be limited to the following items:

- Organization chart for quality control.
 - Curriculum vitae of his staff exclusively appointed for all aspects of quality control during the Contract period.
 - List of the Contractor's staff engaged in quality control and material testing.
 - Name and address of site materials testing laboratory.
 - List of laboratory equipment and description of the laboratory testing capabilities.
 - Arrangements for any tests to be performed beyond the capability of the Contractor's laboratory.
 - Procedures for comprehensive records.
- a) The Contractor shall be responsible for establishing and maintaining procedures for quality control which will ensure that all aspects of the Works comply with the requirements of the Contract.

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- b) The Contractor shall be responsible for routine inspection, sampling and testing of all materials, workmanship, plant and measuring devices.
- c) The Contractor shall establish at Site an efficient, comprehensive records facility and library. Books, drawings, standards, publications and manuals shall be indexed and their distribution controlled.

If the Engineer does not approve the CP as submitted, then the CP shall be amended for further approval. Subsequent changes in terms of the quality assurance work will not cause changes in agreed deadlines or contract sums.

E. Non effective implementation of QAP and CP:

It is not the objective of the Employer and the Engineer to perform QAP and CP on behalf of the Contractor. Then if it appears that the documents provided by the Contractor are badly prepared, non-consistent with other documents not compliant with the Contract, the Employer could claim against the Contractor with reference to Clause 2.5 of the General Conditions.

A lack of QAP and CP compliance shall be based for example in the following cases:

- Document not modified and nevertheless re-submitted,
- Numbering, titling and general data non consistent with the requirements,
- Changes on previously approved document not clearly mentioned,
- Nature of the document not consistent with the requirements.

F. The Contractor's control and documentation

1) General

During the Contract period, the Contractor shall, to the satisfaction of the Engineer and State Quality Control body, document that the Works comply with the quality assurance requirements stipulated in the Contract or approved during the Contract period.

Consequently, based on the approved QAP and the CP's, the Contractor shall during the execution of the Works carry out and document the quality control and its compliance with the stipulated requirements.

The Contractor's quality control does not limit his responsibility for the Works according to the Contract.

If the Engineer, during the period of the Contract, can substantiate that the Contractor's control and/or documentation shall be extended, the Contractor shall follow the Engineer's written instructions to this effect at his own cost and within the agreed time for completion.

2) Method of documentation and filing during execution of the Works

All control activities specified in the Control Plan shall be documented.

The CP's and all other issues related to the QA System shall be kept and maintained by the Contractor in the QA filing system, which shall be kept at the project site throughout the period of the Project.

On the basis of the QAP and CP's the Contractor shall produce the necessary forms for registration, log books, and check lists, etc. before work is commenced.

All documentation shall be provided with identification, the date and signature of the person responsible for the documentation. The identification shall as a minimum comprise:

- name of project,
- activity number as defined in the CP,
- Time and place of the control activity.

The Engineer shall have full access to the filing system and he may without notice commission a quality audit.

The Contractor shall keep and maintain at his own costs the “Construction Book” (Log Book) according to Cypriot regulations and submit it regularly for the approval of the Engineer.

3) Documents at delivery

At the time of delivery of materials and goods, the Contractor shall submit the following documentation to the Engineer in one original and two certified copies, all certificates, documentation of tests etc. of materials and goods to be used in the Works.

All documents verifying that inspection control and tests performed are in accordance with the Specifications.

Identification lists with cross-references between documents and materials and goods.

8. SURVEYS

8.1. REFERENCE POINTS, LINES AND LEVELS

A. Level reference

The data for all levels shall be based on current national datum.

B. General setting out

At the beginning of the Works, the Contractor and the Engineer shall agree on the definition and general setting out of the structures to be built on the site, based on the general network established for the project.

Three points which shall be used as a reference basis in three dimensions (X, Y, and Z) will be made available at site by the Employer by the date of beginning of the work. These three points shall be handed over by the Employer to the Contractor, which will accept them as references. These three points shall be adequately anchored and protected by the Contractor.

Additional bench marks may be installed by the Contractor for triangulation reference.

The Contractor shall be responsible for the conservation of the related benchmarks during the entire duration of the construction and Defects Liability Period.

The Engineer shall draw up a report to confirm completion of these operations in the field.

C. Complementary setting out

During the execution of the Works, the Contractor shall complete the general setting out by as many stakes, seats and gauges as may be necessary.

D. Reference points

At the beginning of erection of equipment, complementary reference points shall be placed by the Contractor at his own expense.

E. Approval

The Engineer will draw up a report to confirm completion of these operations in the field.

8.2. TOPOGRAPHICAL SURVEY

A. The initial topographical survey shall be provided by the Employer as shown on the Drawings. The Contractor may either accept the results of this study or undertake a new topographical survey at his own expense. In this case, the new topography shall be approved by the Engineer before use.

B. In any case, the Contractor will undertake all survey during the implementation of the works as required.

8.3. TOPOGRAPHICAL EQUIPMENT

A. The Contractor shall provide for the use of the Employer and the Engineer permanently on Site for the following equipment:

- 1 level with tripod,
- 1 theodolite (reading 1 sec.) with tripod,
- staff gauges,
- chains or steel tapes,
- all other equipment necessary for the day-to-day surveying,
- 1 paint thickness controller,
- 1 concrete sclerometer.

B. All equipment supplied to the Engineer under this clause shall remain property of the Contractor on completion of the work.

C. All equipment for the use of the Employer and the Engineer on Site shall be maintained in good order by the Contractor.

D. All costs relevant to the present paragraph are deemed to have been spread over the unit prices indicated in the Bill of Quantities.

9. ACCESS TO THE WORK SITE

9.1. THE SITE

The Site shall be deemed to include all areas on which temporary and permanent Works are to be constructed, all other areas made available to the Contractor for the execution of the Works and all roads, tracks and footpaths whether private or public between the various parts of the Works.

9.2. USE OF LAND AND RIGHT OF WAY

A. The Contractor will, during the execution of the Works, have free and temporary use of working areas and accesses thereto, of the land shown on the drawing(s). The working areas will include space for the Contractor's offices, camps, stores, yards, constructional plant, temporary roads, parking areas and other temporary works. The Contractor's proposal for temporary works including overall layout plan in conformity with the Tender Documents shall be included in the Contractor proposal.

All use of land is subject to the Engineer's approval.

If the area of the sites is found to be inadequate, the Contractor shall make his own arrangements for all additional working areas in the vicinity of the Works or elsewhere for his site compound, offices, temporary accommodation and living facilities, for offices for the Engineer's Representative. In this case, neither the Employer nor the Engineer shall have any kind of responsibilities concerning these arrangements.

B. Apart from transport to and from these areas the Contractor shall confine his operations under the Contract to these areas. Before entering any working sites, the Contractor shall give 30 day notice to the Engineer in writing. Such notices shall be given for each occupation of the working sites.

C. Before entering any additional working sites (if any) the Contractor shall obtain and forward to the Engineer a copy of the written consent of the owner or occupier or Authority having charge of the land stating the purposes for which such land is to be used by the Contractor, and defining the extent and periods of his occupation for which such consent is granted. Notwithstanding the requirements of such consent, additional working sites shall be protected by fences or barriers or other works as required by the Engineer. Wherever practicable a passage shall be maintained for vehicles and pedestrians along public roads and to all adjacent properties.

D. In the event of the Contractor making use of any special temporary way leave or additional accommodation acquired by him pursuant to the Conditions of Contract hereof or any trip for the disposal of surplus materials he shall obtain and forward to the Engineer a copy of the written consent of the owner and occupier or Authority having charge of the land in which such way leave, accommodation or tip is situated and shall make a record to be agreed by the Engineer of the condition of the surfaces of the land before entering thereon. The Contractor will not be permitted to occupy space in public roads or thoroughfares along the route of pipelines nor additional accommodation except with the written consent of the Engineer, whose consent will not be given unless the Contractor shall have first obtained the written consent of the Authority concerned and having charge of the road surface.

E. Temporary fences and barriers

Temporary fences and barriers shall be provided by the Contractor for the Sites and Working Sites.

Where there is no existing fencing or boundary walls the Contractor shall provide, erect before commencing the Works and maintain in good condition to the satisfaction of the Engineer temporary fencing in positions around the Contractor's areas shown on the Drawings or where

directed by the Engineer. Except where otherwise specified fencing shall be close-boarded 2400 mm high for structures building sites or chain link for the remaining area; he shall provide lockable gates at each site entrance.

The Contractor shall remove all temporary fencing on completion of the Works, except for such fencing, or parts thereof as the Engineer may direct to be left in place in good condition for the Employer's use.

F. Temporary buildings etc., Classified as temporary works

Starting from the Commencement date, the Contractor shall have to bear the cost of management of all temporary buildings and/or works.

G. Notice boards

The Contractor shall manufacture notice boards and erect these where directed by the Engineer. The notice boards shall be 1 x 2 m of 20 mm thick plywood W.B.P. bonded to BS 1088 or similar approved with softwood surround to Class 2 of BS 1186 Part 1. The notice boards shall have the indication as instructed by the Engineer and be painted after fabrication on all surfaces.

The Contractor shall erect these boards on suitable supports in positions within the Site as directed by the Engineer.

H. Advertising and publicity

Advertising will not be allowed on any hoarding whether temporary or permanent, or on any other part of the Works, except such as the Employer may require for this own purposes.

The Contractor shall obtain the permission of the Employer before publishing any article describing the Works. The Engineer's permission shall be obtained before any member of the public is allowed to inspect the Works. All visitors will be required to sign a form of indemnity.

9.3. SPECIAL CONDITIONS AND HAZARDS

The Contractor shall observe the following conditions when drawing up his proposal for traffic access to the Sites and Working Sites and such proposals shall be submitted to the Engineer for his approval before implementation.

- a) Location of access gates to suit the agreed traffic plan;
- b) Restricted headroom due to flyovers and overhead cables;
- c) Restricted loading to existing services, manholes, etc.
- d) Restrictions on height of temporary structures and/or the location of temporary offices due to the proximity of commercial/residential property;
- e) Buildings in the locality particularly sensitive, due to their use or condition, to undue noise and vibration;
- f) Access to private and public properties and buildings;
- g) High voltage overhead cables;

9.4. TRAFFIC ARRANGEMENTS

- A. The Contractor shall seek information on and comply with all requirements and recommendations of the police regarding traffic safety measures.
- B. Plans for re-routing traffic along public streets during occupation of the Working Sites will be arranged by the Employer with the appropriate Government Authorities which include the Traffic Police. Such arrangements include, if any, the acquisition and costs on behalf of the Contractor of provisional Permits from the traffic authorities to occupy Working Sites. The Contractor shall not occupy any Working Sites without holding such Permits.
- C. The Contractor shall provide, erect and maintain during his occupation all barriers and traffic signs as required by the Authorities or instructed by the Engineer. All signs must comply with standard international practice or as otherwise required by the traffic authorities. All written notices on signs shall be in both national language and English.
- D. The Contractor shall arrange with the owners and occupiers of properties alternative temporary access and shall submit details of such agreed temporary access arrangements where necessary.
- E. The Contractor shall liaise and arrange directly with the Authorities, all required traffic arrangements for transportation of equipment and materials. In all cases, he will comply with the traffic regulation.

9.5. TRANSPORTATION OF MATERIALS AND EQUIPMENT

- A. The Contractor shall take all reasonable precautions to ensure that public streets and thoroughfares used by him either for the construction of the Works or for the transport of plant, labour and materials are not made dirty as a result of such construction or transport and in the event of their becoming thus dirtied in the opinion of the Engineer the Contractor shall take all necessary and immediate steps to clean them.
- B. Vehicles shall be thoroughly cleaned down before leaving the Sites and shall be so loaded that spillage therefore is prevented. Particular care shall be observed when disposing of slurry type material in a highly fluid condition which may additionally be contaminated with bentonite.
- C. Each individual site must be kept clean during the work and must be thoroughly cleaned upon completion.

10. IMPLEMENTATION OF THE WORKS

10.1. AMENITIES TO BE PRESERVED

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be trimmed or felled except as authorised by the Engineer.

All lights provided by the Contractor shall be so placed or screened as not to interfere with the use of adjacent buildings, road users, traffic or signal lights or other equipment of the Employer or other authority.

The Contractor shall store and place all materials, plant and appliances in such a manner as to prevent them causing injury or damage to persons or property and at a safe distance from roads, tracks and footpaths.

10.2. PROTECTION AND DIVERSION OF EXISTING SERVICES

- A. The Contractor shall be responsible for notifying the service authorities and the Engineer of his intention to expose the services and where so required by the service authority shall not commence operations until the service authority is represented on Site.
- B. The Contractor shall excavate, protect until backfill and backfill in a manner so as not to damage the services.
- C. As soon as a service is encountered in the excavation whether previously located or discovered during the course of excavation for the Permanent Works the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.
- D. The Contractor shall be responsible for maintaining all such services including natural and artificial watercourses encountered by him in the construction of the Works and shall make good any damage caused directly or indirectly by his activities.

10.3. PROTECTION OF ANTIQUITIES AND FOSSILS

- A. As soon as antiquities or fossils are encountered during the course of any excavation, the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.
- B. Vulnerable parts of the discovered antiquities of fossils shall be protected by the Contractor as may be reasonable required by the Engineer.
- C. No requirement of the Specifications regarding the disposal of material arising from site clearance or excavation shall override any provision in the Conditions of Contract as to the discovery of ownership, of fossils, coins, articles of value or antiquity of anything of geological or archaeological interest found on the Site.

10.4. SAFETY IN SEWERS AND AT SEWAGE WORKS

- A. The recommendations contained in the booklet « Safety in Sewers and at Sewage Works » published by the Institution of Civil Engineers London shall be adhered to in respect of all work in operational sewers and waste water treatment plants.
- B. The Contractor shall make all necessary arrangements with the appropriate authority before entering in or working on existing sewers and associated works.
- C. The Contractor shall ensure that sufficient resources of supervisory staff are readily available to carry out such continuous working at established levels of safety.

10.5. PREVENTION OF NOISE AND DISTURBANCE

- A. The Contractor shall in general comply with the recommendations of National Law.
- B. The Contractor shall justify the details and arrangements of all plant before installation to ensure that suitable provisions are provided to reduce noise emission in built-up areas.
- C. The Contractor shall take noise intensity readings as required by the Engineer and shall submit the results to the Engineer. The Contractor shall comply with measures required by the Engineer to keep noise and disturbance to the reasonable minimum.
- D. The Contractor shall comply with the requirements stipulated in local Law.

10.6. FIRE PREVENTION

- A. The Contractor shall make arrangements to the satisfaction of the Engineer for the protection of the Works and any Temporary Works and any adjacent property from fire and shall give the Fire Authority all facilities periodically to inspect the fire prevention arrangements.
- B. Particular care must be exercised in connection with the operation of electric-arc welding equipment, oxy-acetylene cutting equipment and other processes involving the use of naked lights. Special arrangements will be necessary for the storage of highly flammable liquids on the Site.
- C. The Contractor shall remove all rubbish and surplus material of a flammable nature and take such other steps as the Engineer may require but this shall not relieve the Contractor of any of his obligations under the Contract.

10.7. WORK IN THE VICINITY OF OPERATIONAL MECHANICAL AND ELECTRICAL EQUIPMENT

- A. Any permanent fencing or other safeguards required to be erected around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer may permit the use of temporary fencing or other safeguards.
- B. Where work has to be carried out in proximity to operational mechanical and electrical equipment other than the Contractor's own plant, the Contractor shall put into operation a « Permit to Work » system to the approval of the Engineer.
- C. The Contractor shall comply with the requirements stipulated in local Law.

10.8. SITE FACILITIES TO BE PROVIDED BY THE CONTRACTOR

10.8.1. ACCESS TO WORKING AREAS

The Contractor shall construct, operate, maintain and remove, if required, access routes to construction site areas from existing permanent access and/or site roads, such alternative proposals and additional proposals by the Contractor as may be approved from time to time by the Engineer. Such proposals shall allow all phases of Construction.

Any of these accesses will not be removed except when formally agreed by the Engineer. Removal of these accesses shall be indicated with full details in the General Programme of Works.

10.8.2. HAUL AND ACCESS ROADS

- A. The Contractor shall maintain the existing roads to different site works, as are necessary for the conduct of the work under the contract.
- B. These roads will also be used as access roads by the Employer, the Engineer and other contractors engaged on the construction and completion of the Works.
- C. As indicated here above the Contractor shall establish reasonable traffic regulations governing traffic on the roads maintained by him, and shall provide signs, pavement markings, traffic signals or other control devices and flagmen as may be required to maintain a safe and unimpeded flow of traffic.
- D. Construction and maintenance of such haul and access roads not explicitly paid under separate bills will not be measured for payment as a separate Contract Item.

10.8.3. ELECTRICITY AND POWER SUPPLIES

- A. The Contractor shall make his own arrangements for the supply of electricity for his Temporary Works and other site usage, including tests.
- B. The Contractor shall install operate maintain and subsequently remove equipment to provide sufficient supplies of electricity for the heating lighting and air conditioning of all offices stores laboratories and other temporary buildings used by the Contractor and by the Engineer in addition to any supplies he may require in connection with the construction of the Works.
- C. In addition to his main source of power supply the Contractor shall where necessary provide and maintain standby power supplies adequate to ensure the safety of the Works in the event of failure of the main supply irrespective of the timing or duration of such failure.
- D. All site electrical installations shall be carried out in accordance with the current Regulations for the Electrical Equipment of Buildings.
- E. The Contractor shall also install on his own expenses all the equipment for the permanent power supply of the plant in accordance with the Drawings and Specifications.
- F. The Contractor shall provide at the date of the completion, all approval and clearance for connection of the Permanent Works, issued by the National Power Supplier.

10.8.4. LIGHTING

- A. The Contractor shall provide sufficient lighting to ensure that, at all times:
- safe working conditions are provided for all personnel on the work sites;
 - the Works can be constructed in complete compliance with the Contract;
 - complete inspections of all work in progress can be made by the Engineer, and security of the Works area and public safety measures are adequate and effective.
- B. Unless otherwise directed the minimum intensity of illumination on ground or working surface to be provided for the various operators or work areas shall be as tabulated below:

Illuminance Operation or Area	Design Value (Lux)	Minimum Measured Value (Lux)
Earthworks and excavation	50	20
Concrete placing	100	50
Maintenance shops and mechanical and electrical works	300	200

- C. The Contractor shall supply a suitable instrument to the Engineer for measuring the intensity of illumination. The instrument shall comply with BS 667 or equivalent standard as approved by the Engineer.
- D. All moving plant used during night operations shall be equipped with sufficient lights and reflectors and fluorescent markings to ensure safe working conditions.

E. The submission to or approval by the Engineer of the Contractor's proposals for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

10.8.5. HOUSING FACILITIES FOR THE CONTRACTOR AND HIS SUB-CONTRACTORS

A. The Contractor shall supply:

- Site offices for his staff.
- Site offices for each of his sub-contractors (one office of 20 m² for each sub-contractor).
- Stores, workshops, compounds.
- Temporary accommodations and living facilities.
- Parking areas.
- All necessary services in relation with these works including water supply, lighting, drainage, heating, air conditioning and refuse disposal.

B. The Contractor shall be responsible for the general cleaning and maintenance of the areas including sanitary installations.

C. Buildings shall be complete ready for use including furniture, household appliances (stove, fridge, fan, air-conditioner, heater, lighting tubes and bulbs). Buildings shall be of the same type as the ones provided for its own staff.

D. The Contractor shall provide medical facilities as required by the Medical Officer for Health.

E. Details and layout of site offices and appurtenant buildings and services shall be to the general approval of the Engineer. The Contractor shall obtain any necessary approval from any local authorities concerned.

10.8.6. WATER SUPPLY

A. The Contractor shall make all provisions for the supply of water required for the execution of the Works as well as adequate quantities of potable water for all personnel.

B. The Contractor shall arrange for the water supply for his staff residences, labour camps, site offices, Works, workshops in addition to the supply of the Operator's Camp. Construction of tube wells, storage tanks, overhead tank, distribution system, and their proper running and maintenance shall be his responsibility. Potable water should be supplied 24 hours a day.

C. Water samples shall be tested every 3 months and certificates submitted to the Engineer indicating that the water is fit for human consumption from an agency approved by the Engineer.

D. The Contractor shall supply water to sub-contractors or other contractors for all their requirements.

E. Construction and maintenance of such water supply facilities not explicitly paid under separate bills will not be measured for payment as a separate contract item, and it is assumed that those items are included in the Bill of Quantities.

10.8.7. STORAGE AREAS

The Contractor shall make his own arrangements for the installation, operation and removal of this temporary storage and works and during the Contract period. Location and layout of these storage and work yard shall be subject to the prior Engineer's approval.

10.8.8. SEWERAGE

The Contractor shall make all provisions, subject to the Engineer's approval to construct, operate and maintain throughout the Construction Period a sewerage system comprising collection, treatment and disposal for all the camps.

10.8.9. SOLID WASTES

The Contractor shall make all provisions, subject to the Engineer's approval, for collection and disposal of solid wastes from all camps and work places. Wastes shall be collected at least twice a week and disposed in an approved location.

10.8.10. STORAGE AND USE OF EXPLOSIVES

The Contractor will not use explosives, except if specifically approved by the Engineer in writing.

10.8.11. WATER CONTROL

A. Without prejudice to other stipulations in the Contract, all constraints related to the presence of or risks caused by water, all additional work which may prove necessary on this account, all damage caused by water, all pumping in all structures not mentioned in the Contract which the Contractor may find he has to build for water control purposes shall be at the expense of the Contractor.

B. Without prejudice or other stipulations in the Contract, the Contractor shall be responsible for all damage caused to the foundations of the structure or any part of the Works and occasioned by floods, surface water or runoff, or by failure of any part of the diversion or protection works carried out by the Contractor. Any repairs that are necessary will be carried out at his own expense.

C. Before any works are begun, the Contractor shall submit to the Engineer's approval the methods and arrangements he proposes to apply in order to protect the Works, unless these are imposed by the design incorporated in the Contract. Such Engineer's approval shall not relieve the Contractor of his obligations and responsibilities under these requirements.

10.8.12. DEWATERING OF FOUNDATIONS

A. The Contractor shall provide, install, maintain and operate all pumping and other equipment for dewatering for all parts of the Site where this is necessary, and for as long as required for implementation of the works.

B. The dewatering facilities shall be such as to avoid any loss of fine materials, and shall ensure stability of the excavation works and adjacent buildings and facilities.

C. Water removed from the excavations must not be allowed to cause nuisance or damage to traffic or any public or private property or service.

D. All costs relevant to the present section are deemed to have been spread over the unit prices indicated in the bill of quantities.

10.9. PROTECTION OF FINISHES

The Contractor shall take every care to prevent damage to the works and shall ensure that adequate protection is given to all works from the activities of following trades and any third party. Vulnerable parts of the works particularly liable to damage shall be protected as may be reasonably required by the Engineer and shall be deemed to be insured against damage in accordance with the conditions of contract.

11. RECORDS

11.1. PROGRESS REPORTS

- A. By the last working day of each calendar month, the Contractor shall submit two copies of a draft monthly progress report which shall contain at least the following information:
- Percentage progress of the Works compared with the approved programme, together with a description and percentage estimate of the work programmed for the following month.
 - List of Contractor's Equipment on Site together with its deployment during the month.
 - List of all personnel employed on Site.
 - Accident record, if any.
 - Summary of all work carried out during the month in question together with a description of any difficulties or problems occurring therein.
 - Description of the daily climatic conditions during the month.
 - Situation with respect to payments, together with the dates on which the Payment Certificates were submitted by the Contractor.
 - Description of any claim made by the Contractor during the month and the Engineer's decision.
 - Progress photographs.
 - State of progress of customs clearance and local transport operations.
 - Inventory of materials stored on Site.
 - Tests in progress or already carried out during the month and those planned for the next month.
- B. Within ten working days of receipt of the draft monthly reports the Engineer will return to the Contractor one copy marked for amendment together with any separate comments for correction or addition to the draft report.
- C. Within two working days of receipt of the Engineer's comments the Contractor shall submit ten copies of the final monthly progress report which will include all of the corrections, additions and amendments requested by the Engineer.
- D. Each monthly report shall be in a format approved by the Engineer.

11.2. PHOTOGRAPHS

- A. To record the general progress of the work as well as particular details and special phases of erection and commissioning the Contractor shall take photographs at regular intervals, not more than 2 months.
- B. Photographs of a given part of the Works shall as far as possible be taken from the same location and at the same angle.
- C. The negatives shall be colour negatives not less than 24 x 36 mm in size, alternatively, digital photographs will be provided on a CD.

- D. The Contractor shall take enough photographs of each stage of work or manufacture to enable the Engineer to make a representative selection of subsequent enlargement.
- E. The procedure shall be as follows:
 - Ten days before the end of each reporting period the Contractor shall furnish two proofs (postcard size) of each view.
 - The Engineer will select the views to be enlarged.
 - Eight enlarged prints (18 x 24 cm) of each selected view shall be supplied with the corresponding Monthly Report.
- F. The number of views to be enlarged shall be 20 per each reported period.

12. MEETINGS

A. The Contractor or his nominated Representative shall participate in progress meetings convened by the Engineer. Such meetings will generally be held at regular intervals through prior notice, but may also be convened without prior notice, in the event of any unusual occurrence, at the discretion of the Engineer.

The Contractor shall immediately notify the Engineer of any unusual occurrence which he considers would justify an exceptional meeting.

B. The agenda shall include approval of the minutes of the previous meetings, progress of the works with respect to the schedule and analysis of the difficulties encountered in the work.

C. The minutes of the meeting shall be prepared by the Engineer and shall be deemed, after approval by the other participants, to be written confirmation of the declarations, instructions and decisions taken during the meeting.

D. The Contractor or his nominated representative shall be able to take decision during the meeting; otherwise he shall be considered that the Contractor didn't attend the meeting.

13. HEALTH AND SAFETY

The Contractor shall submit a Health and Safety Plan. He shall comply with the requirements stipulated in the local Law.

The Contractor shall be responsible for the safety of all workmen and other persons entering the Works and shall, at his own expense (where not otherwise stated) and to the approval of the Engineer, take all measures necessary to ensure their safety. Reference in these respects is made to the Conditions of Contract, but in particular, such measures shall include, but are not limited to, the following:

- A. Provision of proper safety and emergency regulation; fire, gas (if any) and electric shock prevention, stretchers and first aid boxes, together with rescue facilities generally, for each place of working.
- B. Safe shoring of all excavations.
- C. Provision of efficient safety helmets for all personnel including the Employer and the Engineer and each of their staff and any authorized visitors to the Site.
- D. Safe control of water including provision of ample standby pumping plant.

E. Provision and maintenance of suitable lighting to provide adequate illumination of the Works with appropriate spares and standby equipment.

F. Provision of good and safe access to any part of the Works.

G. Provision of notices written in English and local languages to be erected at points likely to be used by the public, which shall warn the public of the existence of the Works. These notices shall be in addition to any statutory requirements demanded of the Contractor.

The Contractor shall submit for the approval of the Engineer detailed proposals under sub-clause A. above. Once the regulations have been approved, and before the work is started, the Contractor shall distribute copies in English and local languages of the national regulations to all his employees and to the Engineer.

The Contractor shall ensure that all his employees are fully conversant with the regulations, emergency and rescue procedures, etc., and the Contractor shall enforce the rule that any employee committing a serious breach of such regulations shall be instantly dismissed and shall not be re-employed.

H. Personal protective equipment shall be available and used by operatives when appropriate, including: safety helmet, eye protection, ear protection, hand protection, foot protection.

14. SPARE PARTS

14.1. SPARE PARTS

Mandatory Spare-Parts are described in the Specifications for each equipment. They are deemed to be included in the Bill of Quantities.

A. Spare part book

The Contractor shall give a spare part book. This spare parts book shall contain an assembly drawing of the plant which shall show all parts of the plant separately marked, designated and referenced.

The book shall also contain sketches of each part with the part number and the designation of the part. The material of the part shall also be indicated. These sketches and lists of parts shall be cross-indexed with the assembly drawings.

The spare parts book shall present information in a simple manner so that non-technical personnel may be able to indent these spare parts. The lists of spare parts required shall be made with reference to the spare parts book.

B. Duplicate

All spare parts shall be duplicates of the original parts furnished and interchangeable therewith.

C. Packing and packing list

The spare parts shall be suitably identified, treated and packed for a long storage in containers plainly marked "SPARE PARTS ONLY". A packing list, indicating the contents of each such container, shall be securely fastened in a moisture-proof envelope to the outside of the container. The packing list shall also provide the following information:

- Contractor and Contract number

- Identification, including Contractor's drawing number, reference of each spare part in the container.

D. Storage room

All spare parts shall be stored in a safe place under the responsibility of the Contractor up to the Taking-Over Certificate; at this date, he will transfer the Spare Parts in a place indicated by the Engineer.

15. TRAINING OF EMPLOYER'S STAFF

15.1. TRAINING

A. General

On-Site Training of the Employer's staff to manage, operate and maintain the project shall be included in the tender.

The objective of the training is to provide selected staff members of the Employer with the necessary knowledge of technology, operation and maintenance of all equipment, installations and work included in the project, which will ensure a sound and stable operation and maintenance of the project components carried out under the contract.

The Contractor shall provide on-site training of the Employer's staff in managing, operating and maintaining the Works on the basis of a structured programme submitted at least two (2) months before the start of the training period for the approval of the Employer's Representative.

The Contractor will be required to provide practical instructions to the Employer's staff during the Operation and Maintenance Period to ensure that by the end of this period, the staff of the Employer will be capable of managing, operating and maintaining the Works to the highest internationally accepted standards without additional supervision.

Training shall be based on all the procedures detailed in the Operation, Maintenance and Safety Manuals including, but not limited to managing, operating, controlling and performance monitoring of the treatment process, data filing and processing, reporting, assembly, dismantling and maintenance of equipment and Plant as well as fault finding, without affecting the normal Operation and Maintenance. Particular emphasis shall be laid on safety precautions during Commissioning.

The training shall in general consist of familiarization with the operational aspects of the systems as a whole, followed by familiarization with specific items of equipment.

The training shall be based on the actual plant and the implementation of operation and maintenance schedules outlined in operation and maintenance manuals provided by the Contractor.

The training shall also be directed towards the specific requirements of the trainee, as the instruction and familiarization of the various personnel involved will vary with respect to their operational capacity, as the personnel will require different aspects to be emphasized.

All training shall be successfully completed and demonstrated before termination of the Commissioning Period can take place. If in respect of progress of works and the daily operation of the plant and systems, it is required that any systems or equipment has to be put into use by the Employer before the Certificate of Substantial Completion, it is the Contractor's responsibility that all necessary instructions and training have been given to the Employer's personnel, for full understanding of the technology and operation, prior to commencement of the Employer's utilization of such systems or equipment.

The Contractor shall employ a specific engineer for the training procedure. This representative shall have an adequate knowledge of the English language and the national language. The Contractor shall make available to him all procedural documents produced in accordance with the Employer's Requirements.

The representative and the trainees shall be allowed the unhindered access at any time to any part of the Works.

The liability for the entire Works during training remains with the Contractor, independently of who may be responsible for any fault or damage.

The Employer will cover all costs in connection with wages the Employer's personnel assigned for training and instruction.

All other total costs to cover the Contractor's expenses in connection with training shall be included in the tender.

15.2. TRAINING PROGRAMME

The training program shall include, but need not be limited to the following:

- Organizational structure of the personnel required for management, Operation and Maintenance of each component of the Works.
- Manpower requirements, by skills and trades, necessary for the management, Operation and Maintenance of each component of the Works.
- Detailed description of each element of the training programme, which will show how the necessary skills shall be imparted to the personnel, assigned by the Employer.
- Identification of the minimum educational levels or standards of technical skill which must have been obtained for each position by the assigned personnel, which levels and standards should be readily available in Palestine.
- Theoretical and on-site technical training.
- CVs of the proposed Instructors, including qualification and education.

15.3. EXECUTION OF TRAINING

To ensure that adequate training is given, the training personnel from the Contractor shall carry out each and every Operation and Maintenance activity identified in the Operation, Maintenance and Safety Manuals and shall train the Employer's personnel to carry out these activities even if they are not required during the actual operation of the Works.

The Contractor shall pay particular attention to safety training for all assigned personnel. Safety training shall not be limited to personal safety, but shall include detailed actions to be taken by all staff in emergency situations and the use of all safety equipment. The Contractor shall be responsible for establishing procedural links with the appropriate emergency services.

The Contractor shall provide all necessary facilities for training including didactic equipment, simulators video, slide and overhead projection equipment. The necessary specialist buildings or rooms for training shall be provided as part of the Permanent Works. All training equipment shall become the property of the Employer at the end of the Training Period.

Training shall be carried out in the English language. However, the Contractor shall provide a sufficient number of local language / English interpreters to overcome any difficulties arising due to the assigned personnel not being completely fluent in the required languages.

15.4. CONTRACTOR'S PERSONNEL

The duties of each of the training personnel shall be to manage, operate and maintain that element or those elements of the Works appropriate to his position, and to train the Employer's assigned staff members for that particular position. The emphasis shall be on "hands-on" training.

In addition to his normal training personnel, the Contractor shall also provide specialist trainers who shall be responsible for formal classroom, laboratory or workshop training.

As a non-exhaustive overview, the training will cover in particular the following aspects:

- Basic theoretical principles of plant and practical use for this plant.
- Description and working limits of each equipment/component.
- Operation of each piece of equipment, including safety rules.
- Understanding and use of the supervision system of the plant.

16. OPERATION AND MAINTENANCE MANUAL

16.1. GENERAL

A. The Contractor shall provide Operation and Maintenance Manuals of the facilities.

B. The manual shall be on paper size A4 (210 x 297 mm) paper 80-90 grams with offset or equivalent printing strongly bound in a durable stiff cover bearing the title in approved legend. Drawings shall be folded or reduced to 297 mm height. All volumes shall bear on the spine an approved shortened version of the title.

C. Each manual shall contain all relevant information on the operation, maintenance, servicing and dismantling of the relevant equipment.

D. General Comments concerning Printings of Manuals

- Technical documents of commercial type, containing the necessary information, may be used partly or in full.
- Drawings, diagrams, sketches or photographs shall be included whenever necessary for easier understanding or clarity.
- Precautions and warnings relating to the safety of persons and of the equipment shall be clearly stated.
- The sections of the Manual shall be arranged in the following order:

- a) Title page
- b) Table of Contents
- c) Section I - Operation
- d) Section II - Maintenance

- e) Section III - Dismantling
- f) Corresponding publications
- g) Perspective drawings, scale drawings, diagrams, etc.

16.2. PROCEDURE

The Contractor shall submit 3 draft copies of each manual to the Engineer 3 months before the Pre-commissioning Tests.

Once the Engineer has given written approval of the draft, the Contractor shall hand over an additional 6 copies of the manuals to the Engineer at the date of the Commissioning Tests.

Final version shall be strictly identical to approved drafts.

16.3. CONTENT

A. Section I - Operation

This section shall include:

- A general description.
- Operating instructions:

These shall specify the precautions which must be taken and critical points to be observed and shall recommend a method for monitoring and recording observations and maintaining operational records.

- Fault-finding table:

A single document for the intention of operating staff shall indicate the full list of all faults that may occur in all the equipment and which are detected by protection systems activating alarms.

For each fault, the document shall indicate the probable causes and the remedial measures to be taken to ensure return to normal operation.

- Characteristic data:

The main specific characteristics of each item of Plant shall be listed including but not limited to rated capacity, power, voltage, amperage, pressure, temperature, number of revolutions per minute, discharge, operating range, efficiency.

- Curves:

Characteristic curves of each item of Plant shall be provided whenever specified or whenever it is normal practice to do so.

B. Section II - Maintenance

This section shall contain the following:

- Maintenance instructions:

These shall include instructions for routine preventive maintenance and lubrication requirements and a list of recommended spare parts. Schedules shall be given for Plant shut-down indicating the frequency in the operating cycle at which they should occur, and the tests to be made during shut-down. The instructions shall also include a brief description and identification of special tools required.

- Calibration and tolerances:

Information shall be given in tabular form of the calibration of instruments and alarms. Information on operating temperatures, pressures, discharges, and other such data, shall also be given in tabular form. Settings for protection relays, contact gaps, clearances, contact pressures shall be given.

This information shall be set out under two headings: "Recommended" and "Actual". Actual characteristics shall be ascertained during the Commissioning Tests on Site after the Plant has been erected.

C. Section III - Dismantling

This section shall describe the sequence and procedure to be followed, operation by operation. Points where exceptional care is needed and precautions to be taken shall be specifically noted.

17. COMMISSIONING

The sequence of the Works completion will be as follows: Fill-in authorization, Pre-commissioning, Certificate of Substantial Completion, Commissioning, and Taking-over Certificate in accordance with the Conditions of Contract.

17.1. FILL-IN AUTHORIZATION AFTER DRY-TESTS COMPLETION

As soon as "dry tests" on equipment and water tightness tests on concrete structures or pipes are successfully performed at the satisfaction of the Engineer, the Contractor is deemed to issue a notice, for informing that the Works have been completed.

It is reminded that dry tests are carried out under the Contractor responsibility only.

Within 7 days after receipt of this Notice, the Engineer will authorize to fill-in all the plant with water and to "switch on" all the equipment under the Contractor responsibility.

17.2. PRE-COMMISSIONING

The pre-commissioning starts with the Engineer's approval to fill in the plant with clean water ("flooding"). During the Pre-commissioning period, the Contractor is fully responsible of the Plant; he will be able to perform and conduct any tests or adjustments he wishes.

The Contractor will take in charge energy, chemical (if any), staff costs and other incidental costs during the Pre-commissioning period.

When applicable, the Contractor shall issue a notice, for informing the Engineer that, based on its judgment, the Pre-commissioning period will be completed at the date he has to fix; then the Engineer will issue, if agreeable at its satisfaction, the Certificate of Substantial Completion, within 7 days after receipt of the notice.

17.2.1. COMMISSIONING PERIOD

As soon as the Engineer shall issue the Certificate of Substantial Completion, the Commissioning period shall be "on".

The commissioning period will be considered as a normal operation period; as such all the equipment and all parts of the plant shall be in operation.

The Employer or its selected Operator will take in charge energy, chemical (if any), newly hired operation's staff costs and other incidental costs during the Commissioning period.

During the commissioning period, the Contractor is liable to successfully perform the followings tasks:

- Additional Adjustments to be made, if any, before the Commissioning tests.
- Training of Employer's staff
- Performance tests on the sludge dewatering equipment

During the Commissioning period, the Contractor remains responsible of the day-to-day operation of the plant. The Contractor shall be responsible to provide all means as described here above.

At the end of the Commissioning Period, the Engineer will issue, the Taking-Over Certificate, if agreeable, in particular if:

- The Contractor demonstrated that the plant was fully operable and workable under nominal running during at least half of the Commissioning Period.
- The performance tests on sludge dewatering equipment have been successfully performed and accepted by the Engineer.

In any other circumstances, the provisions of the Particular Conditions shall apply.

17.3. TAKING-OVER CERTIFICATE

It will be issued by the Engineer as per the provisions of the Contract.

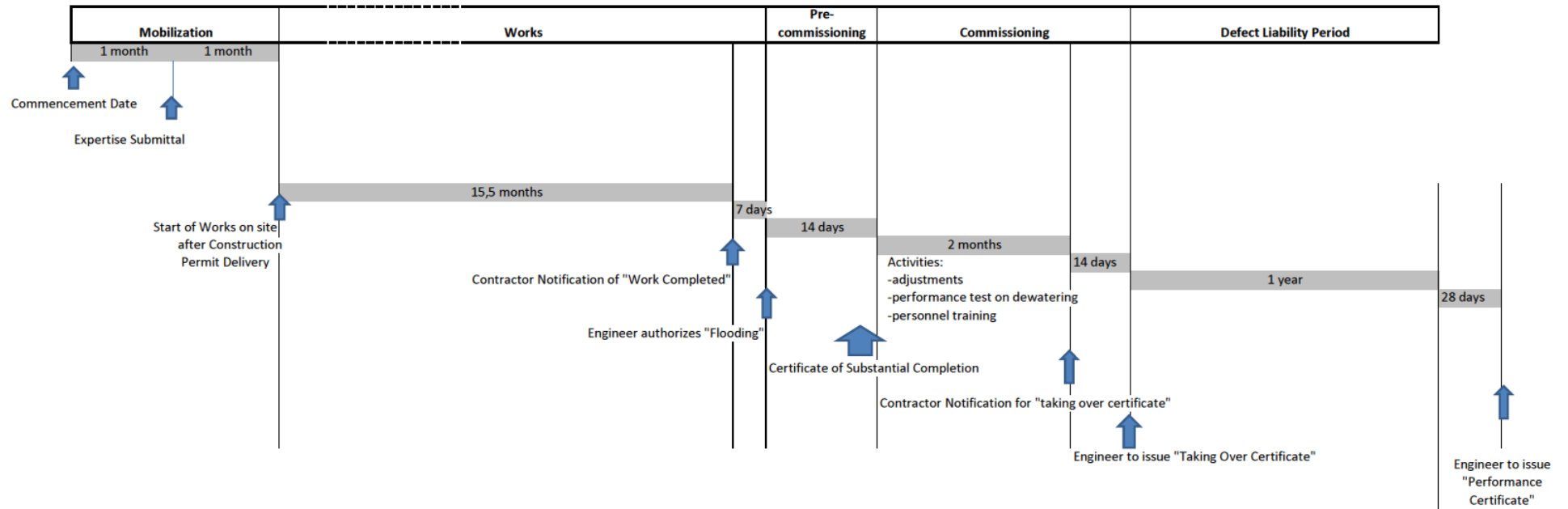
The lack of spare-parts, stored as required, and the lack of as built drawings and Operation manual shall post-pone the issuance of the Taking-over Certificate.

17.4. PERFORMANCE CERTIFICATE

It will be issued by the Engineer as per the provisions of the Particular Conditions.

17.5. DEFECT LIABILITY PERIOD

The Defect Liability Period as define in the Contract shall be 12 months.



Note: This diagram is given only for information; the Contractual Clauses of the Contract General Conditions and Particular Conditions still remain in force. Indicated durations are considered minimum. If these durations need to be extended no additional time shall be given to the Contractor and penalties shall apply if the Time for Completion is overrun.

SECTION 01001

DESIGN CRITERIA FOR STRUCTURAL ENGINEERING

1. STANDARDS

The following Standards shall be used for the structural design:

- HHSN – Seismic Code of the Republic of Armenia
- SNiP – Construction rules and regulations

And more precisely:

- HHSN II-6.02-2006 Earthquake-resistive construction. Design codes
- SNiP 2.01.07-85 Loads and actions
- SNiP 2.02.01-83 Basements of buildings and structures,
- SNiP 2.02.02-85 Basements of hydraulic structures
- SNiP 2.03.01-84 Concrete and Reinforced Concrete Structures
- SNiP 2.03.06-85 Aluminum structures
- SNiP 2.03.11-85 Protection of construction structures against corrosion
- SNiP 2.04.03-85 Sewerage. External networks and structures
- SNiP 2-23-81 Steel structures
- SNiP 2-23-81 Stone and Reinforced Stone structures
- SNiP 2-25-80 Timber structures
- HHSN I-2.01-99 Engineering investigations for construction,
- HHSN II-8.04.01-97 Fire safety of buildings and structures,

2. GENERAL

The following criteria shall be considered in the design:

- 1) Class of consequences of structure: First
- 2) Service life of the structures: 150 years
- 3) Class of water tightness of liquid retaining structures: W6
- 4) Class of exposure:

- a) Moderately aggressive, according to SNiP 2.03.11-85 Protection of construction structures against corrosion
- b) For concrete surfaces exposed to weather and not included in the above category: F100
- 5) Thermal effects:
 - a) The thermal difference between internal and external faces of the reservoir wall is taken to 30°C for thermal moment's calculation
- 6) Crack opening criteria:
 - a) For the concrete elements retaining liquid, crack opening depends on the class of watertightness. For a Class of watertightness W6, crack opening is limited to 0.15 mm.
 - b) In all cases, the maximum stress in steel at Serviceability Limit State shall be limited to 200 MPa for all water retaining structures.
- 7) All dispositions shall be taken into account concerning the stability and the watertightness of pipes embedded into concrete elements.
- 8) Levels indicated on drawings are considered after settlement.
 - a) Maximal absolute settlement: 10 mm
 - b) Maximal relative settlement: 1 mm / meter

3. MATERIALS

A. Concrete

The concrete of the structures shall have a minimum grade of B25 class heavy concrete.

- Minimum concrete compressive strength at 28 days..... = 25 MPa

B. Rebars

- Type A1c, A500c, Br class
- Yield Strength..... = 500 MPa
- Concrete cover to reinforcement in water retaining structures:≥ 50 mm

C. Structural Steel

- Minimum Yield Strength: 355 MPa at a nominal thickness ≤16mm

4. ACTIONS

A. The design of all structures shall take into account all loads as per the requirements of the applicable Standards, for both temporary and permanent works.

Those loads are the following:

- Wind loads,
- Earth pressure loads,
- Hydrostatic pressure loads,
- Snow loads,
- Seismic loads,

- Live loads: in particular, the following live loads shall be taken into consideration in the structural design calculations:
 - Raft, industrial slab and slab receiving public : 5 kN/m²
 - Inaccessible terrace (except for maintenance) : 1,5 kN/m²
 - Accessible terrace : 2,5 kN/m²
 - Heavy load roads : 30 tonnes truck or 5 kN/m²
 - Live loads around structures: 10 kN/m²
 - Grating platforms (for operator access): 2.5 kN/m²
 - Grating platforms (for equipment maintenance): according to equipment loads
 - Equipment support: according to equipment loads

B. Fire

Electrical rooms shall be designed according to HHSN II-8.04.01-97 Fire Safety of Buildings and Structures

C. Freezing

Upper level of pipes (crown) and structures foundations shall be at least -0,70 m under ground level.

5. CALCULATION

All structural calculations shall take into account the geotechnical characteristics of the site, the dimensioning combination of actions as per the applicable Standards and shall ensure that all structures will be stable against uplift pressures (including for buried pipes), and also that all excavations will remain stable regarding buoyancy.

oOo

SECTION 01010

CORROSION PROTECTION

1. GENERAL

1.1. WORK INCLUDED

This section of specifications covers the corrosion protection of all equipment and steel structure element to be supplied, unless different requirements are specified in the subsequent sections.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. CODES AND STANDARDS

Supplies and works shall comply with the following standards or equivalent:

- Standards of the US Steel Structure Painting Council (SSPC) for corrosion and metal protection.
- European scale of rusting degree for anti-rust paint. Published by the European Committee of the association of paint printing inks and art colours (42 avenue Marceau, PARIS 8e).
- BS 729: Hot dip galvanized coatings on iron and steel articles.
- BS 5493: Code of practice for protective coating of iron and steel structures against corrosion.
- BS 7079: Preparation of steel substrates before application of paints and related products.
- BS EN 22063 Metallic and other inorganic coatings –Thermal spraying-zinc aluminium and their alloys.
- Din 55928 or Swedish standard S.I.S. 05590 or equivalent on the cleanness degree of metallic surfaces.

1.4. REFERENCES

The Contractor shall furnish references of the paint manufacturers and of the paint application subcontractors.

1.5. SYSTEM DESCRIPTION AND CHARACTERISTICS

1.5.1. GENERAL

Paint characteristics shall be determined taking into account the function, location of each equipment and/or steel structure element and type of protection required.

With the exception of surfaces to be embedded in concrete, all equipment and steel structure element shall be given marine protection for overseas shipment. Corrosion protection systems shall be selected considering the shipment, site storage and final use conditions.

Equipment and steel structure element shall be protected from the corrosive action of water when they are intended to be submerged or partially submerged, and from the corrosive action of the atmosphere.

The protection shall be designed for all possible types of corrosion, namely: chemical, electrochemical and biological.

When using painting for corrosion protection, each coat of paint shall be of a different colour.

All safety components and accessories which, in contact with water, might be subject to serious corrosion or scaling, liable to cause operating faults, shall be protected from corrosion and, wherever possible, from scaling by the use of materials whose mechanical and physical qualities must meet the conditions of use imposed on the components.

1.5.2. EQUIPMENT AND STEEL STRUCTURE ELEMENT SUBMERGED, PARTIALLY SUBMERGED OR SUBMITTED TO HUMID ENVIRONMENT

Equipment located in parts of the structure where humidity or condensation is high shall be protected with the same system as that used for the submerged or partly submerged parts.

On the parts inaccessible after erection, the entire protective system shall be applied before shipment to the site.

The paints system shall be an epoxy-tar based system. The system selected shall be such that it can accept a final coat at site. The minimum guaranteed thickness of the protective coating shall be 450 micrometers.

1.5.3. EQUIPMENT AND STEEL STRUCTURE ELEMENT EXPOSED TO THE OPEN AIR

The protection system shall be applied without the final coat.

The minimum thickness of the total intermediate coat shall be specified and guaranteed by the Contractor.

1.5.4. PARTS EMBEDDED IN CONCRETE (CAST-IN-PLACE)

All parts (supporting systems, frames, etc.) embedded in concrete shall be made of stainless steel 304L.

1.5.5. BOLTS AND NUTS

All bolts and nuts shall be protected by hot dip process galvanization, unless otherwise specified by the equipment manufacturer for preventing electro-chemical corrosion.

1.5.6. MACHINED SURFACES

A protective varnish shall be applied to the dried and cleaned surfaces either with the aid of a brush or with a spray gun. This varnish must be capable of being easily removed by the application of petrol or trichlorethylene. The Contractor supplying trichlorethylene shall warn personnel of the health hazard resulting from the use of this ingredient.

1.5.7. INTERNAL SURFACES OF METALLIC TANKS

Unless otherwise specified, the internal surfaces of metallic tanks designed to contain oil shall be blast cleaned and immediately protected with two coats of oil-proof enamel paint.

1.5.8. INSIDES OF BOX GIRDERS

The insides of box girders not accessible for painting after erection shall be subjected to a watertightness test using compressed air, unless specified to the contrary for each particular case at the written request of the Contractor. The compressed air pressure will be 1.5 bar for the test.

On completion of this test, a desiccating powder shall be blown into the box girders in order to dry the air. The aperture shall then be carefully sealed by means of a welded plate.

1.5.9. ACCESS WAYS, PLATFORMS, HANDRAILS, LADDERS, COVERS, LAMPPOSTS, STEEL STAIRS, FOOTBRIDGES, GRATING

All these items shall be protected by hot dip process galvanization, unless otherwise specified ;

1.5.10. SURFACES INACCESSIBLE AFTER ASSEMBLY AND ERECTION

Surfaces inaccessible after assembly and/or erection of the equipment and/or steel structure shall be prepared and protected before such erection and assembly are carried out.

1.5.11. COLOURS

The colours of painting proposed shall be submitted to the Engineer for approval.

The colours of pipework for services shall be according to Employer's standards.

1.6. DOCUMENTS TO BE SUBMITTED

For each type of protection system, the Contractor shall submit the following documents to the Engineer for information and comment:

1.6.1. TECHNICAL INFORMATION SHEETS

Technical information sheets concerning the paint used, giving the following:

1. Origin, definition, destination, composition;
2. Properties, including: recommended thickness of dry coat, graphs showing drying times, maximum and minimum coating times and pot life as a function of temperature, highest and lowest duty temperatures, flash point;
3. Conditions of application, including air temperature and humidity and temperature of the substrate;
4. Compatibility and method of protection;
5. Efficiency;
6. Packing and storage;
7. Reference to Standards.

1.6.2. GALVANIZATION PROCESS

1. The galvaniser's references in the field covered by the present Specification.
2. Test certificate for factory galvanised products or attestation of conformity with Specifications.
3. Identification of the factory producing the galvanised products.
4. Identification marks for galvanised parts checked at the factory.

1.6.3. PAINTING PROCEDURE

1. Preparation of surfaces (substrate, underlying layers, damaged area),
2. Products applied and thickness of each coat,
3. The Contractor shall confirm the number of coats (applications) as specified by the Paint Manufacturer if not the minimum given in this specification.
4. Place of application;
5. Description of the paint application facilities;
6. Temperature and humidity limits.

1.6.4. APPLICATION REPORT

1. Daily report of the maximum and minimum ambient temperature and list of parts to be painted;

2. Daily report of the maximum and minimum humidity level in the paint application room;
3. Other pertinent information;
4. A table indicating the various items to be protected (on X-axis for example) and the various types of protection (on Y-axis for example): quality, thickness, colour per coat and areas to be painted.

1.6.5. SCALE OF RUSTING

Stereotype No. 7 of the European scale of rusting for anti-rust paint.

1.7. STORAGE

The storage conditions of painting products shall comply with the recommendations indicated on the supplier's technical data sheets. Non-respect of these conditions may give rise to rejection of the product. In particular, the Contractor is deemed to be fully acquainted with the climatic conditions prevailing on site and shall be required to take such conditions into account.

The stores used for the storage of paints and associated thinners shall be closed and covered, thereby enabling the temperature and degree of humidity to be maintained at a level consistent with the specifications indicated on the product instructions for use.

1.8. ENVIRONMENTAL LIMITATIONS

Sand blasting and painting work shall be carried out only when the ambient air temperature and degree of humidity are within the requirements of the product instructions for use.

Generally, all such work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C. The substrate temperature shall always be at least 3°C higher than the dew point.

The Contractor shall bear the cost of equipping each work station with sufficiently accurate measuring instruments. Temperature and humidity shall be recorded during paint application.

1.9. PROGRAMME

The contractor shall clearly indicate in his manufacturing programme and in his erection programme, the global periods scheduled for the application of corrosion protection coatings.

1.10. SITE CONDITIONS

1. Blast cleaning and painting work shall be carried out only when the ambient air temperature and degree of humidity are within the requirements of the instructions for use of the products.

2. Generally, all such work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C. The substrate temperature shall always be at least 3°C higher than the dew point.
3. The Contractor shall bear the cost of equipping each work station with sufficiently accurate measuring instruments. Temperature and humidity shall be recorded during point application.

1.11. GUARANTEE

1. All the protection systems adopted shall have a design life of 8 years, to be certified by the Office d'Homologation des Garanties de Peinture Industrielle (French Office for Certification of Industrial Painting Guarantees), or equivalent International Organization of Certification.
2. A letter of guarantee shall be submitted by the Contractor from the specialist subcontractor that the products proposed for use when applied with the specifications of this Part and the manufacturer's instructions will withstand the environmental service conditions to be encountered for a period of 8 years.
3. The performance of the protective paintwork during the Maintenance Period will be inspected by the Engineer in presence of both the Contractor and the Employer. No rust point or blister shall be accepted at the end of the maintenance period. Any necessary repair work shall be determined on the basis of the results of these inspections.

2. PRODUCTS

2.1. GENERAL

1. Each coat of paint shall be of a different colour.
2. Equipment exposed to ultra-violet radiation shall be given special protection. Areas to be protected in this manner shall be determined in relation to the normal operating conditions of each item of equipment.

2.2. COLOURS

The colours proposed shall be submitted to the Engineer for approval. For guidance purposes, the Contractor could make the choices indicated hereafter:

1. Aluminium: for equipment exposed to sunlight, the thermal effects of which could be detrimental to protection performance.
2. Moving parts in the immediate vicinity of personnel access ways shall feature black stripes 6 cm wide and inclined at 30° to the vertical.
3. The colours of pipework for services shall be according to RAL standards.

2.3. SCHEDULES OF PAINTING

2.3.1. FERROUS METAL SUBJECT TO CONTINUOUS OR INTERMITTENT IMMERSION IN WATER

1. Abrasive blast cleaning SA 2.5.
2. Two or three coal tar epoxy coats.

The minimum dry film thickness of the system shall not less than 450 µm.

Or:

1. Abrasive blast cleaning SA 2.5.
2. One coat of zinc rich primer minimum thickness 50 µm.
3. Two or three coats of vinyl coal tar.

The minimum dry film thickness of the system shall not less than 450 µm.

2.3.2. FERROUS METAL SUBJECT TO SPLASH, UNFAVOURABLE ATMOSPHERIC EXPOSURE OR HUMID ENVIRONMENT

Same as for ferrous metal subject to continuous or intermittent immersion in water.

2.3.3. PAINTING SCHEDULES FOR TYPICAL OUTDOOR LOCATIONS

1. Abrasive blast cleaning SA 2.5
2. One coat epoxy polyamide metallic zinc rich primer.
3. One coat epoxy polyamide.
4. One chlorinated rubber tie coat.
5. One coat high build chlorinated rubber.

The minimum dry film thickness of the system shall not less than 220 µm.

Or:

1. Abrasive blast cleaning SA 2.5
2. One coat zinc rich epoxy paint.
3. One intermediate coat epoxy paint.
4. One top coat acrylic polyurethane paint.

The minimum dry film thickness of the system shall not less than 180 µm.

2.3.4. PAINTING SCHEDULES FOR TYPICAL INDOOR LOCATIONS

1. Abrasive blast cleaning SA 2.5.
2. One coat weldable holding primer for protection during manufacture and erection.
3. One coat of epoxy zinc rich primer.
4. One intermediate coat of epoxy paint.
5. One coat of epoxy paint.

The minimum dry film thickness of the system shall not less than 150 μm .

Or:

1. Abrasive blast cleaning SA 2.5.
2. One coat of epoxy zinc rich primer.
3. One intermediate coat of modified epoxy paint.
4. One coat of modified epoxy paint.

The minimum dry film thickness of the system shall not less than 150 μm .

2.4. GALVANIZATION

Galvanization shall be applied by the hot-dip process and shall consist of a continuous coating to minimum thickness as follows:

	Average of Specimens tested μm (g/m ²)	Any Individual Specimen μm (g/m ²)
Rolled steel exposed to the atmosphere only		
t < 6 mm	87 (609)	79 (553)
t > 6 mm	100 (700)	87 (609)
Rolled steel directly placed in the ground or in water	210 (1470)	165 (1155)
Cast iron and malleable iron	87 (609)	79 (553)
Bolts, nuts and washers	55 (385)	44 (308)

The zinc coating shall meet the requirements according to ASTM A123, A153, A239 and A385 or equivalent.

A. Zinc for galvanization

Zinc ingots used for galvanization shall comply with British or European Standards.

B. Minimum zinc content in the galvanization bath

98.5% pure zinc with a lowest permissible limit of 98.3%.

3. EXECUTION

3.1. PREPARATION

3.1.1. GENERAL

The Contractor shall take all reasonable precautions to ensure that the protective coatings are not damaged during handling in the factory, during transport or during erection. In particular, he shall ensure that no damage is caused through the use of inappropriate packing systems.

In the event of damage, the Contractor shall make good the existing protective coating, using the same products and under the same conditions of application.

For all the equipment and steel structure element included in the supply, a single make of paint approved by the Engineer and identical products for identical operating conditions shall be chosen.

Regardless of where the corrosion protection coating is applied, the cost of all the necessary installations shall be borne by the Contractor.

3.1.2. SURFACE PREPARATION

3.1.2.1. BARE METAL SUBSTRATES AND DAMAGED AREAS

1. Before any treatment, the surfaces will be cleaned using an appropriate method.
2. Blast cleaning (using non-siliceous sand, corundum, treated slag or shot). The surface quality grade will be DS 2.5, minimum. The surface roughness value to be obtained after cleaning shall be defined by the paint supplier. Wet sand-blasting is prohibited.
3. Careful removal of dust.

3.1.2.2. PRE-PAINTED SUBSTRATES AND SURFACE PREPARATION BETWEEN EACH COAT

1. Before carrying out any treatment, the surfaces will be cleaned using an appropriate method.
2. The surface preparation will be defined in relation to the primer applied in the workshop and to the requirements for the correct adhesion of the other coats, which will be defined by the paint supplier (surface roughness, possible removal of zinc salts, etc.).
3. Careful removal of dust.

3.2. PAINT COATINGS

The choice of place(s) for the application of the final coats shall be made in relation to the following:

1. Type of product,
2. Programme and procedure of manufacture and erection,
3. Climatic conditions,
4. Mode of application of the paint,
5. Equipment, materials and personnel available,

Other factors may be taken into account.

3.3. GALVANIZATION

3.3.1. SURFACE PREPARATION

1. Cleaning: Parts to be treated shall be brushed thoroughly to remove any substances adhering to the surface (such as foundry sand, paint marks, etc.).
2. Degreasing: Irrespective of the technique used (degreasing with alkalis or solvents), this operation shall be carried out with all necessary care and shall not under any circumstances be replaced by pickling operations.
3. Pickling: Parts shall be pickled to remove completely any surface scale and rust. Either of the following processes may be used:
 - Chemical pickling: hydrochloric or sulphuric acid baths for steel.
 - Mechanical pickling: shot blasting.

In this case, the maximum depth of rough surface shall be compatible with the thickness of zinc corresponding to the specified weight of deposit per unit area of surface.

3.3.1. GALVANIZATION PROCESSING

The galvanization process shall be submitted to the Engineer for approval. It may consist of any of the following process:

1. Wet galvanization.
2. Dry galvanization.
3. No-flux galvanization.

3.3.1.1. CHARACTERISTICS OF COATING

1. Appearance: The layer of zinc shall be smooth, uniform and homogeneous, with no interruption of continuity and free from stains or zinc seams and ash. If there should be any

surface crystallization, this must be regular, but the dimensions and shape of the crystals shall not be taken into account at all in assessing the quality of the coating.

2. Weight of zinc per unit area of surface: The weight of zinc deposited shall be on average 7 g per dm² and at least 5 g per dm², with a minimum thickness of 70 µm. In the case of tubes, hollow parts and assembled parts, these values apply to both faces.

3.3.1.2. TYPE OF PARTS

1. The properties, shapes and characteristics of the material shall not be affected by the galvanization process.
2. Bolts with nominal diameters of between 14 mm and 20 mm inclusive shall be tapped so that nuts can be screwed without forcing on to the bolts, while maintaining a sufficient thickness of zinc.
3. Parts consisting of welded components may be galvanized without difficulty provided that the components:
 - a) are of the same quality of steel,
 - b) have been fabricated by identical processes (forging, rolling, casting, etc.),
 - c) have the same degree of surface oxidation.

Any trace of flux or working residue shall be completely eliminated. After cleaning, welds shall have a continuous, regular surface free from any porosity and perfectly watertight.

4. All components of any assembly to be bolted or riveted shall be delivered to the galvanizer unassembled for separate treatment.

Holes for bolts, rivets or pins shall be carefully bored before galvanization to a diameter that takes into account the thickness of the deposit, as no retouching work shall be carried out after treatment.

3.3.1.3. FIELD QUALITY CONTROL

By visual inspection.

3.4. APPLICATION IN WORKSHOP

3.4.1. GENERAL

1. The Contractor shall not proceed with painting of any of the equipment subject to workshop inspections and tests without the prior written approval of the Engineer.
2. All steel work shall be fully fabricated before galvanization, no machine or shop work, boring, punching etc. will be allowed after galvanization is processed. Minor damage to the treated surface resulting from transportation and erection shall be repaired at site in an approved manner, e.g. by painting with an approved zinc-rich paint, containing at least 92 weight per cent zinc powder.
3. After galvanization all members shall be dipped in a dichromate solution bath to avoid formation of white rust during storage and transportation.

3.4.2. APPLICATION REPORT

The Contractor shall submit the application report defined as follows:

- Daily report of the maximum and minimum ambient temperature and list of parts to be protected against corrosion,
- Daily report of the maximum and minimum humidity level in the corrosion protection application room,
- Other pertinent information.

3.4.3. QUALITY CONTROL IN WORKSHOPS

Inspection before shipment:

1. The Engineer reserves the right to inspect the corrosion protection application facilities in the Contractor's and/or his subcontractor's workshops and to ensure that they comply with the prescribed standards and application procedure.
2. The number of protection coats and the total thickness of the coating will be checked and the Engineer reserves the right to have the thickness of individual coats checked in his presence. On a protected surface, a test area and a number of test points shall be defined by the Engineer. The minimum measured thickness shall not be below 90% of the guaranteed thickness and the average of all measurements shall not be below the guarantee. The Contractor shall supply the measuring apparatus, which shall be of the electronic detection type (Brandl Positector or similar), giving readings accurate to within 1 micrometer. One measurement shall be taken every 0.5 m² or every 0.5 linear metres.
3. Adhesion tests shall be performed on submerged and partially submerged equipment or steel structure element, in accordance with British or European standards. The instruments required, in accordance with the same standards, shall be supplied by the Contractor.

3.5. APPLICATION ON SITE

3.5.1. GENERAL

The protective coating on surfaces damaged during handling, transportation and erection shall be repaired using the same surface preparation and products, depending on the protection system approved.

3.5.2. INSPECTION BEFORE APPLICATION

Inspection of the corrosion protection shall be carried out jointly by the Engineer and the Contractor after:

1. Full erection of the equipment and/or the steel structure;
2. Dust removal, washing with fresh water (except where otherwise instructed by the Engineer) and drying if deemed necessary by the Engineer.

Surfaces to touch up will then be defined by mutual agreement.

3.5.3. INSTALLATIONS FOR THE APPLICATION OF PROTECTIVE COATINGS ON SITE

The Contractor shall install all necessary equipment for:

1. Rinsing of structural surfaces that have been in contact with a salty atmosphere during transport, with the exception of surfaces to be sand blasted at site.
2. Drying of surfaces to be sand blasted;
3. Checking of air temperature and degree of humidity at the place of work execution, together with the necessary shelters and special arrangements required for carrying out these measurements;
4. Distributing compressed air for sand blasting and paint work;
5. Removal of sand blasting dust and thinner evaporation gases;
6. The protection of ancillary equipment and structures against the projection of products, their vapours, sand and dust.

3.5.4. APPLICATION OF PROTECTIVE COATING ON SITE

3.5.4.1. SUBMERGED OR PARTIALLY SUBMERGED EQUIPMENT

Reapplication of the protective coating on surfaces damaged during handling and transport, using the same products, depending on the protection system selected.

3.5.4.2. EQUIPMENT IN THE OPEN AIR

1. Reapplication of the primer protection on surfaces damaged during handling or transport, using the same products, and depending on the protection system used in the workshop;
2. Application of top coat;
3. The minimum thickness of the top coat shall be defined and guaranteed by the Contractor.

3.5.4.3. SURFACE OF PARTS EMBEDDED IN CONCRETE

All traces of grease and scaling shall be removed prior to concreting.

3.5.5. QUALITY CONTROL ON SITE

1. Checking of application conditions, compliance with paintwork standards and procedures.
2. Checking of surface preparation.
3. Checking of the number of coats and of the total coating thickness using testing apparatus to be provided by the Contractor.
4. Where deemed to be necessary the Engineer as the right to require additional adhesion tests as per French Standard NFT 30-038 or equivalent British or European Standard. Testing apparatus to be provided by the Contractor.

5. Acceptance of the protection system shall be combined with the overall acceptance procedures for the equipment or steel structure covered.

SECTION 01020

BASIC MECHANICAL REQUIREMENTS

1. GENERAL

1.1. WORK INCLUDED

This section of the specifications covers the general requirements applicable to all mechanical equipment to be supplied, unless different requirements are specified in the subsequent sections.

In case of conflict between the requirements of this general specification and those of the specific equipment specifications, the latter shall have precedence.

1.2. QUALITY ASSURANCE

1.2.1. GENERAL

The equipment shall be manufactured in accordance with established practice. All the components shall be finished as required by their importance, position and destination. The manufacture shall be sound, without any faults likely to impair their ability to fulfil their purpose:

1. All equipment shall be designed in compliance with up-to-date practice;
2. Equipment design shall take into account control and maintenance operations as well as operating incidents;
3. The general aesthetic appearance shall be studied and shall blend in with the overall architecture of the structures.

1.2.2. MATERIALS

1.2.2.1. GENERAL

Materials shall be new and of first class quality.

Rolled and cast steel shall be of good quality and free from blow or shrinkage holes, porosity, cracks or other defects.

Cast iron is not acceptable for any tap, valve bodies or components subject to internal pressure.

The Contractor shall indicate in the calculation notes the quality of the materials with reference to International (ISO) or American (ASTM,...) or European (DIN or BS or NF,...) or Japanese (JIS) or equivalent standards, and their mechanical and chemical properties. Such information shall be given for all materials used in the construction of the main items of equipment before procurement commences.

Materials shall comply with the list below or be similar according to other acceptable standards:

1.2.2.2. MAIN TYPES OF MATERIALS

European standards or equivalent as below:

- Structural steel:.....EN 10025
.....EN 10137
- Non alloy high strength steel: EN 10083
- Low alloy high strength steel: EN 10083
- Corrosion resisting steel: EN 10088
- Iron casting: EN 1561
- Alloy steel casting:..... A 32054
- Steel bolts and nuts: EN ISO 3506
.....EN 20898.
- Corrosion resisting steel bolts and nuts: EN ISO 3506
.....EN 20898
.....EN 10088.
- Steel pipes and fittings: EN ISO 559
..... EN ISO 2604
..... EN ISO 4200
..... EN ISO 5252.
- Bronze: E 44158
..... EN ISO 5755

Alternative materials shall be submitted to the Engineer's approval.

1.2.2.3. TESTING OF MATERIALS

All materials shall be tested in compliance with the relevant European or ASTM or similar acceptable standards. In particular:

- CCH 70-2 for the castings.
- CS GFF 3-72 or equivalent for the forgings.
- ASTM for steel plates pipes and laminated products.

1.2.2.4. CAST STEELS AND CASTINGS

Before any part is cast, drawings of the major items showing the proposed locations of the samples which are to be sent for mechanical and chemical tests, shall be submitted for the Engineer's approval.

Blow holes and all other such defects which become apparent after cleaning or machining must be ground to sound metal before any rectification is undertaken.

Castings shall not be twisted nor show any other form of distortion, nor increase in their dimensions (above that already taken into account) which could cause interference with other parts. The metal structure of the castings shall be homogeneous and free of all non-metallic impurities.

If, at any point of a critical section, the casting exhibits any unacceptably high concentration of impurities or alloying elements, the part will be rejected.

Major castings shall be submitted to ultrasonic inspection or radiographic examination where the results of ultrasonic testing is doubtful or not practical. These tests shall be complemented by magnetic particle inspection or dye penetration test.

The Manufacturer shall establish a quality sheet for each major casting.

Castings exhibiting defects of severity levels 4 or 5 in category A through E in accordance with ASTM-E 186 will be rejected.

Casting defects shall only be corrected by welders of the highest quality using the best welding techniques. All castings requiring rectification during any stage of the manufacturing process after they have been initially annealed, shall, unless otherwise indicated, be re-annealed.

Casting defects which require correction by welding shall be reported to the Engineer and shown on a drawing or by means of photographs. Approval shall be obtained from the Engineer before the corrective work is carried out.

1.2.3. WELDINGS

1.2.3.1. QUALIFICATION

For pressure tanks and hydraulic cylinders, the qualification of welding procedures and welders shall be in accordance with the requirements of ASME, Boiler and Pressure Vessel Code, Section IX.

For other components the qualification of welding procedures and welders shall conform either to ASME, Section VIII, Division 1, Section IX or the Standard Qualification Procedure of the American Welding Society at the Contractor's option.

Other welding standards and procedures translated in English will be accepted only to the extent that they conform to the above accepted codes and specifications. Exceptions to these standards and procedures will be made only where approved in writing by the Engineer.

1.2.3.2. WELDING

Welding shall be performed by the electric-arc method. Electroslag welding will also be permitted.

All welds shall be made continuous. Welds on gate or other submerged equipment shall be watertight. Butt welds shall be full penetration welds welded from both sides.

Contractor will provide sufficient temporary bracing to control distortion during welding.

1.2.3.3. WELDED STRUCTURES - STRESS RELIEVING

Components, mainly those made up of large cross-section members, welded to the middle of the section or having large weld beads, shall be given stress-relieving heat treatment. This treatment shall apply in particular to:

- a. Components which will have to be precision machined;
- b. Structures exposed to buckling forces;
- c. High carbon steel components;
- d. Equipment submitted to internal or external pressure.

This list is given for guidance purposes and shall not relieve the Contractor of his responsibility.

1.2.3.4. WELD FINISH

Welds shall display good appearance and shall be suitable for painting. Structural welds shall be ground.

Final machining of welded parts shall be performed after welding and if applicable after stress relieving.

1.2.3.5. WELD TESTING

Non-destructive tests shall be in accordance with EN 10246.

For each item of equipment the Contractor shall propose for the Engineer's approval the type and extent of non-destructive weld testing.

- A. The Contractor will proceed with examination of at least 20% of the weld lengths completed by each welder.**

Butt welds will be given radiographic test. The Contractor shall propose the best suited type of test for welds other than butt welds.

- B. Welds on pressure tanks and servomotors shall be fully tested.**

- C. In addition to the requirements A, all main welds shall be fully tested by ultrasonic and magnetic particle or dye penetrant tests complemented by radiographic examination where interpretation by other methods is unclear.**

- D. Minor welds shall be spot tested.**

Examination of welds and acceptance or rejection will comply EN 10246.

1.2.3.6. WELD REPAIRS

Defective welds shall be repaired by removing the weld material from the defective zone until sound metal is reached. The weld shall then be remade. Repaired areas shall be subjected to a new radiographic examination.

If a radiograph reveals an unacceptable zone, an extra radiograph will be taken on each side of the said zone.

If the new radiographs do not indicate any defect that would require rejection of the weld, only the zone covered by the first radiograph will be repaired. If further unacceptable defects are indicated, a complete radiographic examination shall be carried out.

Any given weld area cannot be repaired more than twice.

1.2.3.7. ELECTRODES

Electrodes must be stored under the conditions specified by the supplier and used within a maximum time of six months as from their date of manufacture. If this duration is to be exceeded, the Engineer will have the right to require the execution of new electrode quality tests.

For electrodes particularly sensitive to humidity (especially basic electrodes), if they have not been stored in a dry condition in perfectly watertight wrappings, they shall be baked before use, according to the supplier's instructions.

1.2.4. GENERAL PROVISIONS FOR EQUIPMENT DESIGN

1.2.4.1. WEAR

The Contractor shall be considered to be fully aware of the properties of the water used and the atmospheric conditions and, accordingly, under normal operating conditions, the equipment supplied shall not be subject to any abnormal wear.

All parts of equipment subject to water-induced wear shall be provided with interchangeable parts that can be easily refilled by welding or replaced. These interchangeable parts shall be made from a material selected in relation to the intended use and the probable wear of the part. The Contractor shall indicate the composition and properties of the materials used on the basis of analyses carried out by the suppliers. He shall specify the type of electrode suitable for refilling by welding if this process is used. The design of bearings shall be such that no friction-induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

The design of bearings shall be such that no friction-induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

All electrical equipment parts liable to normal or accidental wear shall be designed to resist the action of atmospheric agents and climatic conditions.

1.2.4.2. NOISE

The project is designed to limit noise as much as possible.

- In technical equipment rooms:

The sound power radiated by all the equipment during maximum operation must not exceed the following values (per octave band):

Frequency in Hz	25	250	500	1000	2000	4000	8000
Log in dBA	82	82	78	75	72	69	65

Overall value: 80 dBA.

- Generally speaking, the levels must not be in excess of 80 dBA at 3 m of each equipment.

1.2.4.3. VIBRATIONS

During normal operation, the vibration r.m.s velocity, measured on the unit bearing supports, shall not exceed 4.5 mm/s. The vibration r.m.s speed is defined in standard VDI 2056.

The various manoeuvres of the gate and valve equipment shall be carried out under all possible loads without any harmful vibration or excessive noise occurring.

The knife edge of each gate shall be streamlined and designed to prevent vibrations regardless of their degree of opening.

1.2.4.4. ACCESS AND PROTECTION EQUIPMENT

Provision shall be made for access to and protection of the equipment so as to ensure safety during operation, maintenance and inspection. All rotating parts such as wheels, shafts, transmission belts and all live electrical equipment shall be suitably protected by metal housings. Such provision is to be made at the locations and in the positions approved by the Engineer.

The Contractor shall supply all catwalks, platforms, ladders, railings, trap-doors, manholes, and access hatches tied up to the equipment and necessary for proper operation, maintenance and personal safety.

The Contractor shall submit to the Engineer for approval his proposals for the passage of gutters and for the locations of trap-doors, platforms, access doors and ladders, together with all dimensions of spaces to be allowed for the passage of equipment.

1.2.4.5. ARRANGEMENT OF OPERATING EQUIPMENT

No manual controls for lifting or pulling manoeuvres shall require a force of more than 200 Newton, and no manual controls involving the operation of a wheel crank shall require a force of more than 100 Newton.

Wheel cranks shall be located approximately 1 m above floors or platforms. The controls and measuring instruments shall be readily accessible, without any need for special equipment, and clearly marked with identification numbers.

1.2.4.6. HANDLING AND DISMANTLING

All equipment shall be installed by using the normal operational ways. No acceptance will be done by the Engineer for installations using exceptional means.

Equipment shall be designed for easy dismantling and maintenance operations. Dismantling and maintenance of electrical equipment shall be possible without stopping or disturbing other equipment in its vicinity.

All equipment or parts of equipment designed to be dismantled and handled shall be provided with:

- a. Lifting rings, lugs, hoisting collars;
- b. Slings, chassis and special handling apparatus such as: grappling beams, monorails, trolleys, jacks, pulley and ratchet systems, etc.;

- c. Special jack screws appropriately located and in sufficient numbers for the dismantling of the relevant parts.

For heavy components, the Contractor shall provide special facilities for lifting each component. The Contractor shall also provide the necessary lifting gear for this equipment such as manually or electrically operated monorail hoists, hydraulic jacks, etc.

The above equipment shall be included in the Contractor's supply and shall be retained by the Employer.

1.2.4.7. INTERCHANGEABILITY

All machined parts included in winches, pumps, gears, etc. and all moving parts in general, shall be interchangeable and capable of being easily erected on a similar type of apparatus, except for standardised equipment.

For all the contract equipment, all electrical or hydraulic apparatus, equipment, instruments and accessories (for air, water or oil circuits) of the same rating and designed to perform the same functions or operate under comparable conditions within a given operating range, shall be identical and interchangeable.

If certain modifications are made to the equipment during manufacture or erection, these modifications must be submitted for the Engineer's prior approval and shall be made to all the equipment of the same type.

At his own expense, the Contractor shall keep for a minimum period of ten years all the manufacturing drawings and all design data likely to be of use in making repairs or possible replacement of components of the equipment.

1.2.4.8. TEMPERATURE RISE

The maximum temperature of metal parts of bearings and thrust bearings and that of lubricating oil shall be:

- Metal parts: 80°C.
- Lubricating oil: 60°C.

These temperatures when reached shall trigger an alarm in the control room.

The temperatures hereunder shall trigger emergency shut down of the unit:

- Metal parts: 85°C.
- Lubricating oil: 65°C.

The temperature rise of metal parts of bearings, thrust bearings, reduction gears and other mechanical systems shall not exceed 40°C above the ambient temperature or, in the case of outdoor equipment, 40°C above the outdoor temperature in the shade.

The rise in temperature of lubricating oil, measured around the metal parts quoted above shall not be more than 30°C above the ambient temperature or, in the case of outdoor equipment, 30°C above the outdoor temperature in the shade.

PART 3 – TECHNICAL SPECIFICATIONS

1.2.4.9. LUBRICATION

Lubrication devices and systems are included in the supply. Lubricating bearing materials shall be submitted to the Engineer's approval.

Self-lubricating systems will be provided wherever possible and are mandatory for submerged or temporarily submerged equipment unless the loads applied prevent their use.

Self-lubricating systems for submerged or partially submerged parts shall be provided with protective seals.

The systems proposed shall be of proved and referenced design. References shall be supplied by the Contractor.

1.2.4.10. OPERATING SPEEDS AND LOADS

The operating speeds defined in the technical specifications shall be guaranteed under normal operating conditions and under all loads within a 5% tolerance band.

The maximum operating loads specified by the Contractor shall be considered as guaranteed.

1.2.4.11. NAMEPLATES

All equipment shall have a permanent engraved metal nameplate secured by screws clearly showing all pertinent information regarding the equipment, in the English language, including at least the following:

- a.** Manufacturer's name and address,
- b.** Name, type, serial number and other equipment identification data,
- c.** Rating and other design data,
- d.** Date of manufacture.

1.2.5. DESIGN OF MISCELLANEOUS DETAIL EQUIPMENT

1.2.5.1. AUXILIARY PIPEWORK AND PRESSURE TANKS

Pipework shall be supplied with the corresponding flanges, nuts and bolts, threaded unions, isolating valves (cast iron excluded), supports and anchoring.

Pipework design shall comply with the following values:

- a.** Slope greater than 1% for the drainage lines.
- b.** Water and oil flow velocities not to exceed 4 m/s.

Pipework embedded in concrete shall be systematically tested under pressure before concreting. All pipe end seals or blank flanges necessary for these tests shall be provided by the Contractor. No pipework made of malleable materials, such as lead, copper, etc. shall be embedded in concrete.

Pipe internal and external protection shall be by hot galvanizing. Subsequently, after each welding operation, the galvanization is to be repaired by wire brushing and application of a compatible enriched zinc paint.

Galvanization is not required for oil piping. The external surface of the oil pipes shall be protected by painting as per Section 01010 - Corrosion protection.

All flanges and couplings shall be suitably placed to facilitate dismantling of corresponding equipment and appliances, with a sufficient number of isolation valves to avoid loss of fluid when partial dismantling work is carried out.

All pipes shall be installed in order to be easily dismantled for maintenance.

Flanges and couplings shall be suitably placed to facilitate dismantling. These flanges and couplings shall be indicated on drawings, with the dimensions.

Tests:

- c. Pressure tanks and pipework shall be tested at a pressure at least 50% greater than the maximum operating pressure.
- d. Free-surface tanks and basins shall be tested for watertightness before painting. They shall be filled with water for 24 hours. The watertightness of the welds shall be tested with compressed air and a soapy solution, or by any other method approved by the Engineer.

1.2.5.2. TIGHTNESS OF WATER AND OIL CIRCUITS

All bearings, oil, water and air pipes, pumps and other associated apparatus shall be perfectly tight. No water, air, oil or grease leak shall take place. Any condensation and possible leakage shall be collected and drained off. The design shall be such that no oil splashes or vapour will reach electrical equipment.

1.2.5.3. COUPLINGS

Couplings between electric drive motors and the various types of driven equipment shall be of the semi-elastic type and shall have a service factor of 1.5.

1.2.5.4. BOLTS, NUTS, SCREWS

All bolts, nuts and screws in contact with water or in a damp atmosphere shall be made of corrosion-resisting materials. A pre plating treatment of 10-12 microns shall be applied to High Resistance Bolts subject to continuous or intermittent immersion in water. Particular care shall be taken to avoid contact corrosion. Threads under vibration shall be especially treated with special resins.

All shims to be used shall be protected from corrosion by cadmium plating, sherardisation or by any other process approved by the Engineer.

1.2.5.5. ANCHORING

For all anchoring, use of "fish-tail" systems is strictly prohibited.

1.2.5.6. SEALS FOR GATES AND VALVES

The Contractor shall pay particular attention to seal joints, especially in corners, so that a continuous line of contact is maintained. The seal corner joints shall be cast in one piece and vulcanised or glued to the lateral and frontal seals.

The seal backing plate holding bolts shall be of stainless steel. The bolt holes in the gate skin plate, the seals themselves and the backing plate shall be drilled in the workshop. If the gates are to be shipped dismantled, the seals shall be removed and packed separately.

All gate and valve seals shall be free of any defect. The seals must be made of synthetic rubber, non-reactive to contact with grease or hydrocarbons. The seals shall be designed to make field adjustment and maintenance easy.

The seals of the gates shall comply with the requirements given hereunder without any special devices having to be used. Local leaks and average leaks per linear metre of seal shall not exceed the following values:

- a. Local leaks: 0.25 litres per second;
- b. Average leaks: 0.10 litres per second per metre.

Valves seals shall be completely watertight.

1.2.5.7. HOLES FOR CONCRETING AND GROUTING

Holes of at least 200 mm in diameter shall be provided in the horizontal part or bottom of linings between stiffeners and welded seams, in order to concrete a surface area of approximately one square-metre. Hole-covers shall also be provided.

All holes in the hydraulic conduits for concreting and grouting purposes shall be fitted with screwed plugs and then seal welded in place, rendering the part watertight, and shall be carefully ground flush.

1.2.6. EMBEDDED PARTS AND LININGS

1.2.6.1. GENERAL

All embedded parts and linings shall be designed to withstand both the hydrostatic pressure at the point of installation as well as the grouting pressure.

The stiffeners of the vertical embedded parts shall be designed so as not to hinder the concreting carried out on site.

Sufficient quantities of tie bars and adjusting rods shall be provided. The latter shall be attached to the steel plates embedded in the primary concrete. The steel plates will be designed solely for adjusting the position of the corresponding embedded parts and shall under no circumstances be subjected to high loads nor shall they replace the anchorings embedded in the primary or secondary concrete. If, according to the design of the embedded parts, the Contractor supplies and installs steel sections to be embedded in the secondary concrete for adjustment of the embedded parts, then such sections shall not be less than 40 mm from the concrete surface facing.

All surfaces having contact with the seals as well as the sliding surfaces shall be made of corrosion resisting materials.

All corrosion resisting parts, whether intended for the sill, the side walls, etc. installed in the sluiceway shall be perfectly flush with the sluice profile. Any unevenness or level differences will be rejected.

For normal stiffening of vertical or horizontal embedded parts (except in the case of self-resisting embedded parts), the end of the stiffeners shall not, insofar as possible, cut the concrete in the form of "L" or "T" sections.

1.2.6.2. FIXED PARTS FOR GATES

In order to facilitate the introduction of gates into their slots, the top of the embedded parts making up the gate slot shall have a lead-in section which diverges 30° from the vertical. The frontal embedded parts shall comprise an upper section to ensure good contact with the transverse seals when the gate arrives in the closed position.

1.2.6.3. LININGS

The welds joining the steel plates together and joining the steel plates to the corrosion resisting steel sliding surfaces located in the sluices shall be very carefully ground flush and refilled if necessary, so that there are no cracks, protrusions nor misalignments.

All welds shall be continuous, solid and watertight. They shall all be subjected to crack detection tests:

- a. Crack detection tests along 100% of the joints between liners;
- b. Crack detection tests for 20% of all other welds.

No indentations or protrusions over 1.5 mm in depth or height, or with a slope greater than 3° shall be permitted on any part of the sluices surface.

1.2.6.4. LOADING CONDITIONS

1.2.6.4.1. *Water loads*

Water loads shall be considered as follows:

- 10 kN/m³ for clean water
- 11 kN/m³ for sewage water

1.2.6.4.2. *Allowance shall be made for the following loads:*

- a. Weights, buoyancy, hydrodynamic loads and loads generated by gates, valves and penstocks movements (such as friction forces);
- b. Loads generated by the guiding systems;
- c. Loads generated by the obstruction of trash racks.

1.2.6.4.3. *Earthquakes:*

The Contractor shall design structures according to local seismic rules and data, submitted to the approval of the Engineer.

1.2.6.4.4. *Hydraulic transient*

The pressure surges generated by the closure of valves and gates shall be taken into account. The maximum amplitude of the pressure surge to be taken into account is specified in the corresponding section.

1.2.6.4.5. Load combination

Each of the following conditions shall be considered for normal loading of gates.

a. Gate or valve closed:

The effect of the following loads shall be combined:

- Hydrostatic load corresponding to the water level acting on the gate or valve, no water on the opposite side;
- Dead weight of the gate and hoist connecting rods bearing on the gate, reaction forces acting on the supports;

b. Gate or valve being closed or opened at any point of travel:

The effects of the following loads shall be taken into account:

- Weight of the gate (included weight of any other gate-mounted equipment, ballast,...);
- Weight of hoist connecting rods bearing on the gate;
- Hydrostatic load corresponding to the piezometric level acting on both sides of the gate or valve;
- Hydrodynamic loads corresponding to flow conditions;
- Rated hoist pull, rated thrust (if any) or required control load acting on the gate;
- All load components caused by seal friction, guide loading, friction of pistons and pins of cylinders after a long inactive period and other effects;
- Additional friction and/or blocking forces in the guiding devices and against the seals.

1.2.6.5. ALLOWABLE STRESSES

Gate: unless otherwise specifically indicated for a type of structure or equipment, allowance shall be made for the following values: - DIN standard 19704. Chapter 7 or equivalent.

1.2.6.6. BUCKLING OF CYLINDRICAL PARTS, CONDUITS, PENSTOCKS

The factor of safety against buckling for cylindrical parts shall be as specified in the CECT design code.

1.2.6.7. LOADS ON SUPPORTS, ANCHORS AND CONCRETE

The Contractor shall furnish the values of the loads applied by the equipment on the supports and anchors.

The allowable compression stress applied on the concrete shall meet DIN 19704/4114 standards or equivalent.

1.2.6.8. PERMISSIBLE TOLERANCES ON GATES AND FITTINGS

(Any tolerances specified in the subsequent sections have priority over these tolerances).

Tolerances shall be as follows:

1. For all stainless sealing strips: sills, lateral risers and frontal cross pieces: In the longitudinal and transverse directions:
 - a) local flatness: 0.5 mm over 100 mm
 - b) general flatness: 1 mm
 - c) general straightness: 1 mm
2. On the standard lining panels:

Along the height and width of the sluice:

 - a) local flatness: 1.5 mm over 500 mm
 - b) general flatness: 2 mm
 - c) general straightness: 2 mm

Along the length of the lining panels:

 - a) general straightness: 2 mm

The general flatness condition shall apply to the lining panels after on-site welding, i.e. along the whole length of a given side wall.

Between the lateral stainless steel sealing strips:

1. Parallelism (between sealing strips): 2 mm.
2. Perpendicularity (of each sealing strip to the sill): 1 mm.

All tolerances shall allow a good operation of the equipment. All tolerances not in agreement with above specified values shall be submitted to the Engineer's approval.

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SECTION 01030

BASIC ELECTRICAL REQUIREMENTS

1. GENERAL

1.1. WORK INCLUDED

This contract includes the supply and the installation of all the electric equipment as well as all the electric works allowing to assure the smooth running of the Water-treatment plant Aeratsia.

Electrical works include arranging both main and a spare power supply for the wastewater treatment plant.

1.1.1. REQUIRED POWER FOR WWTP

Electrical power is needed in Aeratsia WWTP for operating equipment and for lighting. The required power is inventoried based on four geographic zones on the site plan.

- Decanted Water Area (110) & Transformer Building (400).
- Screening Areas (101 & 102), Well Water (110) & Electrical Room (402).
- Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300).
- Sludge Building (200) & Outlet Chamber (107).

The power estimates are detailed for each component within each area and are summarized in the following three tables.

Tabl. 1 - Power Requirements for Decanted Water Area (110) & Transformer Building (400) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
110 - Well Water	Surpression Pump	N	5			6.25
	Surpression Pump	N	5			6.25
400 – Transformer Building	Air Conditionning Unit	N	1			1
	Air Conditionning Unit	N	1			1
Miscellaneous	Outdoor Lighting	N	1			1
	Building Lighting	N	1			1
	Building Electrical Outlets	N	3			3
Total Normally Used			17			19.5
Total Stand by Used						
Total Futur Equipment						

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
Total Installed			17			19.5

Note: (N: Normal Use, SB: Stand-by, FE: Future Equipment)

The electrical power required for the Decanted Water Area (110) & Transformer Building (400) areas is estimated at 20 kVA.

Tabl. 2 - Power Requirements for Screening Areas (101 & 102), Well Water (110) & Electrical Room (402) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
101 – Coarse Screening	Coarse Screen	N	0.55			0.69
	Coarse Screen	N	0.55			0.69
	Coarse Screen	FE			0.55	0.69
	Belt Conveyor	N	2.2			2.75
	Heat Tracing	N	0.3			0.3
102 – Fine Screening	Fine Screen	N	0.55			0.69
	Fine Screen	N	0.55			0.69
	Fine Screen	N	0.55			0.69
	Fine Screen	FE			0.55	0.69
	Screw Conveyor / Compactor	N	1.5			1.88
	Air Compressor	N	2.2			2.75
	Submersible Pump Drainage	N	0.75			0.94
110 - Well Water	Existing Artesian Well Pump	N	45			56.25
402 – Electrical Room	Air Conditionning Unit	N	1			1
Miscellaneous	Outdoor Lighting	N	2			2
	Building Lighting	N	1			1
	Building Electrical Outlets	N	3			3
Total Normally Used			61.70			
Total Stand by Used						
Total Installed			61.70		1.10	76.70

Note: (N: Normal Use, SB: Stand-by, FE: Future Equipment)

The electrical power required for the Screening Areas (101 & 102), Well Water (110) & Electrical Room (402) areas is estimated at 77 kVA.

Tabl. 3 - Power Requirements in the Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
103 - Grit & Grease Removal Tank	Grit Pump	N	2.4			3
	Grit Pump	N	2.4			3
	Submerged Air Turbine (x8)	N	27.2			34
	Submerged Air Turbine (x8)	N	27.2			34

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Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
	Submerged Air Turbine (x8)	N	27.2			34
	Submerged Air Turbine (x8)	N	27.2			34
	Air Lift Compressor	N	3			3.75
	Air Lift Compressor	N	3			3.75
	Travelling Bridge	N	0.5			0.63
	Travelling Bridge	N	0.5			0.63
	Surface Scraper	N	0.18			0.23
	Surface Scraper	N	0.18			0.23
	Surface Scraper	N	0.18			0.23
	Surface Scraper	N	0.18			0.23
	Grit Classifier	N	0.75			0.94
	Grit Classifier	N	0.75			0.94
	Grit Classifier	SB		0.75		
	Drain Sump Pump	N	11.8			14.75
	Drain Sump Pump	SB		11.8		
	Grit Tank Heat Tracing	N	0.3			0.3
	Grit Tank Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Grease Tough Heat Tracing	N	0.3			0.3
	Pump Room Electro-heating	N	3			3.75
	Pump Room Exhaust Ventilation	N	2.2			2.75
105 - Pr Settling Tanks	Pickets Fence	N	3			3.75
	Pickets Fence	N	3			3.75
	Pickets Fence	N	3			3.75
	Pickets Fence	N	3			3.75
	Air Compressor	N	1.5			1.88
	Immersed Mixer	N	4			5
	Immersed Mixer	N	4			5
	Progressing Cavity Pump	N	7.5			9.38
	Progressing Cavity Pump	N	7.5			9.38
	Progressing Cavity Pump	N	7.5			9.38
	Progressing Cavity Pump	FE			7.5	9.38
	Submersible Pump for Gallery Sump	N	1			1.25
	Heat Tracing Sedimentation	N	0.3			0.3
	Heat Tracing Sedimentation	N	0.3			0.3
	Heat Tracing Sedimentation	N	0.3			0.3
	Heat Tracing Sedimentation	N	0.3			0.3
	Pump Gallery Electroheating	N	6			7.5
	Pump Gallery Electroheating	N	6			7.5
	Pump Gallery Exhaust Ventilation	N	8			10
105 – Decanted Water	Decanted Water Pump	N	7.5			9.4
	Decanted Water Pump	N	1.5			1.88
300 – Odor Control	2 Speed Fan Unit	N	4			5
	Heater	N	12			15

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Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
	Heat Tracing Biofilter	N	0.5			0.5
Miscellaneous	Outdoor Lighting	N	3			3
	Building Lighting	N	2			2
	Building Electrical Outlets	N	6			6
Total Normally Used			244.32			
Total Stand by Used				12.55		
Total Installed			244.32	12.55	7.5	312.24

Note: (N: Normal Use, SB: Stand-by; FE: Future Equipment)

Electrical power required for the Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300) areas is estimated at 312 kVA.

Tabl. 4 - Power Requirements in the Sludge Building (200) & Outlet Chamber (107) areas

Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
200 – Sludge Building	Air Condionning Unit	N	1			1
	Exhaust Ventilation	N	10			12.5
	Exhaust Ventilation	N	10			12.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
	Solids Handling Room Electroheating	N	6			7.5
201 - Sludge Conditioning	Polymer Preparation Package	N	6.88			8.6
	Surpression Pump	N	2.2			2.75
	Motorized Valve	N	0.15			0.15
	Motorized Valve	N	0.15			0.15
	Motorized Valve	N	0.15			0.15
	Motorized Valve	FE			0.15	0.15
202 - Sludge Dewatering	Dewatering Unit	N	18.75			23.45
	Dewatering Unit	N	18.75			23.45
	Dewatering Unit	N	18.75			23.45
	Dewatering Unit	FE			18.75	23.45
203 - Sludge Liming	Dust Filter	N	0.2			0.25
	Dust Filter	N	0.2			0.25
	Dust Filter	N	0.2			0.25
	Arch Breaker	N	0.55			0.69
	Arch Breaker	N	0.55			0.69
	Arch Breaker	N	0.55			0.69
	Screw Dosing	N	1.1			1.38

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Building	Type	Used (N/SB/FE)	Power N (kW)	Power SB (kW)	Power FE (kW)	Power (kVA)
	Screw Dosing	N	1.1			1.38
	Screw Dosing	N	1.1			1.38
	Screw Dosing	FE			1.1	1.38
	Conveyor	N	1.1			1.38
	Conveyor	N	2.2			2.76
	Conveyor	N	1.1			1.38
	Conveyor	FE			1.1	1.38
	Screw Injector	N	0.75			0.94
	Screw Injector	N	0.75			0.94
	Screw Injector	N	0.75			0.94
	Screw Injector	FE			0.75	0.94
	Sludge-lime Mixer	N	2.2			2.76
	Sludge-lime Mixer	N	2.2			2.76
	Sludge-lime Mixer	N	2.2			2.76
	Sludge-lime Mixer	FE			2.2	2.76
	Screw Conveyor	N	15			18.75
	Screw Conveyor	N	15			18.75
	Belt Conveyor	N		2.2		2.76
	Liming Room Electroheating	N	6			7.5
	Liming Room Electroheating	N	6			7.5
204 – Sludge Storage	Heat Tracing	N	0.3			0.3
205 – Sludge Building for Water Pit	Immersed Pump	N	10			12.5
	Immersed Pump	SB		10		
206 – Odor Control Sludge Building	2 Speed Fan Unit	N	11			13.75
Miscellaneous	Outdoor Lighting	N	2			2
	Building Lighting	N	3			3
	Building Electrical Outlets	N	6			6
107 – Outlet Chamber	Submersible Pump	N	0.5			0.63
Total Normally Used			219.28			
Total Stand by Used				10.0		
Total Futur Equipment					24.05	
Total Installed			214.88	12.2	24.05	291.45

Note: (N: Normal Use, SB: Stand-by; FE: Future Equipment)

Electrical power required for the Sludge Building (200) & Outlet Chamber (107) areas is estimated at 292 kVA.

Electrical power required for all areas is estimated at 701 kVA.

The power supply at existing substation is not sufficient to power the new installation. Therefore it is necessary to build of a new substation.

The new substation will be used to power all the new equipments. The existing substation spare capacity of 140 kVA could be used for the future Phase 2 Digestion.

The location of the new substation is projected near the odor treatment area, in the vicinity of the former grit tanks.

1.1.2. MEDIUM VOLTAGE LINE

The existing medium voltage will be extended, buried and deviated to power the new substation. A new buried medium voltage cable will be laid between the new substation and the existing substation . (See Electrical Cables Layout drawing)

All networks will be provided by the contractor (Trenches, cables, connections etc...). The Contractor will ensure the continuity of operation of the existing facilities during this work. A temporary generator will be required for the transition.

1.1.3. MAIN POWER SUBSTATIONS AND SWITHGEARS

1.1.3.1. NEW SUBSTATION

The contractor will have in is scope of works the supply of the equipment of MV and LV for the realization of a substation near the odor treatment area. (See Electrical Cables Layout drawing)

He will owe all the necessary works for the supply, the installation, the cabling and the connections of the following equipment:

- MV arrival cell.
- MV departure cell.
- MV metering Cell.
- MV general circuit breaker cell.
- Two cells protection transformer
- Two transformers 6kV/410V de 800 kVA.
- The low voltage general cupboard.
- Reactive power compensation capacitor.

1.1.3.2. NEW LV GENERAL CUPBOARD

The contractor will have in is scope of works the supply of the equipment for the realization of the Low-Voltage General Cupboard.

The Low-Voltage General Cupboard shall be installed in the electrical room in the transformer building (area 400) and power supply the Decanted Water Area (110) and Transformer Building (400).

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below:

Tabl. 5 - Low-Voltage General Cupboard supply of departure

Area	Departure	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
402	Screening divisional cupboard	1	63	4x100
103	Grit and Grease divisional cupboard	1	253	4x400
200	Sludge Building Divisional cupboard	1	249	4x400
110	Surpression Pump	2	5	3x16

Area	Departure	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
400	Air Conditionning Units	2	1	2x10
400	Outdoor Lighting	1	1	2x20
110	Building Lighting	1	0.5	2x10
110	Building Electrical Outlets	1	3	2x16
400	Building Lighting	1	0.5	2x10
400	Building Electrical Outlets	1	3	2x16
400	230Vac to Control Circuits	1	3	2x16

1.1.3.3. SCREENING DIVISIONAL CUPBOARD

The contractor will have in is scope of works the supply of the equipments for the realization of the Screening Divisional Cupboard.

The Screening Divisional Cupboard shall be installed in the electrical room (area 402) and power supply the Screening Areas (101 & 102), Well Water (110) and Electrical Room (402)

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below.

Tabl. 6 - Screening Divisional Cupboard

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
101 – Coarse Screening	Coarse Screen	2	0.55	3x10
	Belt Conveyor	1	2.2	3x10
	Motorized Sluice Gate	2	0.1	2x10
	Solenoid Valve	1	0.1	2x10
	Heat Treacing	1	0.3	2x10
102 – Fine Screening	Fine Screen	3	0.55	3x10
	Screw Conveyor / Compactor	1	1.5	3x10
	Motorized Sluice Gate	5	0.1	2x10
	Air Compressor	1	2.2	3x10
	Submersible Pump	1	0.75	3x10
110 – Well Water	Existing Artesian Well Pump	1	45	3x80
402 – Electrical Room	Air Conditionning Unit	1	1	2x10
	Uninterruptible Power Supply	1	1.5	2x10
	Building Lighting	1	1	2x10
	Building Electrical Outlets	1	3	2x16
	230Vac to Control Circuits	1	3	2x16
	Outdoor Lighting	1	2	2x20

1.1.3.4. GRIT AND GREASE DIVISIONAL CUPBOARD

The contractor will have in is scope of works the supply of the equipments for the realization of the Grit and Grease Divisional Cupboard.

The Grit and Grease Divisional Cupboard shall be installed in the Grit Pump room (area 103) and power supply the Grit and Grease Removal Tank (103), Primary Settling Tank (105) and Odor Control (300).

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below.

Tabl. 7 - Grit and Grease Divisional Cupboard

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
103 – Grit & Grease Removal Tank	Grit Pump	2	2.4	3x10
	Submerged Air Turbine	32	3.4	3x10
	Air Lift Compressor	2	3	3x10
	Travelling Bridge	2	0.5	3x10
	Surface Scraper	4	0.18	3x10
	Grit Classifier	3	0.75	3x10
	Submersible Pump	2	11.8	3x20
	Heat Tracing	2	0.3	2x10
	Grease Trough Heat Tracing	4	0.3	2x10
	Pump Room Electro-Heating	1	3	4x10
	Pump Room Exhaust Ventilation	1	2.2	2x10
	Uninterruptible Power Supply	1	1.5	2x10
	Building Lighting	2	1	2x10
	Building Electrical Outlets	2	3	2x16
	230Vac to Control Circuits	1	3	2x16
	Outdoor Lighting	1	3	2x20
105 - Primary Settling Tanks	Pickets Fence	4	3	3x10
	Air Compressor	1	1.5	3x10
	Immersed Mixer	2	4	3x10
	Progressing Cavity Pump	3	7.5	3x16
	Submersible Pump	1	1	3x10
	Sedimentation Heat Tracing	4	0.3	2x10
	Pump Gallery Electro-Heating	2	6	4x16
	Pump Gallery Exhaust Ventilation	1	8	4x16
	Motorized Sluice Gate	2	0.1	2x10
105 - Decanted Water Service	Sludge Dewatering Pump	1	7.5	3x16
	Odor Treatment Pump	1	1.5	3x10
300 – Odor Control	2 Speed Fan	1	4	4x10
	Heater	1	12	4x20
	Heat Tracing	1	0.5	2x10

1.1.3.5. SLUDGE BUILDING DIVISIONAL CUPBOARD

The contractor will have in is scope of works the supply of the equipments for the realization of the Sludge Building Divisional Cupboard.

The Sludge Building Divisional Cupboard shall be installed in the electrical room in the Sludge Building (area 200) and power supply the Sludge Building (200) and Outlet Chamber (107).

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the departures listed in the table below.

Tabl. 8 - Sludge Building Divisional Cupboard

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
200 – Sludge Building	Air Conditionning Unit	1	1	2x10

Building	Type	Number of Departures	Power (kW)	Calibre of the protection circuit-breaker (Ampere)
	Exhaust Ventilation	2	10	4x20
	Solids Handling room Electroheating	5	6	4x16
	Uninterruptible Power Supply	1	1.5	2x10
	230Vac to Control Circuits	1	3	2x16
	Building Lighting	2	1.5	2x10
	Building Electrical Outlets	2	3	2x16
	Outdoor Lighting	1	2	2x20
201 - Sludge Conditioning	Polymer Preparation Package	1	7	4x16
	Surpression Pump	1	2.2	3x10
	Motorized Valve	3	0.15	2x10
202 - Sludge Dewatering	Dewatering Unit	3	18.75	4x32
203 - Sludge Liming	Dust Filter	3	0.2	3x10
	Arch Breaker	3	0.55	3x10
	Screw Dosing	3	0.75	3x10
	Conveyor	2	1.1	3x10
	Conveyor	1	2.2	3x10
	Screw Injector	3	0.75	3x10
	Sludge-lime Mixer	3	2.2	3x10
	Screw Conveyor	2	15	3x32
	Belt Conveyor	1	2.2	3x10
	Liming Room Electro-Heating	2	6	4x16
204 – Sludge Storage	Heat Tracing	1	0.3	2x10
205 – Sludge Building Foul Water Pit	Submerged Pump	2	10	3x16
206 – Odor Control	2 Speed Fan	1	11	4x16
107 – Outlet Chamber	Submersible Pump	1	0.5	3x10

1.1.4. ELECTRICAL WORKS

The contractor will have in is scope of works the supply of the others equipments for the realization of the lighting system, of the low power installations, of the building service, of the lighthning protection system, of the heating system, of the ventilation system, of the air conditionning system, of the telephone system and of the other electrical needs.

The contractor will owe all the necessary works for the supply, the installation, the cabling and the connections of the equipments of this systems.

The contractor will owe all the necessary works for the cabling and the connections of all the equipments of the process; of the monitoring (instrumentation) and of the control systems.

2. ELECTRICAL PLANT

2.1. APPLICABILITY

The following clauses specify the general requirements for the electrical equipment. General specification clauses shall apply except where specifically redefined elsewhere in the Specification.

2.2. POWER TRANSFORMERS GENERAL

1. Power transformers shall comply with IEC 76 unless otherwise specified. They shall be suitable for General use on a three-phase system.
2. The materials used and the method of construction shall be of the first class quality and shall be such as to ensure optimum performance and uniform temperature throughout the transformer.
3. In the design of the transformer, special attention shall be paid to reduce noise level to a minimum.
4. Each transformer shall be provided with a main frame earthing terminal which shall be separate from the neutral terminal of a star connected winding.

Where the neutral of a star connected winding is to be separately connected to earth, an insulated neutral connection shall be brought out via a separate neutral chamber having provision for housing one or more current transformers for earth fault protection. A removable cover shall permit access to the current transformers and their secondary wiring.

5. Main cable terminations shall be provided to suit the type of cable used.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable and cores.

The boxes shall provide sufficient space for segregating the cores and maintaining the minimum insulation clearance and creepage distances applicable.

Cable boxes to accommodate low voltage (up to 1 000 volts) PVC or XLPE insulated cables shall be air insulated, designed to exclude direct ingress of moisture and dirt.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

6. Auxiliary wiring from current transformers, Buchholz relays, winding temperature indicators, pressure switches, etc., shall be marshalled to a separate termination chamber with separate access cover. The terminal boards or blocks shall be as specified for switchboard components. Removable, undrilled cable gland plates shall be provided.

2.3. OIL FILLED TRANSFORMERS

1. Oil filled transformers shall be suitable for outdoor service and arranged for natural air cooling (Type ONAN) and shall comply with the specification for power transformers.
2. Constructional steelwork shall be shot blasted or chemically pickled internally and externally and shall be thoroughly descaled and degreased before being given the first coat of a comprehensive painting process which shall, for the interior, be of paint or varnish able to resist the action of oil. The exterior shall be primed with one coat of zinc-enriched paint followed by two undercoats of contrasting colour followed by one top coat of durable, oil resisting and weather resisting paint.
3. Main connections shall be brought out through oil-tight bushings into their respective connecting chambers and shall be provided with disconnecting links to facilitate cable testing and complete removal of the connecting chamber from the transformer without the necessity of breaking the cable termination.
4. Each transformer shall be delivered filled with oil.

5. Temperature sensing devices shall operate a dial type indicator with a red line showing maximum permissible operating temperature. The indicator shall incorporate adjustable alarm and trip contacts to operate on excess temperatures.

Silica-gel breathers shall be fitted with indicators and shall be conveniently located for regular inspection and ease of silica-gel renewal.

Buchholz relays shall have their gas sampling cocks conveniently placed for operation from ground level.

2.4. TAP-CHANGERS

Off-circuit tap-changers shall comply with IEC 76-4, unless otherwise specified.

Tapping on HV side (%) shall be: ± 2.5 , ± 5 .

Tap-changers shall be delivered filled with oil.

2.5. ENCLOSURES FOR ELECTRICAL POWER APPARATUS

1. Enclosures shall be fabricated from sheet Electrical Power steel of adequate thickness, suitably braced to form a rigid structure. The thickness of medium voltage boards and low voltage boards shall be 2 mm as a minimum. Exterior corners and edges shall be rounded to give a smooth overall appearance. Designs involving the use of externally visible assembly bolts and screws or rivets will not be acceptable.

Enclosures mounted indoors and outdoors shall provide a degree of protection not less than IP54 to IEC 529 unless otherwise specified. The design of the enclosures shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Cable entries shall be closed and made vermin proof.

Unless otherwise specified, enclosures shall be suitable for floor mounting.

Where wall mounting enclosures are provided, the fixing details shall preferably comprise externally welded brackets but internal fixing arrangements will be acceptable provided that they prevent ingress of moisture. With either arrangement, the rear of the enclosure shall be not less than 10 mm from the wall.

Lifting eyebolts shall be removed after installation and replaced by bolts.

2. Enclosures shall be pleasing in appearance, extensible, and symmetrically arranged as far as possible with projections kept to a minimum.

Where two or more enclosures are fitted together, they shall form a flush fronted continuous suite of uniform height. Instruments, relays, and control devices shall not be mounted at a height greater than 2 000 mm nor less than 300 mm from floor level.

All individual components of equipment associated with a single item of plant shall be contained in a single enclosure. Where a number of plant items are in close proximity, the use of individual enclosures shall be avoided and composite enclosures shall be provided. Enclosures for multi-circuit switchboards shall be subdivided into single circuit compartments. Compartments shall be segregated by rigidly braced steel sheets and screens arranged so that, in the event of internal fault conditions, the fault damage is entirely confined to the faulted compartment.

3. The arrangement of the equipment within each enclosure shall be such that all normal maintenance can be carried out from the front through a hinged door. Composite enclosures shall be provided with a hinged access door for each compartment.

Enclosures containing switchgear and motor control gear shall be fitted with hinged front access doors to each compartment and, where rear access is available, bolted removable covers or hinged access doors at the rear.

Enclosures not requiring front access doors shall be fitted with hinged access doors at the rear.

Access doors shall have a flush appearance, and shall be fitted with locks or lockable handles. Front access doors shall be of rigid construction and free from distortion when equipment is mounted and supported on the door. Rear access doors shall have lift-off hinges arranged so that one shank engages before the other to permit ease of fitting. No instruments, relays or other equipment shall be mounted on rear access doors or removable covers.

4. Panels and cubicles shall be provided with earthing arrangements.

On single cubicles, an earth stud shall be provided.

Multi-panel switchboards or composite enclosures comprising a suite of individual sections or cubicles shall incorporate a continuous earth busbar.

The earth busbar shall extend to all panel/cubicle sections. All panels and individual sections/cubicles shall be earthed by direct connections to the earthing busbar, which shall also include extensions and terminations for the earthing of the metal cladding and armouring of all incoming and outgoing power cables.

On equipment having only front access, the main earth busbar shall be internally mounted but readily accessible.

The earth busbar shall incorporate an external terminal assembly for the connection of a copper tape or cable from the station earthing system.

A positive earthing conductor and termination shall be provided on all enclosure doors on which electrical equipment is mounted.

The short-time rating of the earth busbar and connections shall be not less than that of the associated switchgear equipment, or the maximum through-fault current of the power source, and under fault conditions, the temperature rise of the busbar and connections shall not cause damage to the connections or any equipment to which they may be connected.

For main distribution and plant control switchboards the cross-sectional area of the earth busbar and connections shall be not less than 25 x 3 mm.

No earth terminal bolts or studs shall be less than 8 mm diameter.

5. Panels and cubicles shall be provided with anti-condensation heaters.

2.6. BUSBAR AND PRIMARY CONNECTIONS

Busbars and primary connections shall be of electrolytic copper and shall be rated for continuous operation. The mechanical and dielectric strengths of busbar and connection insulators and supports shall be able to withstand the worst conditions of electrical surge which can occur on the installation, for any system fault condition internal and external to the switchboard.

Busbars and primary connections shall be housed in air-insulated enclosures which shall be arranged such that no direct access to or contact with live conductors is possible via slots or apertures.

All bars and contacts shall be coated with tin or any suitable paint resistant to hydrogen sulphide. Suitable baffles shall be provided to prevent the accidental entry of tools, etc., whilst maintenance work is being carried out in the vicinity of the chambers which shall be fitted with suitable warning labels.

The busbar shall be divided for both high voltage and medium voltage to provide maximum security and easy maintenance.

The busbars and primary connections shall have a short-time rating of not less than that of the associated switchgear.

All busbars, primary connections and power circuit conductors and wiring shall be colour coded.

Phase sequence indicator shall be provided at the main feeders.

2.7. CABLE TERMINATIONS AND CABLE BOXES

1. On multi-circuit switchboards and control panels, the power and control cables shall be glanded and terminated directly to the panel/circuit or compartment concerned.

The cable boxes or gland plates for individual circuits shall be designed and located to permit the termination of the circuit cable without impeding access to the cable terminations of other circuits or sections of the switchboard.

The use of common cable termination compartments on multi-circuit and low voltage switchboards will be approved only when the equipment location or mounting arrangement impedes direct access to individual circuits.

Common cable termination compartments shall be complete with cable core terminations, with permanent wiring or cable riser connections to the individual circuits. Cable gland plates shall be arranged or split to permit the independent termination of individual circuit cables.

Cable gland plates and/or supports for cable sealing boxes shall be provided and positioned to provide a minimum gland height of 250 mm from the surrounding floor level.

2. Cable boxes to accommodate PVC or XLPE insulated cables for voltages up to 1 000 volts shall be air insulated and designed to exclude direct ingress of moisture and dust.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

Cable termination methods shall be as specified.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable cores.

The boxes shall provide sufficient space for segregating cores and maintaining the minimum insulation clearances and creepage distances applicable.

2.8. CIRCUIT BREAKERS – GENERAL

1. Circuit breakers for indoor installation on systems having a nominal voltage up to 15 kV shall be of the air, vacuum, or sulphur hexafluoride (SF₆) filled type and, unless otherwise specified, shall be of the withdrawable pattern incorporated in metal-clad switchgear.

Circuit breakers for installation on systems having a nominal voltage up to 36 kV shall be of the minimum vacuum or SF₆ pattern.

Circuit breakers shall be capable of interrupting all faults up to their maximum rating without damage to equipment or danger to personnel.

Test evidence of the normal current rating, and certification by an independent switchgear testing authority of the symmetrical breaking capacity of circuit breakers shall be submitted when required.

Isolating facilities shall be provided for all circuit breakers. Means shall also be provided for testing the normal operation of the circuit breaker when in the fully isolated position.

2. Circuit breaker operating mechanisms shall be of the following types:

- Independent manual spring.
- Hand-charged spring with manual release.
- Motor-charged spring with electrical release.
- Direct current (dc) solenoid.

All operating mechanisms shall be trip-free and shall have mechanical “ON” and “OFF” indicators and a manual trip device fitted with locking facilities. Hand charged and motor charged spring mechanisms shall have “SPRINGS CHARGED” and “SPRINGS DISCHARGED” indicators.

Operating mechanisms of the hand-charged and motor-charged spring types shall be arranged so that release of the spring energy to close the circuit breaker can only be achieved by deliberate action. It shall not be possible for vibration or mechanical shocks to release the charged springs. Motor-charged spring mechanisms shall be arranged so that the charging is initiated automatically following a discharge and the necessary limit stops and switches for the automatic control of the charge once initiated, shall form an integral part of the mechanism. It shall be possible to hand-charge a motor-charged spring mechanism.

The closing solenoids of d.c. solenoid operated mechanisms shall be suitable for operation at a minimum of 80% of the nominal supply voltage, and shall not mal-operate or cause excessive vibration when energised at a voltage equal to that of the closing battery with the charger set at the maximum rate, or equal to that from a full wave rectified source designed for multiple simultaneous operation. Unless otherwise specified or agreed, this higher voltage shall be taken as 120% of the nominal supply voltage.

To facilitate maintenance and adjustment of contacts, it shall be possible to “slow-close” the circuit breaker, but this operation shall only be possible in the fully isolated position. Any necessary operating handle or lever shall be supplied.

3. Circuit breakers shall be provided with interlocks to ensure that:

- The breaker shall be open before operation of the circuit isolation device is possible.
- The breaker cannot be closed until the circuit isolation device has been fully operated.
- The breaker cannot be closed in the service position without completing the auxiliary circuits.
- The breaker cannot be “slow-closed” except in the fully isolated position.
- With hand charged or motor charged spring mechanisms, the springs cannot be discharged until they have been fully charged and until the means for charging has been removed or disconnected.

Where key interlocking (Castell or similar) is employed, tripping of a closed circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism.

4. A set of safety shutters shall be provided on indoor metal-clad switchgear to cover each three-phase group of stationary isolating contacts. The shutters shall be opened automatically by a positive drive from the circuit breaker moving portion and when closed shall prevent access to the stationary isolating contacts. When the circuit breaker is withdrawn, each set shall be capable of being individually operated and of being padlocked in the closed position.

To facilitate high voltage and current injection testing via the isolating contacts, a device shall be provided for fixing (not locking) the shutters in the ‘open’ position and for releasing them into the ‘closed’ position. The device shall be arranged to be cancelled by the circuit breaker moving portion to ensure the restoration of the automatic features of the shutters.

Busbar shutters shall be coloured red and labelled “BUSBARS” in large white letters. Shutters in bus-section units shall be coloured red and shall be labelled with a large white arrow pointing in the direction of the section of busbars to which the isolating contacts are connected.

5. Indoor circuit breaker moving portions shall be fitted with positive guides so as to ensure correct alignment of the isolating contacts.
6. Indoor high voltage circuit breakers shall be provided with circuit and/or busbar earthing facilities. Circuit and busbar earthing shall be carried out through the circuit breaker and so arranged that the earthing operation is completed on closing the breaker by its normal local means of operation.

Selection of either circuit or busbar earthing shall only be possible after the circuit breaker has been fully isolated, and by means of a fully interlocked and labelled “SERVICE/EARTH” position selector which shall be designed to permit padlocking in any position.

Facilities shall be provided on all incoming feeder circuit breakers for earthing, the circuit side. On at least one circuit breaker panel in any section of busbar facilities shall be provided for busbar earthing. Where the switchboard incorporates a busbar sectionalising panel, this panel shall have the busbar earthing facility and it shall be possible to earth either section from this panel.

When the circuit breaker is connected to an earthing location, tripping shall only be effected by the manual device on the operating mechanism and automatic tripping shall be inhibited. The manual tripping device shall be capable of being locked to prevent unauthorised operation.

The mechanical interlocks on the breaker shall remain operative when the circuit breaker is in either earthing position.

7. Indoor fixed pattern high voltage circuit breakers shall be provided with three-phase test sockets on the circuit side for high voltage and current injection testing. Test sockets shall be provided with a hinged, lockable access cover which shall be mechanically interlocked to prevent it being opened until the circuit breaker has been opened and isolated.

2.9. HIGH VOLTAGE CIRCUIT BREAKERS

1. High voltage circuit breakers shall mean circuit breakers working at above 1 000 volts. They shall comply with the requirements given below.
2. Vacuum circuit breakers shall incorporate means of measuring contact wear in-situ without the necessity to dismantle the breaker or mechanism assembly.
3. SF6 circuit breakers shall be fitted with pressure switch contacts for remote initiation of a gas failure alarm. Easily accessible means shall be provided for refilling the breaker with dry SF6 gas at the correct operating pressure after carrying out maintenance.
4. Enclosures for high voltage switches-fuses shall be metal-clad conforming to IEC 298.

2.10. LOW VOLTAGE CIRCUIT BREAKERS

Low voltage circuit breakers (up to 1 000 volts) shall be of the air break horizontal withdrawable pattern.

Earthing facilities through the circuit breaker are not required.

2.11. LOW VOLTAGE CIRCUIT BREAKERS

Miniature circuit breakers (MCB's) and moulded case circuit breakers (MCCB's) shall comply with IEC 898 and IEC 947-2 and shall be fitted with thermal over-load and instantaneous magnetic short-circuit protection; this protection to be adjustable in frame sizes above 63 amps. Where earth leakage protection is specified, it shall be of the current operated type.

Current limiting fuses shall be fitted where necessary to provide the specified interrupting capacity. The ratings of MCB's and MCCB's shall be correctly coordinated with fuse ratings to achieve the necessary degree of discrimination. MCB's shall be rated in accordance with IEC 899.

MCCB's shall be operated by a toggle type handle and shall have a quick-make quick-break over-centre switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held closed against abnormal currents. Tripping due to overload or short circuit shall be clearly indicated by the handle automatically assuming a position midway between the manual on and off positions. All latch surfaces shall be grounded and polished. All poles shall operate simultaneously.

MCCB's shall be completely enclosed in a moulded case. Non-interchangeable trip breakers shall have their covers sealed; interchangeable trip breakers shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be of non-welding material. Arc extinction shall be accomplished by means of arc chutes, consisting of metal grids mounted on an insulating support.

The protective actions shall be so coordinated that overcurrents will be cleared by the thermal action; short circuits of relatively low magnitude will be cleared by the magnetic action; high fault currents above a pre-determined point will be cleared by the current limiting fuses. The current limiting fuses shall not be affected when the thermal and/or magnetic trip functions clear the circuit. Regardless of which tripping device serves to clear the circuit, all poles of the breaker shall simultaneously open automatically.

The breaker shall not be resettable until current limiting fuses which have functioned have been replaced by an identical or similar fuse and the cover refastened. The current limiting fuse shall have a visual means to determine which has operated and requires replacement when the cover is removed.

MCCB's used for motor protection shall provide instantaneous short circuit protection by means of a front adjustable magnetic element on each pole of the breaker. The adjustment button(s) shall have main setting points and mid-setting points following a linear scale so that each point has a significant value within calibration tolerances. Current limiting fuse may be incorporated into the circuit breaker where required, to cater for high interrupting currents.

All MCCB's shall be ambient temperature compensated. Compensation shall be accomplished to allow the breaker to carry rated current between 25°C and 50°C with tripping characteristics that are approximately the same throughout this temperature range.

2.12. CORROSION PROTECTION

High voltage switches shall mean switches operating above 1 000 volts. They shall conform to IEC 265-1 as general purpose switches category II with normal service conditions adjusted as specified. Switches shall have rated voltages, normal current, breaking capacity and making capacity suitable for the system and load circuit being switched, or as specified.

Closing and opening mechanisms shall be of stored energy pattern both manually charged and released or as an independent manual operation.

The assembly shall incorporate an earthing switch connected to the feeder cable side of the main switch. This shall comply generally with IEC 129 with a minimum continuous current rating of 200 amps and making capacity and short time current rating to suit the system, or as specified. The operating mechanism shall be independent manual for both closing and opening. Mechanical interlocks shall be provided to:

- Prevent closing of the earth switch unless the main switch is open.

- Prevent closing of the main switch unless the earth switch is open.

High voltage combinations of switches and fuses shall conform to IEC 420. The switches shall conform to IEC 265-1 except that the rated breaking current shall be seven times the rating of the largest size fuse in the combinations. The switch closing mechanism shall be independent manual and shall provide stored energy for opening mechanically by fuse-striker or by manual release.

High voltage fuses shall be cartridge type, current limiting with striker pins, conforming to IEC 282-1. Current ratings shall be as required for the circuit protection or as specified. Fuses shall be accommodated within an air insulated chamber, the access door or cover of which shall be interlocked so that it can only be opened if the main switch is open and the feeder connections are earthed. It shall not be possible to open the earth switch or close the main switch if the fuse access door/cover is open.

Earthing switches for high voltage switch-fuses shall earth the feeder cable side of the fuse and shall otherwise be as required for high voltage switch units.

2.13. AIR BREAK ISOLATORS AND FUSE SWITCHES

Air break isolators and fuse switches mounted indoors or incorporated in indoor metal-clad switchgear shall comply with IEC 947-3 and shall be of the “on-load” type.

Operating mechanisms shall be fitted with mechanical “ON/OFF” indicators. Operating handles shall be of semi-flush or telescopic pattern to reduce front projection to a minimum.

Fuses in fuse-switches shall be of the HRC cartridge type.

Isolators and fuse switches shall be provided with means of locking in the “OFF” position.

Access to outgoing terminals of isolators and fuse switches shall not expose live incoming supply terminals or contacts.

2.14. CONTACTOR TYPE MOTOR STARTERS

1. Contactor starters shall incorporate air break, SF6 or vacuum contactors. Contactors shall be selected to suit the particular duty and application but shall have a minimum standard of mechanical endurance of 3 million operations and electrical endurance of 150 000 on-load operations. The utilisation category and duty class shall be as specified.

Vacuum contactors shall be provided with means of measuring contact wear, and any necessary gauges or other measuring devices shall be provided.

Starters shall incorporate HRC fuses unless otherwise specified. These fuses may be incorporated in the starter isolator as a composite fuse switch assembly. Overcurrent and earth leakage protection shall be incorporated together with all necessary auxiliary relays, contactors, timers, auxiliary fuses, wiring and terminals. Control and indicating facilities shall be provided on each starter.

2. Low voltage starters up to 1 000 volts shall comply with IEC 9474-1 and shall incorporate contactors complying with IEC 947-4-1.

Low voltage starters shall incorporate a triple pole fully interlocked load breaking isolating switch capable of breaking the stalled motor current. Moulded case circuit breakers may be fitted, where specified.

Where low voltage starters incorporate moulded case circuit breakers, fault switching coordination between the circuit breakers and the contactors shall comply with IEC 947-4-1.

Isolators shall be provided with an external operating handle, mechanical “ON/OFF” indication and facilities for locking in the “OFF” position. Operating handles shall be of the telescopic or semi-flush pattern to reduce front projection to a minimum.

Starters shall be of the fixed or withdrawable pattern as specified. If withdrawable, facilities shall be provided for testing the starter control circuits and operation when withdrawn without the necessity for complete removal of the starter chassis.

Where control circuit supplies and interlock circuits are broken via plugs on withdrawal of the starter, at least one jumper lead and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn (isolated) position.

Three-phase motor starters shall be complete with a triple pole hand reset thermal overload device with single phasing protection unless otherwise specified.

3. High voltage contactor starters above 1 000 volts shall incorporate contactor complying with IEC 470.

High voltage starters shall be of the fixed or withdrawable pattern as specified and shall incorporate facilities for earthing outgoing cables. Fixed pattern starters shall incorporate a fully interlocked triple pole off-load pattern isolator having three positions ‘CLOSED’/‘OPEN’/‘EARTHED’. Interlocks shall be provided to ensure off-load operation.

On withdrawable pattern starters, cable earthing shall be effected by means of a fully interlocked integral earthing switch arranged so that cables can only be earthed when the starter is withdrawn (isolated). Re-entry of the starter shall be prevented whilst the cables are earthed.

Means shall be provided to permit control circuit testing with the main isolator open.

2.15. SWITCHBOARD

1. All individual components of control equipment associated with any item of plant shall be contained in a single control cubicle or panel.

Instruments, relays, switches, lamps, pushbuttons and the like shall be arranged on the cubicle in a neat, functional and logical manner. Similar items shall be of the same type, style, pattern or appearance throughout.

Instruments, controls and relays mounted on different panel sections but having similar functions shall be located in a physically similar position.

2. All instruments, gauges and meters which perform similar duties shall be of uniform type and manufacture. They shall be flush pattern, dust and moisture proof suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks. Indicating instruments shall be of the dial or digital type fitted with zero adjuster externally accessible from the front, have no parallax error and normal maximum reading at approximately 60% full scale. Dials shall be white with black scales and lettering not subject to fading. Scales shall be of such material that no peeling or discolouration will take place with age under humid conditions.

Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

3. Unless otherwise specified, all control circuit supplies for contactor starters shall be obtained from a 110 volts 50 Hz integral control transformer contained in the starter cubicle. In the case of multi-motor and composite boards, one or more master control circuit transformers shall be provided for each section of busbars in the switchboard to feed a group of outgoing starters via bus wires in the board. Each control transformer

shall be busbar connected and shall be provided with isolation facilities, and primary and secondary MCB's.

Transformers shall be of the double wound pattern and shall be provided with earth screens between primary and secondary windings. One end of the secondary winding shall be earthed.

4. Indicating lamps on panels shall be rated to withstand not less than 10% continuous over-voltage. Alternatively lamps shall be transformer operated or of a low voltage with series dropping resistors. On DC operated lamp circuits, suitably rated resistors shall be connected across each lamp operating contact.

Lamps shall be well ventilated and the design shall permit removal of lamp glasses and bulbs from the front of the unit.

5. Electrically operated circuit breakers shall be fitted with control switches of the pistol grip type, with spring return to the "neutral" position, and with an interlock to prevent repetitive closing without moving first to the "trip" position. They shall be capable of being padlocked in the "neutral" or "trip" position.

Switches for control selection, motor control and other purposes shall have spade, tee or other approved shape handles.

6. Pushbuttons shall be coloured as follows:

- START - green.
- STOP - red.

"START" pushbuttons shall be effective only in selected circuits, primarily hand control circuits.

"STOP" pushbuttons for motors controlled by circuit breakers shall be arranged to trip the circuit breaker and shall have an additional contact to interrupt the breaker closing circuit.

7. Where practicable, all fine wire operating coils and wire wound resistors shall be vacuum impregnated with an approved insulating varnish.
8. Terminal boards or blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw. Pinch screw type terminal blocks will not be acceptable. The minimum size of terminal shall be suitable for a 4 mm conductor. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled, and the voltage grouping and terminal board layout shall correspond with the wiring diagrams. Where approved, barrier-pattern screw or stud-type terminal boards are used, covers of transparent insulating material, which does not sustain combustion, shall be provided.

Terminals which may be live when the main equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact. All terminals shall bear a permanent identification number or letter.

Terminal boards shall be located adjacent to the point of cable entry and adequate space shall be allowed for terminating the cable tails on site.

An extra 25% spare terminal shall be provided for terminating spare cable cores.

9. Fuses or MCB's and links shall be provided to enable any circuit to be isolated as necessary for maintenance and test purposes without isolating the whole panel. All fuses shall be of the HBC cartridge type. Fuse carriers and solid link carriers and bases shall be made of plastic moulded insulating material of an approved make. Ceramic materials will not be accepted. Accessible live connections shall be efficiently shrouded and it shall be possible to change fuses with the circuit live without danger of contact with live metal. The fuses shall be rated to give maximum protection to the apparatus in circuit and the rating shall be inscribed on the fuse label.

Earthing and neutral links in main supply circuits shall be of the solid copper bolted pattern.

Fuses or MCB's and links functionally associated with the same circuit shall be mounted side by side.

Descriptive circuit/function labels shall be mounted adjacent to all fuses or MCB's, the layout of which shall correspond to the wiring diagram.

10. Auxiliary switches shall be supplied as required for indication, protection, metering, control, interlocking and supervisory purposes. They shall be readily accessible and enclosed in a transparent dustproof cover. Adequate secondary disconnects shall be included where appropriate to enable the auxiliary switch to be wired to the fixed portion of the equipment.

Two normally open and two normally closed spare auxiliary contacts shall be provided and shall be wired to suitably identify spare terminals.

11. Where volt-free contacts are specified on any equipment, e.g. a circuit breaker or contactor starter, they shall comprise contacts operated directly by the equipment but electrically separate such that no potential derived from the equipment appears at the contacts. Volt-free contacts shall be used to complete external control, alarm or indication circuits, the supplies for these circuits being obtained from an external source.

Unless otherwise stated, these supplies will be from low voltage ac or dc sources and auxiliary isolating poles, e.g. on starter isolators, need not be provided.

12. Switchboard and panel wiring shall be carried out in 1 000 volts grade PVC insulated cable. Flexible wiring shall be 600 volts grade.

Wiring shall be carried out in a neat and systematic manner and securely fixed by insulated cleats or other approved methods and arranged so that access to any apparatus or connection point is not impeded. Wiring installed in trunking shall have a space factor not greater than 50%.

Where wiring passes between compartments, the access hole shall be fitted with a suitable grommet.

Sleeve type identification ferrules shall be fitted on all wires at both ends. The numbers and letters used shall correspond with the appropriate wiring diagram and shall read from terminals outwards.

The wires shall not be joined or broken into between terminal points.

Terminations for screw or stud terminals shall be of the claw washer pattern or equal, or of the crimped-on-ring type, the latter being preferred. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.

Wiring for future equipment shall be provided as far as possible and all wires shall be terminated.

Not more than one core of either internal or external wiring shall terminate on any outgoing terminal. Where duplication of terminal blocks is necessary, suitable solid bonding links shall be incorporated in the design of block selected.

13. Switchboard cubicles shall incorporate anti-condensation heaters. The heater circuits shall be energised from a single-phase supply obtained from an independent power source.

Individual floor mounting cubicles shall each be fitted with an anti-condensation heater together with a suitably positioned adjustable thermostat, rotary "ON/OFF" heater switch and MCCB protection.

Multi-tier type cubicles shall have a cubicle heater and thermostat for each vertical panel section except that multi-tier motor starters may have individual heaters controlled by a normally closed contact on the contactor auxiliary switch in place of the controlling thermostat.

14. Switchboard for outdoor installation shall be provided with suitable sunshade for protection against direct sunlight.

2.16. SWITCHBOARD SAFETY ARRANGEMENTS

Switchboards, control panels and all items of electrical control equipment shall be designed and constructed to provide a maximum standard of safety for all Operation and Maintenance procedures.

Multi-circuit switchboards shall be fully sectionalised and provided with dividing sheets and screens to give safe access to individual switchboard circuits, and to permit all normal Operation and Maintenance procedures to be carried out without interference to, or risk of accidental contact with live conductors or components of independent circuits within adjacent switchboard sections.

Access to circuit compartments or cubicles through hinged doors shall be inhibited by a positive interlocking arrangement, until the isolator or switching device feeding unscreened or exposed conductors or equipment terminals within the cubicle is switched to the “off” position.

Isolators, clearly labelled, shall be provided in such positions and connected so that maintenance can be carried out with maximum safety. This particularly applies to control circuits fed from a remote position. Where it is necessary to maintain certain components in a cubicle in a live condition when the isolator is in the “off” position such apparatus shall be screened and labelled to eliminate the possibility of accidents. Additionally, a system of removable insulated links or isolating type terminal blocks shall be provided to enable particular components to be isolated for maintenance purposes whilst retaining other essential circuits energised.

Terminals, connections, relays and other components which may be live when front access doors are open shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle when any door is opened.

Where several outgoing circuits occupy a common termination chamber, all copper work, cable lugs, terminations and terminal boards shall be fully screened or insulated to enable work on any one circuit to be carried out with other circuits live.

2.17. PROTECTION TRANSFORMERS

Protection and instrument transformers shall comply with the following:

1. Current transformers shall be of the bar primary pattern where practicable. Current transformers shall have a short-time current rating of not less than that of the switch panel in which they are incorporated. For bar primary current transformers, this rating shall be for a period of 3 seconds and for wound primary designs, the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 second subject to the approval of the Engineer.

Current transformers for high voltage equipment shall be resin encapsulated, except that for bar primary designs with ring type cores mounted on resin insulated bushings, alternative secondary winding insulation will be accepted, provided that an earthed screen is introduced between the toroidal winding and the bushing and that the toroid is adequately clamped either to the bushing or to the main structure.

Where multi-ratio current transformers are supplied, a label shall be provided, clearly indicating the connections required for the alternative ratios. These connections shall also be shown on panel wiring diagrams.

Secondary winding currents shall be 1A or 5A.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels shall be fitted on the exterior or the mounting chambers suitably located to enable reading without the removal of any cover.

Current transformers for balanced earth fault protection shall be designed for a stability of not less than six times the rated primary current.

Current transformers for unit protection schemes shall be designed for a stability of not less than the maximum through fault current of the units.

Where attracted armature relays are employed, the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

Magnetisation characteristics, calculated performance and protection setting shall be provided by the Contractor.

Current transformers for use in conjunction with a portable precision kWh meter shall be of class 0.2 accuracy. Other metering current transformers shall be of class 0.5 accuracy.

2. Voltage transformers (up to 1 000 volts) shall be supplied where test metering connections are required to terminate at test terminal blocks. They shall have a winding ratio to give a three-phase voltage between lines of 110 volts. They shall have a rated burden, at the stated accuracy, in accordance with the requirements of all connected instruments, meters and relays and of any instruments or meters to which they may be connected via test blocks.

The primary circuit shall be protected by HRC fuses having a short-circuit rating not less than that of the switchgear. The connections between the fuses and the switchgear primary conductors shall be of sufficient cross-section and be supported to withstand the short-circuit rating of the switchgear.

The secondary circuit shall be protected by HRC fuses mounted as closely as possible to the secondary terminals. The fuses shall have safe access for renewal without the necessity for complete isolation of the switchgear.

3. Voltage transformers on high voltage (1 000 volts and above) systems shall have a rated burden, at the stated accuracy, in accordance with the requirements of all instruments and meters to which they may be connected via test blocks. The windings shall be resin encapsulated. Voltage transformers for metal-clad switchgear shall be housed in naturally air-cooled, totally-enclosed sheet-steel enclosures which shall be of the isolatable pattern capable of being padlocked in the plugged-in position.

Safety shutters shall be provided to cover automatically the fixed isolating contacts when the transformer is isolated, the means shall be provided to padlock the shutters in the closed position. The shutters shall be coloured yellow, when the isolating contacts are connected to the feeder side of the circuit, and red, inscribed "BUSBARS" in large white letters, when connected to the busbars side of the circuit.

Connections to the primary isolating contacts shall have a short-time rating equal to that of the switchgear and shall be capable of carrying 200 amps continuously.

The primary winding shall be connected through cartridge type fuses incorporating current limiting resistances. These fuses shall be removable only when the transformer is isolated. Secondary circuit fuses shall also be provided and shall be readily accessible for renewal.

2.18. PROTECTION RELAYS

Protection relays shall fully comply with the requirements of BS 142 or equivalent IEC.

Relays shall be contained in dustproof cases, shall be mounted on the front of the switchgear or relay panel. Auxiliary relays may be mounted within the panel but shall be accessible for

inspection and wiring. Plug-in pattern relays shall have a positive means for retaining them in the service position.

Relay contacts shall be capable of making and breaking the maximum current which can occur in the circuit they control. Contacts for remote alarms and indications shall be volt-free, hand reset type.

Operation indicators shall be fitted to tripping relays and such other protection relays or relay elements as will enable the type of fault condition to be identified. Indicators shall be capable of being reset without the relay case being opened.

2.19. EMERGENCY STOP PUSH BUTTONS

Emergency stop pushbuttons shall be provided and positioned in the immediate vicinity of the associated motor drive in all cases where:

1. there is no direct line of sight between the motor and the controlling starter; or
2. where the distance between the motor and the controlling starter exceeds 5 metres.

Emergency stop pushbuttons shall be connected in control circuits so that they are effective under all operating conditions and shall have red mushroom headed pushes of the stay-put pattern. A deliberate re-set action shall be required before the drive can be put back into service and resetting of the pushbutton shall not restart the drive.

Where a “start/stop” pushbutton controlling station is specified, local to the motor drive the emergency stop pushbutton shall be integral with the local controlling station.

2.20. DIRECT CURRENT SUPPLY SYSTEMS

Batteries shall be of the nickel-cadmium type having cells contained in heat resistant, transparent, high impact plastic containers. Cell containers shall be clearly marked to show the maximum and minimum levels of electrolyte, and shall be provided with vented filler plugs. Cells shall be numbered consecutively. Cell terminals shall be of robust construction and shall be permanently marked to show their polarity.

Battery trays shall be factory treated with an electrolyte corrosion resistant finish, e.g. plastic coating.

Battery chargers shall be of the solid state constant voltage type incorporating a self-protecting current limiting feature for protection against low battery volts and short circuits. Reverse battery protection shall also be provided.

Chargers shall be suitable for continuous operation in an ambient temperature of 50°C. Their output voltage regulation shall be not less than $\pm 2\%$ irrespective of ac mains input variations of $\pm 10\%$ for load variations from 0% to 100%.

Chargers shall be fitted with an “ON/OFF” switch, dc ammeter, and indicating lamps for “automatic charger” and “charger output failed”. In addition, volt-free changeover contacts shall be provided on relays to give remote indication of “charger supply failed” and “charger output failed”.

Battery and charger equipment shall be housed in well ventilated sheet steel enclosures having front access doors. The enclosure shall be designed to provide total segregation of the battery and charger equipment.

Direct current distribution boards shall be as specified for distribution boards except that suitably rated load breaking double pole switches with HBC fuses for the incoming and outgoing circuits shall be incorporated.

Distribution boards shall be fitted with relays for battery earth fault and battery voltage low, with local lamp or flag indication and volt-free contacts for remote indication. A dc ammeter and voltmeter shall also be fitted to the incoming equipment.

2.21. MOTORS

1. All electric motors shall comply with the requirements of IEC 34.

Constant speed alternating current motors shall be of the induction type suitable for operation on a three-phase supply and shall be capable of operating continuously, at rated torque, at any voltage between $\pm 10\%$ of the nominal value, and nominal frequency ± 2 Hz.

Direct current motors, which are to operate from batteries, shall be capable of operating under service conditions at any voltage between $\pm 10\%$ of the nominal value.

Motors operating from rectifier equipment shall meet the voltage and frequency conditions required for ac motors.

All motors shall, unless otherwise specified, be capable of running continuously at an output not less than 10% in excess of maximum power absorbed by the driven plant under any operating conditions.

2. Enclosures shall afford a degree of mechanical protection not less than IP54. Submersible motors shall meet the requirements of IP58. Motors for outdoor installation shall comply with protection class IPW 55.

Totally enclosed motors shall be provided with suitable means of breathing and drainage to prevent accumulation of condensation.

Motors for installation outdoors shall be provided with suitable covers for protection against direct sunlight.

3. Windings shall be impregnated to render them non-hygroscopic and oil resistant, and shall be braced to prevent any movement of the coils during all conditions of service.

Motors operating in an ambient temperature not exceeding 50°C shall be insulated to IEC 85, with the limits of temperature rise applicable to Class B insulation.

All motors shall, unless otherwise specified, be designed for direct-on-line starting, and 6 starts per hour, S4 switching duty to BS 4999 Part 101 or equivalent IEC at maximum site ambient temperature.

4. Bearings shall be plain or roller type as appropriate, vertical shafts having approved thrust and guide bearings.

Where necessary to prevent damage by any shaft currents which may be produced, the bearings and their lubricating and cooling systems shall be insulated from the bedplate or frame.

Bearings shall be sealed or self-lubricated and provided with readily accessible filler. Dial type bearing thermometers with adjustable alarm and cut-out contacts shall be provided for large motors.

5. Embedded temperature detectors for stator temperature measurement shall be provided on HV motors. All detectors shall have the same characteristics and instruments shall be provided with adjustable alarm and tripping contacts.

6. Anti-condensation heaters shall be provided on all motors above 40 kW. The heaters shall be suitable for use on a single phase ac supply and wired to a separate terminal box.
7. On slip-ring and commutator motors the brush gear shall be designed to operate without injurious sparking and with the minimum need for adjustment or replacement of brushes. Removable covers shall provide access to brush gear, slip-rings or commutator.
8. Terminal boxes shall be positioned to accept cables which rise vertically from below, or angled to accept cables without stress being introduced to the cable. Phase segregation shall be provided on power cable terminal boxes fitted to all high voltage motors.

All terminal boxes shall be provided with disconnecting links and be designed so that the cable box may be removed without the necessity of breaking the cable termination. Alternatively, pre-moulded cable connectors, with stress relief provisions for HV cables, may be employed provided that their use complies with the recommendations of the specialist manufacturer of such connectors.

2.22. STATIC INVERTERS

Inverters shall be solid state type and shall provide a single phase or 3-phase output as specified.

Inverters shall have the following characteristics:

- Maintain an output frequency constant within $\pm 1\%$ of nominal.
- An adjustable ac output voltage of $\pm 5\%$ at nominal dc input voltage.
- A maximum deviation of ac output voltage of $\pm 2\%$ over the entire ranges of load, dc voltage and power factor, whilst supplying a symmetrical load.
- Be capable of supplying unbalanced ac loads to an extent and at a voltage deviation referred to the line to line voltage which shall be stated by Contractor for 3-phase inverters.
- Be capable of continuous operation under the ambient temperature specified.
- A limited overload capacity.
- An in-built current limiting circuit to provide short circuit protection.
- An ac output filter to limit the total harmonic voltage distortion across linear loads to 5%, over the entire ranges of load, voltage and power factor.
- A dc input filter to ensure that the r.m.s. value of ac voltage does not exceed 5% of the dc voltage.
- A totally enclosed floor mounting sheet steel enclosure with front access doors.

2.23. FIXINGS AND FIXTURES

All nuts and bolts shall be threaded in accordance with ISO standards and fitted with 3 mm thick washers beneath bolt and nut.

All bolts, nuts, washers, except high tensile, for all ferrous parts shall be steel galvanised to ISO 1459-1460-1461 or equivalent, primed and painted hereof after assembly and tightening.

All bolts, nuts, washers and anchor plates, for fastening galvanised components or aluminium alloy components shall be of stainless steel Grade 316S16 to BS 970 or equivalent and shall remain unpainted. PTFE washers shall be fitted beneath stainless steel washers for bolt head and nut.

Holding down and anchor bolts, nuts, washers shall be galvanised steel to ISO 1459-1460-1461 or equivalent, and shall be painted after assembly and tightening.

Woodscrews shall be brass with round head or countersunk heads and single slotted for a standard screw driver.

Drilled anchor fixings for use on concrete structures shall be of a type approved by the Engineer's Representative.

All holes in concrete and civil works for anchor fixings or plugs for wood screws shall be made with a rotary drill.

Single shot cartridge tool fixings may be used only at the discretion of the Engineer.

3. CABLING AND EARTHING

3.1. APPLICABILITY

The following clauses specify the general requirements for the supply and installation of cabling and earthing systems. The general specification clauses shall apply where appropriate except where redefined elsewhere in the Specification.

3.2. POLARITY

Power cables shall be connected between main switchboards, distribution boards, plant and accessories so that the correct sequence of phase colours is preserved throughout the system.

Cable cores shall be identified with the phase colours corresponding to those used in the electrical plant. The use of different phases on a number of single phase circuits in one room shall be avoided wherever possible. If unavoidable, then the live cores shall be identified with their appropriate phase colour. When more than one single phase circuit live conductor of different phase polarity is terminated in a common multi-gang switch or other apparatus, that equipment shall be sub-divided by metal or insulating material screens to segregate the different phase circuits. Danger labels shall be provided and fixed adjacent to the terminal equipment to warn of the presence of different phases.

3.3. CABLES

Cables shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum, the cable end and the end left on the drum shall immediately be sealed in an approved manner to prevent the ingress of moisture.

Conductors shall be of high conductivity copper.

The Contractor shall ensure that each cable is of sufficient rating for its duty under both normal and possible fault conditions. In assessing the rating and cross section required for each cable, the following factors shall be taken into account:

1. fault level and duration;
2. ambient air and soil temperatures;
3. soil thermal resistivity;

4. voltage drop under steady state and transient conditions;
5. loading under steady state and transient conditions;
6. overcurrent settings of circuit breakers;
7. disposition of cables.

Cable referred to as PVCSWAPVC shall be PVC insulated and bedded single wire armoured cable with an overall PVC sheath. Non-magnetic armour of hard drawn aluminium shall be used on single core types.

Cables referred to as PVCPVC shall be PVC insulated and sheathed.

Power cables referred to as XLPESWAPVC shall be cross linked polyethylene insulated, single wire armoured cable with PVC overall sheath. Non-magnetic armour of hard drawn aluminium shall be used on single core types.

Cables referred to as MICV shall be copper sheathed cables, with powdered mineral insulation and copper conductors with a PVC outer sheath to IEC 702-1. MICV cables shall be 1000 V rating.

All buried cables shall incorporate a metal tape termite barrier with PVC outer sheathing.

3.4. CABLE TERMINATION AND JOINTING

3.4.1. CABLE TERMINATIONS

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall be of a type to seal the cable against ingress of dirt and moisture and provide adequate mechanical support. Glands shall conform to BS 6121 or equivalent and shall have PVC shrouds and an earth tag at one cable end only.

Termination glands for armoured cables shall provide a positive armour clamp both for cable support and for a high level of earth continuity.

Encapsulated termination techniques, either heat shrink and/or pre-moulded, with stress relief provision for HV terminations, shall be employed for these cables.

All cable conductors shall be terminated in a suitable copper lug crimped or sweated.

Particular care shall be taken in the drying out and sealing of the ends of MICV cables and in the making of connections to boxes and fittings. The manufacturers' terminations shall be used throughout. MICV cable glands shall conform to IEC 702-2. Cable end seals shall be of the brass pot type.

The Contractor shall ensure that any special tools required for the installed MICV cable are made available to his operatives and that they understand and are competent in their use.

The ends of all cable shall be at all times temporarily sealed to prevent the ingress of moisture. When MICV cables are used in conjunction with equipment liable to vibrations, suitable terminal boxes shall be provided in the vicinity of such motors or equipment and the final interconnections shall be made by means of flexible cable or multi-strand wiring in flexible conduit.

Cable glands shall be protected by corrosion-resistant PVC hoods.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

3.4.2. UNDERGROUND CABLE JOINTS

The underground cable joints in power and auxiliary cable installations shall not be used unless specified.

Underground cable joints in power and auxiliary cable installations shall only be used (subject to the approval of the Engineer) in circumstances where cable route lengths exceed the maximum possible cable drum lengths.

All underground joints shall be by encapsulated jointing techniques.

Wherever it is necessary to remove the PVC sheath of a cable for jointing or termination, only the minimum length necessary shall be removed and the exposed armour or copper screen shall be protected by PVC tape or sleeves.

3.5. CABLE INSTALLATION WITHIN BUILDINGS

Cables which are to be run on walls, ceilings or other building structures shall unless otherwise agreed by the Engineer, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

Suitable screens shall be provided to protect the cables run on the external surface of structures or above ground level, from the effect of the sun radiation. All screens used to protect the cables shall be of an approved design, securely fixed to the structure or ground and be fully ventilated.

All vertical cable runs shall be protected to a height not less than 450 mm above floor level by inverted cable tray, cable channel, conduit or other approved method.

Where the building structures incorporate covered floor trench systems, cables shall be installed on horizontal trays racked against the side(s) of the trench. Other support systems may be used for heavy power cables subject to the approval of the Engineer. The minimum vertical distance between horizontal trays shall be 300 mm. Adequate space shall be provided at the side of the trays to facilitate easy installation. Cables installed close to the bottom of the trench shall be arranged and spaced to allow adequate air circulation. No cables shall be laid direct onto the trench floor.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the trench walls.

The Contractor shall supply all covers and associated steelwork for the structure and building cable trench systems. Trench covers shall be chequer plate pattern.

Throughout the installation due regard shall be paid to the spacing of cables to maintain current rating, to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips, etc., shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable fixing on horizontal trays and ladders shall be arranged to secure the cables and maintain the specified cable grouping and segregation. The spacing of clips and saddles shall be not greater than 600 mm.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self locking plastic buckle clips and strapping shall not be used.

Where a number of cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment - from a common direction and are individually terminated in an orderly and symmetrical fashion.

3.6. CABLE TRAY AND LADDERS

3.6.1. HOT DIP GALVANISED TRAYS

Perforated tray and cable support systems for dry structures shall be heavy duty hot dipped galvanised steel.

Wherever tray and ladder sections are cut and shaped on site, cut edges shall be dressed and painted with a coat of cold galvanising compound within two hours of cutting and dressing followed by a further coat in accordance with the coating manufacturer's instructions.

3.6.2. GLASS REINFORCED POLYESTER (GRP) TRAYS

Cable tray systems in chemically corrosive locations and areas affected by the effluent shall be of pultruded glass reinforced ultra violet and corrosion resistant stabilized polyester pattern.

GRP cable tray systems shall be of the ladder type design having "Z" shaped side rails. Rungs shall be of the same material as the side rails and securely bonded in place. Rungs shall be mechanically locked into place by means of an intermediate side rail flange to prevent roll-over when cables are pulled into the tray.

Where appropriate GRP cable tray sections shall not be less than 6 m long and each, straight section shall be furnished with pre-punched holes for splice plate attachment. Trays shall be complete with all necessary fasteners, hold-down clips, splice plates, support systems, covers, etc.

Splice plates and cable fasteners used with GRP tray systems shall be fibreglass encapsulated stainless steel and shall be installed using torque limiting tools to prevent damage to the encapsulating coating.

3.6.3. CABLE TRAY INSTALLATIONS

Cable tray and ladder systems shall be installed using factory made supports, joints and junction/bend pieces.

Brackets shall be provided at a maximum of 1 200 mm centres and be prefabricated hot dipped galvanised steel.

Fixing of galvanised trays shall be by means of non-corrodible screws inserted into approved wall fixings.

Where GRP tray systems are installed, all fixings and supports shall be stainless steel.

Bends and tees shall be prefabricated and have an inside radius of not less than 300 mm and where large cables are to be accommodated the radius shall be sufficient to fully support correct minimum cable radius.

Cables shall be fixed to trays by means of purpose made fixing clamps. Cable fasteners used with GRP trays shall be fibreglass encapsulated stainless steel.

Single core cables of the same circuit shall be laid and mounted in purpose made trefoil cleats.

Vertical tray systems shall be provided with protective covers to a height not less than 1 000 mm above floor level.

Particular care should be taken on vertical rise trays providing adequate cable fixings to ensure distribution of load and security.

3.7. CABLES INSTALLED IN THE GROUND

3.7.1. GENERAL

Power, control and signal/monitoring cabling external to, and interconnecting the main plant buildings, shall be installed in underground duct systems under permanently made-up areas, and shall be directly buried in trenches in all other areas.

The Contractor shall prepare drawings showing his precise requirements for cable ducts and trench work. The drawings shall detail the number of ducts required, the width and depth of trenches and the number and location of drawpits. These drawings shall be prepared in consultation with the Engineer and shall be approved before issue.

Cable routes shall be agreed with the Engineer.

The excavation and backfilling of trench works and the supply and installation of all cable ducts shall be the responsibility of the Contractor.

The Contractor shall supply and lay the sand bedding, supply and lay the cables, supply and lay sand blinding and supply and lay protective tiles and warning tape; he shall also supply and lay cable route marker posts after the backfilling and top soiling has been carried out.

3.7.2. CABLES DIRECT IN THE GROUND

When cables are buried, the bottom of the excavated trenches shall be free of sharp objects and shall be covered with sand or fine sifted soil to a depth of 50 mm. The depth of excavated trenches for low voltage and high voltage cables shall be as specified.

Cables shall be unrolled from the drums so as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath.

Cables shall not be straightened completely after laying into the trenches to avoid excessive tensile stresses during backfilling or from subsequent settlement. After laying, cables shall be covered to a minimum depth of 100 mm with sand or sifted soil. Cables shall be overlaid with protective interlocking tiles.

A warning tape shall be installed along the entire cable route. The tape shall be yellow coloured polyethylene nominally 150 mm wide and 100 microns thick with the words CAUTION ELECTRIC CABLES BELOW in both English and Armenian at regular intervals. The tape shall be installed approximately 400 mm above the associated cable(s).

Concrete marker posts shall be provided at 40 metres intervals and at points of change of direction along the cable run, each fitted with a suitably inscribed metal plate showing the voltage of the cable marked. Similar plates shall be provided and fitted to the outer walls of buildings at the points of entry. Marker posts shall also identify the position of any cable - joints.

3.7.3. CABLES IN DUCTS

When installing cables in ducts the following procedures shall be used:

- Cables shall be pulled in a straight line.
- Rollers shall be positioned at the edges of drawpits both at the drawing-in and drawing-out points.
- Plastic pipes and cable sheaths shall be lubricated with boiled-down soap of low alkali content or other approved lubricant.
- A continuous check on the tensile forces shall be carried out by means of a strain gauge or a dynamometer attached to the rope holding the winch, with the latter resting on rollers.
- A shearing pin or other tension limiting device shall be provided at the winch, which shall interrupt the pulling if the maximum permissible stress is exceeded.
- The pulling rope shall be guided by rollers.

Cable ducts shall be made of UPVC or glazed earthenware material having a minimum diameter of 150 mm. Duct systems under roadways and areas liable to subsidence shall be encased in concrete.

3.7.4. SEALING OF CABLE ENTRY HOLES

Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of moisture. Individual cable entry points shall be sealed by using Denso tape and "Denso-mastic" compound or similar approved materials. Multiple cable entries shall be sealed by multi-cable transit units (MCT) comprising steel frames and insert blocks. MCT'S shall be flange mounted on the inside surface of substructure walls or cable ducts.

3.8. JOINT BOXES

The use of through and tee joints are prohibited on main and auxiliary control cable installations unless otherwise approved by the Engineer.

Junction boxes in auxiliary control cable circuits for the purpose of marshalling a number of cables feeding to a common item of equipment shall only be used with the written approval of the Engineer.

Any such junction box shall be of the wall mounting pattern with double terminals with cores ferruled and identified in accordance with the system schematic and cable diagrams.

3.9. CABLE IDENTIFICATION

Every cable shall be permanently identified at each end by its cable number as shown on the cable schedule. Cable markers shall comprise an approved system of engraved plastic or

stamped metal marker plates, secured to the cables by self locking plastic buckle clips or similar fixings.

Cable marker plates shall also be installed at exit and entry points of buried ducts, exits from buildings and in such other positions as are necessary to identify and trace the route of any cable.

All power cables shall be connected at main switchboards and other items of plant so that the correct phase sequence and phase colour coding are preserved throughout the system. Cables shall be identified with phase colours for three and four wire systems and red and black for single phase. On rotating plant, where to achieve the required direction of rotation it is not possible to connect the phase cores to the appropriately identified terminals, special core ferrules shall be fitted to identify each core with the terminal to which it is finally connected.

Control and instrument cables shall have individual cores identified by means of suitable permanent ferrules bearing the same numbers or letters at both ends and corresponding with terminals on equipment. Core identification shall occur at every point of termination using an approved system of ferrule markers.

Numbering shall read from the terminal outwards on all cores. At those points of interconnection between wiring where a change of number cannot be avoided, double ferrules shall be provided on each wire. The change of numbering shall be shown on the wiring diagrams of the equipment at which the change is made.

3.10. EARTHING

1. A complete earthing system shall be provided for each equipment installation comprising a copper tape/conductor earth network and earth electrodes, which shall comply with the requirements of the BS 7430 or equivalent.
2. The earth networks shall comprise a main tape/conductor earth, conductor run around the structure with separate subsidiary branched copper tape/conductor connections taken from the main conductor to each item of electrical equipment, metal frameworks and castings, and to the neutral points of generators and power transformer secondary windings as appropriate to the method of system earthing.

All metal pipework shall be bonded to the main earth network at the point of entry to a building.

The earth network conductor shall comprise annealed high conductivity hard drawn copper strip which shall be supported on building or substation structures or cable trench walls by means of clamps suitably spaced. It shall be neatly run parallel to adjacent walls, ceilings and beams.

The earthing of each item of electrical equipment shall be effected by bonding the earth tape/conductor to the special earth terminal provided thereon. Particular care shall be taken on cable termination boxes to ensure that the cable sheath and armour is adequately bonded to the frame of the item of plant to which the cable is connected. If the earth continuity through the cable termination gland is inadequate, a special copper connection shall be made, between the apparatus frame and the cable earth sheath and armour.

Joints and connections in the earthing network shall be riveted, tinned and soldered, or brazed to the approval of the Engineer.

Earthing on low voltage distribution and sub-distribution circuits of connected load capacity not exceeding 20 kW shall be affected by means of the metal sheath and/or armouring of cables which shall be securely bonded at each end to the metalwork or the apparatus concerned.

Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and, should the design of such an item of apparatus not give adequate and lasting continuity through its structural body, additional earthing clips and conductors shall be provided to bond the cable sheaths or armouring together. Similarly, additional earthing clips shall be provided to bond

the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection of termination gland prove inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

Where rigid or flexible conduit is used, an internal earth conductor shall be run which shall be securely bonded to the terminating or intermediate apparatus by means of a special earth terminal.

3. Unless otherwise specified two earth electrodes shall be provided for each installation.

Subject to determination by tests on Site, which shall be carried out by the Contractor, each electrode shall comprise either a system of interconnected driven rods, or alternatively buried copper plates.

The two electrodes shall be physically arranged and spaced to be electrically independent and leads from each shall be brought to an earthing bar located inside building or to common concrete disconnection chamber set in the ground. Two bolted copper links shall be provided in the disconnection chamber to enable each electrode to be disconnected from the system for test purposes.

Each electrode shall be capable of providing an effective earth of resistance not greater than the values specified, with the other electrode disconnected.

Earthing rods shall be steel cored with a metallic bonded copper outer surface of thickness not less than 0.38 mm and a total diameter not less than 16 mm. Rods shall be provided with special hardened tips and caps to avoid distortion when being driven into the ground. The rod extension length shall be of the screwed type arranged so that the diameter of the rods is not greater at the point of extension.

Each rod shall be provided with an approved non-ferrous clamp for the connection of the copper strips and these connections shall each be housed in individual inspection chambers set flush with the ground level.

Interconnections between electrode rods or plates and between the electrode test chamber and the main plant earthing conductor system shall be by stranded copper cable.

After the earth installation has been completed, the Contractor shall demonstrate to the Engineer that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the positions of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

3.11. CABLING AND EARTHING RECORD DRAWINGS

Record drawings for the cabling and earthing installation shall include cable route drawings, block diagrams and cable schedules. Cable schedules shall detail the cable type, voltage rating, core size, installed length and terminal equipment. Core identification numbers shall be given for control cables.

Block diagrams shall illustrate the complete power and control cabling systems, each cable being identified as in the cable schedules.

Within buildings, cable route record drawings shall show to scale the location of all items of electrical plant and the route and method of installation of all cables, e.g., on tray, in trench, on hangers, in ducts and in conduits.

External cable route drawings shall show:

- The route of the buried cable.
- The depth of laying including any deviations to avoid local obstructions encountered during installation.

- Positions of marker posts.
- Positions of joints, test terminal points, drawpits, etc., located from marker posts or other agreed key points.
- Distances of cable runs from pipe runs or other buried services.
- Positions of earth electrodes, earth rod inspection chambers and interconnecting earth tapes/conductor.

3.12. NEUTRAL EARTHING RESISTORS

3.12.1. RESISTORS

The resistor elements shall be of the air insulated, air coded grid pattern, formed from continuous, rustless and non-magnetic alloy steel.

The resistor elements shall be mounted on mica or porcelain insulated steel rods. The resistor elements shall be assembled in tiers on interlocking insulators and supported on a welded steel framework. Interconnections between resistor elements shall be made using copper strip.

The whole resistor unit shall be designed to ensure ample strength to withstand the mechanical and thermal stresses imposed during the passing of the rated current.

The resistor voltage and current shall be as specified. The resistance value shall be that at the design ambient temperature, and the unit shall, unless otherwise specified, be capable of carrying the specified current for a minimum time of 30 seconds with a maximum temperature rise as stated in the Schedules.

3.12.2. ENCLOSURES

The resistor unit shall be provided with a sheet steel enclosure with side covers.

The enclosure shall be suitable for indoor or outdoor location as specified.

3.12.3. CONNECTIONS

The resistor unit shall be provided with either cable termination facilities or porcelain top bushing as specified. A stud, insulated from the resistor unit metalwork shall be provided for the main earth connection. A separate stud shall be provided for the earthing of the metalwork.

3.12.4. FINISH

Unless otherwise specified, all metalwork shall be hot dipped galvanised.

3.13. LIGHTNING PROTECTION SYSTEM

Lightning protection system shall be provided for the buildings in accordance with IEC 1024-1.

Lightning pole shall be connected to an earth rod separate from the earth networks of the installations.

4. BUILDING SERVICES

4.1. ELECTRICAL SERVICES

4.1.1. APPLICABILITY

The following clauses specify the general requirements for the supply and installation of electrical services for buildings and area throughout the works. The general specification clauses shall apply where appropriate except where redefined elsewhere in the specification.

4.1.2. DISTRIBUTION BOARDS

Distribution boards shall be of zinc coated mild steel sheet construction of adequate thickness, suitably braced to form a rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance. Doors shall be fitted with gaskets and shall be easily removable to simplify installation. Each distribution board shall be arranged for top and bottom cable entry and shall be provided with removable termination plates and space to enable cables and conduits to be neatly grouped and terminated. Distribution board shall be wall or floor mounted and shall, when specified, incorporate on-load isolators which shall be front of panel operated with “ON/OFF” indicators and capable of being padlocked in the “off” position. Distribution board shall incorporate combinations of single pole and neutral and triple pole miniature circuit breakers (MCB’s) as specified.

Each bank of MCB’s shall be clearly identified with its appropriate phase colour/code, and the mounting framework for the banks of MCB’s shall be easily removable to simplify installation. Adequate phase barriers and shields shall be fitted to ensure that, after installation and wiring, all bare terminals and wires are covered to prevent accidental contact with live conductors when resetting MCB’s.

MCB’s shall be rated to afford “close” overcurrent protection to circuits as defined in the IEC Recommendations.

Distribution boards shall incorporate neutral bars or terminal assemblies providing an independent terminal for each MCB circuit.

The termination of circuit cables at distribution board shall be neat and slack left to enable complete internal assembly to be partly removed for inspection without disconnection. Neutral conductors shall be connected to the bar in the same order as the phase conductor to the busbars.

Each distribution board shall be complete with a permanent circuit identification chart, mounted within the front door. This chart shall be permanently and legibly filled in as circuits are completed.

4.1.3. CONDUITS

Conduits shall be hot dipped galvanised steel. Conduits shall be neatly run on the surface or sunk as specified and shall be installed so as to permit complete rewiring without the need to remove false ceilings or wall cladding materials or carry out builders work.

Only continuous lengths of buried conduit shall be installed between boxes. No joint boxes shall be installed in the floor screeds. Conduits crossing expansion joints shall be fitted with couplings of approved manufacture with an earthing clip at each side of the coupling, connected by the correct size of tinned copper stranded wire.

Inspection couplers may be used in long runs to facilitate drawing in cables.

The ends of the conduit laid or set in formwork prior to concreting shall be temporarily sealed off with a coupler and a solid brass plug.

Particular care shall be taken to ensure that no water is allowed to enter the conduit and all conduits shall be arranged with adequate ventilation and drainage. Inaccessible junction boxes will not be allowed.

The sizes of conduit used shall be determined by the number of cables to be drawn in, but conduit smaller than 20 mm diameter shall not be used.

Fixings to surfaces of walls shall be by means of spacer bar saddles securely fixed by screws. Where conduits are concealed or laid in construction floors, they shall be held in position with substantial fixings of a make and pattern to be approved by the Engineer.

Surface run conduits shall be supported at intervals in accordance with the following schedule:

Size	Interval
20 mm	1.2 m
25 mm	2.0 m
32 mm	2.5 m

Where bends and sets occur in the conduit run, the conduit shall be securely fastened at a distance of 225 mm either side of the diversion.

The conduits shall be screwed into spout outlets of conduit boxes or, where fixed to boxes drilled with properly sized clearance holes, they shall be secured by means of sockets and hexagon smooth brass bushes. Threads shall be cut clean and all burrs shall be removed with a reamer.

Any exposed metal such as ends of conduit or exposed threads cut on site shall be treated by a cold galvanising compound or lead based anti-corrosive paint.

Any bends and sets shall be formed in the conduit itself. Factory made bends shall not be installed without the written permission of the Engineer.

Standard junction or adaptor boxes shall be provided at all junctions and at sharp changes of direction.

Junction and adaptor boxes shall be made from galvanised steel and shall be provided with gasketed flat covers secured with brass screws.

Weatherproof boxes and accessories shall be used outdoors.

Conduit ways shall be installed for telephone services run as for other conduit with a single cable pulled in and left for draw-in purposes.

For telephone points, conduits shall be terminated at flush standard boxes each with a stainless steel telephone outlet plate.

4.1.4. FLEXIBLE CONDUITS

Where the conduit system terminates at any equipment requiring a non-rigid connection, a flexible conduit shall be installed of the PVC or PVC sheathed metallic type fully watertight with purpose made connection adaptors.

Each flexible connection shall include not less than 400 mm length of flexible conduit and a separate earth conductor shall be run within the conduit connected to the earth terminals in the equipment and the fixed conduit run. The flexible conduit shall not be used as an earth continuity conductor.

4.1.5. TRUNKING

Trunking shall be manufactured from heavy gauge continuous hot dipped galvanized steel. Each length shall be supplied with the necessary connection sleeves and shall have sides suitable for flush fitting.

The Contractor shall ensure that the size of trunking is adequate for the number of cables passing through it, but the minimum size shall be 50 mm x 50 mm. Bends, tees and intersections shall be of the gusset type and manufactured by the maker of the trunking and to similar standards. Trunking shall be fixed to ceilings by means of a secure and permanent fastening. Where standard lengths of steel trunking are cut, the Contractor shall, prior to assembly, treat the cut edge with a cold galvanising compound or lead powder based anti-corrosive paint.

4.1.6. WIRING

Cables for drawing into conduit shall be single copper core PVC insulated, non-sheathed, 1 000 volts grade and shall be supplied by an approved manufacturer. Insulation shall be coloured to indicate phase and neutral.

The conductor sizes shall not be less than 1.5 mm² for lighting circuits, and 2.5 mm² for socket outlet circuits.

No conduit serving a single phase socket outlet, lighting point or switch shall contain more than one phase.

Wiring shall be carried out on the looping-in system and no joints other than at loop-in points will be allowed.

4.1.7. SOCKET OUTLETS

All socket outlets shall incorporate an earth continuity pin or, subject to the approval of the Engineer, a scraping earth contact. Socket outlets of differing voltages shall have differences in plug dimensions and/or incorporate the appropriate keyway interlock for supply discrimination.

Switch socket outlets shall incorporate dolly type switch levers, either fully recessed or having a raised surround to prevent damage or inadvertent operation.

Socket outlets shall be of the shuttered pattern or, subject to the approval of the Engineer, shall be fitted with spring operated flap covers.

Each socket outlet shall be complete with a steel mounting box incorporating an earthing terminal and a metal cover plate.

Special care shall be taken to ensure that all fittings are securely fixed truly vertical, and that in the case of a flush mounted socket outlet, the mounting box is fitted flush with the wall finish so that the overlapping cover plates seat onto the rims of the boxes.

4.1.8. LIGHTING SWITCHES

Interior lighting switches shall be supplied complete with metal box, cover plate and fixing screws.

At multi-switch positions, the switches shall be contained in multi-gang boxes.

Exterior lighting switches shall be metal-clad, galvanised and watertight, with rotary switch action.

All switches shall be securely fixed truly vertical and flush mounted switches shall be flush with the wall finish so that the overlapping cover plates seat onto the rims of the boxes.

4.1.9. BULK SWITCHING CONTACTORS

Bulk switching contactors (e.g. for large lighting or heating loads controlled from a single switch) shall comply with IEC 947-4-1. The contactors shall be continuously rated for the duty specified and shall have a minimum utilization category AC1 and shall have an intermittent duty Class 1 with the characteristic mechanical endurance of that class.

Contactors shall be single pole or triple pole as required, each type with a neutral terminal.

Where contactors are not integral with main switchboards, enclosures shall be constructed similar to those for distribution boards and shall have a minimum protection characteristic IP52 to IEC 529.

4.1.10. LIGHTING

Luminaires shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with heat resisting flexible cables of a minimum core size of 24/0.20 mm insulated with silicon rubber.

The earthing of all luminaires shall be by a separate core in the connecting flex of cable securely bonding the earth terminal of the fitting to that of the interconnecting cables. Pendant chains or conduit support tubes shall not be used as a means of earthing.

Where weatherproof luminaires are installed, all cable entry and securing holes shall be adequately sealed to prevent ingress of moisture.

Fluorescent luminaires shall have two suspension or fixing points.

The length of fluorescent tubes shall be not greater than 1 200 mm.

When luminaires are installed in areas incorporating suspended ceilings, they shall not be attached to or transmit load to the suspended ceilings unless the ceiling and lighting is of integrated design with the appropriate supports.

Where high bay discharge luminaires are suspended from the structural ceiling, the connection between the fitting and fixed wiring shall be by plug and socket to facilitate removal of the complete fitting.

Lamp holders for flexible pendants shall be of the all insulated skirted pattern with cord grips.

The point box suspensions and other parts of the luminaires shall be erected at times to suit the building programme for finishes. The glassware, diffusers, shades, lamps and tubes shall not be fitted until all building work is complete.

Fittings shall be left clean inside and outside and be ready for use; fluorescent fittings shall be suitable for switch start operation.

Fluorescent tubes shall be of energy efficient type and of an approved manufacture and standard white.

Incandescent lamps shall be of an approved manufacture with metal coiled filaments, gas filled and pearl in all sizes. Bayonet type fixtures shall not be used for lamps rated above 100 watts.

Exterior luminaires for site and area lighting shall be of the outdoor, weatherproof, anti-vandal, high pressure sodium vapour or metal halide type.

Security lighting shall be designed so as to be inaccessible to intruders.

The level of required illumination is at minima for:

- Outside ways 20 luxes.
- Inside ways and stairs 100 luxes.
- Rooms inside buildings 300 luxes.
- Offices inside buildings 500 luxes.

4.1.11. EMERGENCY LIGHTING

Emergency light fittings shall be designed to provide a level of illumination under mains failure in compliance with BS 5266 Part 1 or equivalent.

Emergency lighting fittings shall be self contained, incorporating fluorescent lamp(s), battery charger and mains failure relay.

The fittings shall be fully automatic in operation, providing instant illumination in the event of mains failure for a duration of 3 hours. The battery shall be automatically recharged when the mains supply is restored.

Alternatively self-contained emergency power modules may be incorporated into the normal lighting luminaires, such fittings being distinctively labelled for identification.

4.2. HEATING, VENTILATION AND AIR CONDITIONING PLANT

4.2.1. APPLICABILITY

The following clauses specify the general requirements for the supply and installation of heating, ventilating and air conditioning plant to be provided throughout the Works. The general specification clauses shall apply unless redefined elsewhere in the Specification.

4.2.2. PACKAGED AIR CONDITIONING UNITS

Packaged air conditioning units shall be one piece air to air electric cooling units, each comprising an air cooled condensing section containing compressor/condenser coil and cooling fan and an air handling section containing return air/fresh air dampers, filters, direct expansion cooling coil, electric heater battery and centrifugal fan. The units shall be complete with all internal interconnecting pipework and control equipment and shall be supplied as a single packaged unit suitable for direct site installation.

Each packaged unit shall be housed in a totally enclosed fabricated steel floor-mounting cubicle, complete with removable panels or doors to facilitate access to all component parts for

maintenance purposes. The units shall be designed for outdoor mounting and all component steel parts shall be hot dip galvanised. The units shall be installed on raised anti-vibration mountings.

The air handling section shall incorporate air filtration, air mixing and fan components. Air mixing dampers for return air and fresh air control shall be galvanised steel construction individually adjustable with damper rods, rotating in nylon bearings.

Air filtration shall be by cleanable filter cartridges located on slides for ease of access. Air filtration shall have an efficiency of not less than 90% based on EN 779.

The condenser coil shall be constructed of seamless copper tubes, arranged in staggered rows, mechanically expanded into aluminium fins.

The condenser fans shall be propeller type providing vertical air discharge. Fan blades shall be statically and dynamically balanced, protected above by anodized fan blade guards. Each fan shall be driven directly by an individual motor.

Compressors shall be of the serviceable hermetic type. The compressor and fan motors shall be suitable for continuous 380 Volts, three-phase, 50 Hz operation.

The units shall be complete with all motor and refrigeration control equipment, factory wired and suitable for direct connection to the power supply. All control equipment shall be contained in an integral but fully segregated cubicle compartment with lockable hinged access doors. The units shall be suitable for pushbutton starting locally, or from a remote control station.

4.2.3. INDIVIDUAL ROOM AIR CONDITIONING UNITS

Each individual room air conditioning unit shall be of the through the wall pattern comprising two sections for indoor and outdoor equipment divided by an insulated steel bulkhead. The indoor section shall contain the evaporator electric heater battery, centrifugal fan, electrical terminal block and all electrical capacitors. The outdoor section shall house the compressor, condenser and propeller fan. The entire unit shall be mounted on a slide-out chassis within a weatherproof cabinet with removable front panel.

The compressor shall be hermetically sealed and resiliently mounted.

The evaporator shall be a single pass copper coil with light gauge aluminium fins and with an automatic thermostat to prevent excessive frosting.

The condenser shall be a copper coil with aluminium fins.

Filtration shall be provided by a washable filter accessible from the front.

The unit shall be suitable for continuous operation in an ambient temperature of 45°C.

4.2.4. PACKAGED AIR COOLED WATER CHILLERS

Packaged air cooled water chillers shall be completely factory assembled, including all interconnecting refrigerant piping and internal wiring of controls, and shall be mounted on a steel base which shall accommodate the air cooled condenser, compressor and cooler. The units shall be delivered complete with full operating charge of the refrigerant (R22).

Frames and panels shall be fabricated from heavy gauge galvanised steel, complete with removable panels to facilitate access to all component parts for maintenance purposes. The compressors shall be of the hermetic reciprocating type with all rotating parts statically and

dynamically balanced. The compressor shall have a forced feed lubrication system using a reversible positive displacement type oil pump.

The compressor shall also include a suction strainer, oil strainer, crankcase oil sight glass, crankcase oil heater and back seating seal-cap suction and discharge stop valves. The compressor shall be mounted on spring isolators.

The evaporator shall be direct expansion shell and tube type with refrigerant in the tubes and liquid to be chilled in the shell. The water connections shall be fully accessible without going through the condenser sheet metal panel section.

The condenser coil shall be constructed of seamless copper tubes, arranged in staggered rows with aluminium fins. The condenser shall include as an integral part of the design a sub-cooling circuit. The condenser coils shall be of a “V” bank arrangement and shall be fully protected by sheet metal panels.

The condenser fans shall be propeller or axial flow type, providing vertical air discharge. Fan blades shall be statically and dynamically balanced, protected above by anodized fan blade guards. Each fan shall be driven directly by an individual motor. Each packaged chiller shall be complete with a built-in control centre. The control panel shall be split into two compartments, one housing the power circuits and one the auxiliaries. The control panel shall be complete with weather proof doors. The control panel shall include but not be limited to the following items:

- High and low level refrigerant pressure cut-outs.
- Low water temperature thermostat.
- Control thermostat.
- Motor starters.
- Overload relays.
- Time delay relays for starting compressors in sequence.
- Fuses.
- “On-off” switches for each compressor and reset pushbuttons.
- Auxiliary terminals for interlocking.
- Anti-short cycling device.

The units shall be suitable for operating continuously on a three-phase 50 Hz supply at an ambient temperature of 45°C.

4.2.5. AIR HANDLING UNITS

1. Air handling units shall comprise a number of sections combined into ventilation or air conditioning units.

Ventilation units shall be any combination of a fan section, panel filter, bag filter, mixing section or intake damper and sand trap louvers.

Air conditioning units shall be any combination of a fan section, cooling coil, electric heater, filter and mixing section.

2. Each section shall consist of a rigid assembly, formed from enclosure panels, constructed from double skinned galvanised steel sheet with 25 mm mineral wool internal insulation, resting on supporting beams.

The different unit sections shall be assembled on robust clamping strips provided with seals to prevent air leakage. Inspection panels shall be provided with quick-acting opening locks.

3. The air filter section shall consist of disposable type filter bag cartridges located on slide rails for ease of replacement. Each filter bag cartridge and slide rail shall be provided with seals.

The filter type shall be in accordance with ASHRAE 52 and filter efficiency shall be to BS 2831 or equivalent.

Each filter section shall be provided with two spare complete sets of filter cartridges.

Pre-filters shall be of the disposable panel type, with filter media of fibreglass. Filters of this type shall have an efficiency of not less than 90% based on the test specified in BS 2831 or equivalent with test duct No. 2.

A manometer shall be fitted to each filter section, arranged for measuring the pressure drop across the filter.

4. The mixing section shall contain two sets of dampers for mixing the outside and recirculated air.

The dampers shall be of galvanised steel sheet double skinned construction and shall be interlinked externally to the casing. The dampers shall be individually adjustable with the damper rods rotating in nylon bearings.

5. Direct expansion cooling coils shall be provided where specified. They shall be of the extended surface, non-ferrous, fin type.

The casing shall be constructed of heavy gauge galvanised steel. Coils shall have suction tapings located to permit universal mounting of the coil for right or left hand airflow and shall have equal pressure drop through all circuits. All long coils shall have stays to hold the fin-tube assembly in place. Primary tubes shall be seamless copper tube brazed into a heavy gauge header tube with intruded holes to allow for expansion or contraction of small radius return bends. Secondary surfaces shall consist of copper fins mechanically bonded on to the copper tubes. The coil fins and tube shall be electro-tinned after assembly. Brass liquid distributors of the pressure type shall be provided. Loading of each circuit shall maintain the refrigerant pressure drop within adequate limits to prevent loss of coil capacity.

Coils shall be factory air tested to 2100 kN/m² under water. Coils shall be dehydrated and sealed after manufacture.

6. Chilled water cooling coils shall be constructed as described for direct expansion cooling coils. The primary tubes shall be seamless copper with secondary surfaces of copper fins, mechanically bonded to the tubes and electro-tinned after assembly. Tubes shall be brazed into copper headers and filled with screwed male copper connections. Vents and drains shall be provided at the highest and lowest points.
7. All cooling coils shall have a maximum air velocity across the coil not exceeding 2.5 m/s to prevent moisture carry over. A condensate tray shall be provided at the base of the cooling coils complete with a drain connection. The condensate drip tray shall be coated with corrosion resistant paint.
8. Electric heater batteries shall be arranged to balance the electrical load over three phases. The heating elements shall be removable for cleaning and inspection. The connections from each heating element shall be taken to an accessible terminal box arranged for conduit entry. Each element shall be separately fused.

4.2.6. FANS

1. Fans shall be provided as specified. Each fan shall be capable of providing the required duty when tested in accordance with BS 848 or equivalent.

To standardise fan performance, standard air shall be taken as having a weight per unit volume of 1.2 kg/m³, corresponding to atmospheric air at a temperature of 20°C, a barometric pressure of 1013 mbar and a relative humidity of 50%.

All rotating assemblies shall be balanced both statically and dynamically after assembly in the manufacturer's works.

2. Axial fans shall be of aerofoil cross-section and of the single stage type or the multi-stage contra-rotating type, with each impeller driven by a separate motor, and mounted in a cylindrical casing. The blades of each impeller shall be fabricated from die cast aluminium, with pitch angles adjustable without removal from the fan casing. Balancing shall not be affected by altering the pitch angle.

Casings shall be rigidly constructed from heavy-gauge hot-dipped galvanised steel sheet, with the overall length containing the impeller and the motor. The casing shall be provided with flanged connections and with two inspection doors incorporated diametrically opposite to each other.

The impellers of the fans in the Chlorine House duct system shall be non-adjustable bifurcated rigid PVC pattern with non-overloading characteristics. The motor casing and fan support metalwork shall be constructed of hot dipped galvanised steel and protected with an approved chlorine resistant rubber based paint.

Motor bearing arrangement and bearing ratings shall permit continuous fan operation in the vertical or horizontal position. Ball or roller bearings shall be used.

3. Centrifugal fans shall be double-inlet or single-inlet. The fans shall be V-belt driven with backward or forward curved impellers. The fans shall consist of galvanised steel casing, fan impeller shaft and bearings, motor, steel frame, anti-vibration mountings, belt drive, pulleys and guards. The steel frame shall have adjustable rails. The fans shall be provided with an inspection cover.
4. Propeller fans shall be suitable for ring mounting or diaphragm mounting. The impellers shall be of steel or aluminium and fastened to the hub or formed with the hub in one piece. Ball or sleeve bearings may be used. The motor and impeller shall be a complete integrated unit. Anti-vibration mountings shall be fitted. Unless otherwise specified, the arrangement shall be with the motor upstream of the impeller. All fans impellers shall be finished with corrosion resistant coatings.
5. Air intakes and exposed fan moving parts shall be protected by rigid galvanised wire guards. Access shall be provided for measurement of shaft speeds and belt tension.
6. Roof extract units, where provided, shall be fitted with propeller or mixed flow type fans.

The housing shall be constructed from corrosion resistant spun aluminium with a glass fibre base and weathering skirt for kerb mounting.

7. Where duplicate extract fan units are specified for toilet areas, each fan shall provide the full air flow required. The fans shall be connected in parallel and arranged for automatic changeover upon failure of the duty fan. Either fan shall be capable of being selected as the duty fan. In the event of failure of the operating fan, an airflow switch shall detect the failure and immediately activate the standby fan. A damper shall be provided to prevent back feed of air through the idle fan. A warning light shall be provided to indicate fan failure.
8. Ceiling mounted ventilation fans shall comprise capacitor start and run type motor, supporting down rod and three bladed fans. Blades shall be of steel. Each unit shall be complete with a surface mounted six speed and off speed regulator.

4.2.7. AIR DISTRIBUTION

1. Grilles, diffusers and louvers shall be provided throughout and shall be sized to meet the requirements of the system and in accordance with approved design. Diffusers, grilles and louvers shall be constructed of spun anodised aluminium.

Supply and return air grilles and diffusers shall incorporate key operated, opposed blade, manual, volume control dampers.

2. Ceiling mounted and duct mounted supply air diffusers shall incorporate removable and adjustable cores to provide a full range of air control. Return air diffusers shall match the supply air diffusers within the same space.

Ceiling mounted diffusers shall be installed flush with the ceiling surface on duct extension collars arranged so that no load is imposed on the ceiling structure.

3. Supply air grilles shall incorporate double deflection, individually adjusted, air foil blades with front blades arranged parallel to the grilles longest side.

Return air grilles shall be of the fixed horizontal blade pattern.

Transfer grilles shall be of the single deflection fixed horizontal blade pattern.

4. External intake louvers shall be of the sand trap pattern. Each louver shall comprise fixed pattern, extruded aluminium, vertical mounted blades designed to form an effective sand trap. The intake louver frame structures shall incorporate an effective vermin screen, external sand drainage holes, removable bottom cover plates for cleaning, and shall be designed for mounting into the building structure.

5. The size of the louvers shall be such that the face velocity does not exceed 0.5 metres per second and at this velocity shall be capable of removing 85% of a typical desert sand and dust mixture from the incoming air.

6. The pressure loss across the louvers at 0.5 metres per second face velocity shall not exceed 25N/m².

7. External exhaust louvers shall comprise fixed pattern, extruded aluminium, horizontal mounted blade incorporating an effective vermin screen, and shall be designed for mounting into the building structure. The louvers shall be fitted with automatic non-return dampers incorporating edge seals to provide a fully air tight seal when closed.

4.2.8. DUCTWORK

1. The ductwork and all component fittings for installation in Chlorine House shall be constructed of unplasticized polyvinyl chloride (uPVC) extruded sheets and circular sections to BS 3757 and BS 3506 or equivalent.

The ductwork and all component fittings in all other areas shall be constructed from hot-dipped galvanised steel to EN 10142.

2. PVC duct systems shall be designed and constructed in accordance with the Heating and Ventilating Contractors Association (HVCA) Specification DW151 or equivalent.

Ductwork joints shall be flanged with neoprene gaskets secured with cadmium plated mild steel bolts.

3. Galvanised steel duct systems shall be designed and constructed in accordance with the HVCA Specification DW141 and DW144 or equivalent for low velocity duct systems.

Ductwork shall be constructed with lap or standing seams. Normal cross section joints shall be spigot and socket slip joints with a minimum 50 mm overlap. Bolted flange joints shall be provided for all fan and duct fitting insert sections. Lap joints and seams shall be sealed and riveted. Flanged joints shall incorporate neoprene gaskets and shall be secured with cadmium plated steel bolts.

4. Air flow control, non-return and fire barrier dampers shall be provided as required.

Air flow control dampers shall be of the opposed blade pattern and provided with external operating handle with position indicator and means of padlocking in any set position.

Dampers in uPVC ductwork shall be constructed of uPVC coated galvanized steel. Operating shafts shall be stainless steel.

Fire dampers shall be of the single blade, hinged, self-closing pattern. Dampers shall be held open with fusible links set to release the damper at not greater than 72°C.

Duct access openings shall be provided wherever necessary for plant routine maintenance, lubrication and adjustment. Hinged plates and removable covers shall be gasketed and secured with bolts.

Duct test holes shall be provided for system balancing and commissioning.

5. Support brackets and fittings for all ductwork shall be of hot-dip galvanised steel.

Fans, dampers and other duct inserts shall, wherever possible, be supported independently from the ducts to which they connect.

Duct sleeves shall be provided where ducts pass through floors and walls. Duct sleeves shall be sealed after installation by an approved method.

No duct support fixings shall be made to the building structural cladding.

4.2.9. THERMAL INSULATION

1. Thermal insulation shall be provided for all air conditioning ductwork systems. Each duct or pipe shall be individually insulated and shall have a complete vapour seal. Supports shall not be in direct contact with the pipe or duct.
2. Ductwork within plant rooms shall be insulated with aluminium foil-faced rigid fibreglass slabs 50 mm thick. The slabs shall be securely held in position with adhesive and 50 mm x 50 mm aluminium angles fitted as additional protection on all corners. Ductwork over 900 mm size shall be further held in position by means of stick clips and washers. The whole shall then be encased in a layer of heavy quality canvas, and sealed with a vapour sealer.
3. Internal ductwork outside plant rooms shall be insulated with aluminium foil-faced rigid fibreglass slabs 50 mm thick, applied with an adhesive and vapour sealed.
4. External ductwork shall be insulated as described for plant room ductwork, then further protected with a layer of 2-ply aluminium foil-faced roofing felt which shall be well lapped at joints and secured with 32 mm mesh x 19 gauge galvanized wire netting, and the whole vapour sealed.

4.2.10. NOISE CONTROL

Acoustic attenuators shall be provided as required to achieve the noise levels specified. Attenuators shall be uncased units for plenum chambers and builders' ducts, or cased units elsewhere. Cased units shall be of the straight-through splitter bend, lined bend or straight-through cylindrical type.

Rectangular splitter type attenuators shall be constructed from galvanised mild steel sheet of the following thickness:

- Longest side up to 680 mm - 1mm.
- 680 mm and over - 1.6mm.

Galvanised steel angle flanges shall be attached to the casing.

Internal splitters shall be constructed from profiled galvanised steel sheet which contains absorption acoustic material. The absorption material shall be incombustible and shall incorporate a 40% free area (electro-galvanised) expanded metal facing to prevent erosion of fibrous particles.

Cylindrical attenuators shall be of similar construction to the cased splitter type and, where higher insertion losses are needed, axially-mounted acoustic pods shall be fitted.

Attenuators shall be lined with a transparent polyester film not less than 0.025 mm thick to prevent absorption of dirt and contaminants.

Mechanical equipment shall be mounted upon anti-vibration mountings so that the transmission of dynamic forces to the building structure shall be attenuated by not less than 90% for all possible equipment operating speeds. The mounting types shall be either rubber in shear or steel spring.

Mechanical equipment shall be provided with flexible connection. The flexible connectors shall provide maximum structural isolation between the mechanical equipment and the distribution pipework or ductwork. Flexible connectors shall be as near to the mechanical equipment as possible.

4.3. TELEPHONE SYSTEM PLANT

4.3.1. GENERAL

The Contractor shall furnish all materials, labors and services required for the installation of a complete private telephone system for the job site(s) as specified herein.

Approvals on all items included in this section must be obtained from the local telephone network Administrator and the Engineer, before supply of any item.

The Contractor to arrange with local telephone network Administrator to ensure the completion of the telephone services for each of the job sites. This shall include but not limited to liaison with the local telephone network Administrator to carry out inspection for the whole telephone installations.

4.3.2. SYSTEM DESCRIPTION

The system shall comprise an Electronic, Private Automatic Branch Exchange (EPABX) with a Main Distribution Frame (MDF) equipped with power supply equipment and UPS of 4 hours full autonomy.

The telephone system installations shall be complete with all wiring, conduits, telephone junction boxes (TJB), outlets and telephone sets.

4.3.3. REGULATIONS AND STANDARDS

All equipment and installations thereof are to be in new standard material in accordance with the relevant national and local codes and regulations.

4.3.4. MANUFACTURER

All major items of equipment are to be the product of one manufacturer, where practical, to ensure a unified quality and comparable styling and appearance.

4.3.5. SYSTEM PERFORMANCE AND FACILITIES

4.3.5.1. SYSTEM FUNCTION

System is to provide a means of intercommunication within the different parts in each of the waterworks sites as well as distribution of the incoming and outgoing telephone calls.

4.3.5.2. SYSTEM FUNCTION

The system features shall include the following:

1. Extension-to-Extension Calls

Extension-to-extension calls are to be directly made by dialing the other extension number without operator assistance.

2. Direct Outward Dialing (DOD)

Non-restricted and semi-restricted extensions are to be able to gain access to lines without operator assistance by dialing an access code and then dial the exchange number.

3. Direct Inward Dialing (DID)

External callers can reach extensions by dialing the exchange and the extension numbers without the operator assistance.

4. Camp-On-Busy

If an extension called is busy, the caller can dial a digit and hang up and be called back when the busy extension becomes idle.

5. Call Forward

Any extension is to be able to have all calls to his extension automatically forwarded to any other extension.

6. Call Hold

Any extension can hold a call on his extension while calling a third party. Extension is to be able to confer privately with the third party, recalls the first party thus, establishing a three-party conversation or transfer the first party to the third party.

7. Call Pick-Up

Any extension in an assigned extension group is to be able to pick-up and answer an incoming call to any other extension within the group.

8. Executive Override

Selected extensions are to be able to cut into a busy extension following a warning tone to the talking parties.

4.3.5.3. EQUIPMENT AND MATERIALS

1. Type

EPABX is to be fully electronic, time-division, switching-based, stored program controlled and designed to support all types or key telephone sets.

2. Characteristics

EPABX shall have the following characteristics:

Operator's Console:..... 1

Operating Temperature: 0 - 50 °C

Relative Humidity:..... 60 - 100%

3. Housing

All exchange components are to be grouped in a modular, totally enclosed, sheet metal cabinet with lockable front access door. Cabinet is to be dust and insect proof. Ventilation is to be provided as required for the specified ambient conditions.

4. Power Supply Equipment

Mains-operated power supply comprising rectifier, charger and batteries are to supply continuous DC power at the specified voltage to the EPABX. Batteries are to provide a minimum of four hours of continuous operation without loss of system functions or reduction in the system capacity after power supply failure.

4.3.6. OPERATOR'S CONSOLE

The console shall be desktop, compact type equipped with the necessary controls and displays to provide all services specified herein and verify full control of the system operation.

1. Terminals

All internal and external lines are to be connected by means of high quality and reliable quick-clip connectors. No soldering or wire wrapping will be allowed.

Cables are to be arranged and guided in cable positioning slots.

2. Numbering

Terminals are to be identified by numbered tags corresponding to the respective lines or extensions. The Contractor shall submit proposed numbering scheme for prior approval by the Engineer.

3. Protection

All trunks are to be fully protected by a set of plug-in, gas discharge tube over-voltage protectors, fuse ring for thermal protection against prolonged mains contact and rated fuses for over-current protection. Frame earthing is to be provided and interconnected to the earthing system.

4.3.7. TELEPHONE CABLES

Cables are to be two-pair or multi-pair, polyethylene insulated, tinned solid copper conductors, twisted into pairs, color coded, with wrapping of aluminum polyester tape and PVC sheath of

gray color. Minimum diameter of the conductor shall be 0.65 mm for multi-pair cables and 0.6 mm for two-pair cables.

4.3.8. OPTICAL FIBER CABLES

Optical fibers, cables shall be multi-mode, graded index optical fibers with nominal 62.5/125 μm core/cladding diameter.

Fibers shall comply with ANSI/EIA/TIA 592-A AAAA (Ref. B1.18) and also with ANSI/EIA/TIA 568A Paragraph 12.5.1 on mechanical terminations.

Outdoor optical fibers shall be used to connect MCC buildings to the main distribution frame.

Outdoor optical fibers shall comply with the same specifications, however cables shall also be steel jacketed, jelly filled, rodent proof specifically made for outdoor applications, with 12 strands.

Optical fibers shall meet the graded-index multi-mode performance specified in following table.

Graded-Index 62.5/125 μm Multi-mode Cable Characteristics

	850 nm	1300 nm
Attenuation – dB/km	3.75	1.5
Bandwidth – MHz. km	160	500

Attenuation shall be measured in accordance with EIA fiber optic test procedure ANSI/EIA/TIA 455-46, 61, or 53 (Ref. B1.39). Information transmission capacity shall be measured in accordance with the ANSI/EIA/TIA 455-51, or 30 (Ref. B1.39)

Mechanical and environment specifications for indoor fiber optical cables shall be in accordance with ANSI/ICEA S-83-569 (Ref. B1.40). Outdoor fiber optic cables shall be in accordance with Bellcore TR-TSY-000020 (Ref. B1.36).

4.3.9. PATCH PANELS

Patch panels shall be type RJ45, 16 port, 1U type in rows of three with extension possible of up to six patch panels.

Patch panels shall be housed inside racking system (19" preferred) cabinets with hinged doors on either sides and lockable front doors.

Ventilation slots shall be provided in both sides.

Rack size shall suit patch panels.

4.3.10. PATCH CORDS / LINE CORDS

Patch cords, shall be 2 meters long with adapters at both ends suitable for connection to RJ45 16 port IU patch panels.

Patch cords shall be Category 5 and be flexible enough to bend without losing any performance.

Patch cords shall be the flexible stranded type.

Line cords shall have the same specifications as patch cords, however these shall be the solid type, used at wall outlets to connect computers or terminals to distribution cabling systems.

Cables shall comply with the performance data specified in the following Table.

Specifications for Category 5 solid/stranded line cords or patch cords		
Frequency (MHz)	Attenuation (Max. dB/305 m)	Next (Min Loss dB/305 m)
1.00	6.80	62.0
4.00	14.0	53.0
10.0	22.4	47.0
16.0	28.3	44.0
20.0	31.7	42.0
25.0	35.9	41.0
31.25	40.9	40.0
62.5	59.3	35.0
100.0	76.1	32.0

4.3.11. OUTLETS

These shall be twin outlet type RJ45 to EN 60950 IBS 7008 having white molded plastic plates with black shutters for computer outlets and white shutters for telephone outlets.

Outlets shall conform to the following specifications:

1. Attenuation (dB): <-0.12.
2. Return loss (dB): <-21.54.
3. Bulk resistance (milli-ohm): 21.85.
4. Voltage rating: >1050 V DC for 1 minute.

4.3.12. TELEPHONE OUTLETS

Outlets are to be cord-grip outlet cover and setscrew terminal block inside box, fixed mounted. Cover plates are to be as other power socket outlets and switches and complying with the building furnishing.

4.3.13. TELEPHONE SETS

4.3.13.1. TYPE

Telephone sets shall be desk or wall mounted type as shown on the drawings, provided with the necessary keypad. Telephone set construction is to be shock-resistant molded plastic of attractive design and color. Design and color are to be subject to the Engineer's approval. Telephone set is to be dust and insect tight with bell and adjustable volume control.

Telephone sets shall be with digital programmable facilities to comprise in addition to the standard keypad, a set of programmable function keys, alphanumeric LCD display, push buttons and associated LED's as well as a memory with a minimum of ten (10) telephone numbers. Selection of number of programmable telephone sets is to be subject to the Engineer's instructions.

4.3.13.2. CONNECTORS AND CORDS

Telephone sets are to have lock-in plug-ended cords for connecting handset to the telephone set base and for connecting base to the wall outlet. Cord is to be of not less than three (3) m long.

4.3.14. FIELD AND INSTALLATION WORKS

4.3.14.1. INSTALLATION

All equipment shall be installed in accordance with the manufacturer's recommendations and in coordination with other trades on site. The Contractor to consider local regulations during installations.

4.3.14.2. CABLES

Cables are to be run inside heavy gauge PVC conduits with a diameter of 25mm, concealed in walls or under floors.

Outdoor telephone cables shall be installed inside Upvc conduits with a diameter of 90mm, with the required hand holes and inspection chambers.

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SECTION 02100

SITE PREPARATION

1. GENERAL

1.1. WORK INCLUDED

1.3.1. SCOPE OF WORK

This section covers all operations in connection with clearing, grubbing and stripping of various parts of the Works sites and other locations related to the Works.

1.3.1. LIMITS OF WORK

It is the intent of these Specifications that the site preparation in connection with demolition, excavation and backfill shall be within the limit lines and grades shown on the Drawings and defined herein, but the right is reserved by the Employer to modify such limits and grades as may be deemed necessary and/or directed by the Engineer during the progress of the work.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. SUBMITTALS

The overall sequence and programme of site preparation works shall be as set forth in the Contractor's Programme of Work to be submitted within fourteen (14) calendar days after the award of the Contract in accordance with the stipulations of the Conditions of Contract

Not less than seven (7) days prior to commencement of clearing, stripping and grubbing of any section or area of the Works the Contractor shall submit to the Engineer a method statement detailing the arrangements the Contractor intends to adopt to carry out the work, so as to enable the Engineer to assess the consequences of the clearing and stripping works, as regards to the final site conditions and requirements of the relevant Authorities.

No clearing, stripping or grubbing shall be carried out without prior approval by the Engineer.

1.4. SEQUENCING – SCHEDULING

The clearing component of site preparation works shall be performed at the earliest practicable time in order to facilitate further survey works.

2. PRODUCTS

Not applicable

3. EXECUTION

3.1. CLEARING

Clearing shall comprise the removal from the specified area of the works and disposal to the satisfaction of the Engineer of all surficial trees, vegetation, structures, fences, rubbish, and other objectionable matter.

3.2. STRIPPING AND GRUBBING

Stripping and grubbing shall consist of removing natural ground surface layers of natural soil comprising top soil, vegetal matters, and humus as well as excavation and removal of all solid roots, stumps, embedded logs structural foundations and other embedded materials foreign to the natural surface soil layers...

Stripping and grubbing shall be required for all earth foundations of permanent works where the foundation is not specified to be prepared by excavation.

Topsoil removed shall be disposed in a stockpile on site as directed by the Engineer.

All waste shall be removed prior to any work in the area and shall be placed on the existing waste area on site which is specified to be subsequently capped and closed as part of the works under the Contract.

No separate stripping or grubbing will be required in areas to be excavated when the excavated materials will not be used in the Permanent Works.

The minimum depth of stripping shall be 25 cm or where this requirement is inapplicable as directed by the Engineer.

The Contractor shall not dispose of any surplus topsoil from stripping operations or excavated soil from excavations without the written permission of the Engineer.

3.3. DEMOLITION

Demolition works is included in clearing; they concern all structures, pipes, roads to be demolished in the works area as shown on the Drawings or directed by the Engineer.

3.4. PROTECTION OF OTHER AREAS

The Contractor shall ensure that trees and other vegetation outside the areas of the permanent works and the areas required for temporary works including access are protected and preserved from damage.

Any additional clearing required by the Contractor for construction of temporary works, Contractor's facilities, or for any other purpose shall be at the Contractor's expense and shall not be carried out without the prior approval of the Engineer.

The Engineer reserves the right to direct the reinstatement of any damage to vegetation and the surface of the ground beyond the areas of the Works resulting from the Contractor's construction activities (including temporary works) at the expense of the Contractor.

3.5. DISPOSAL OF MATERIALS

All inert materials from demolition works shall be disposed of within the site limits, as directed or approved by the Engineer, or shall be reused as recycled materials for construction works, upon Engineer's approval, if they comply with the Contract documents and the local regulation.

Stumps, roots, logs and other objectionable matter removed in the site preparation operation and other than inert materials arising from demolition works shall be removed from the limits of the work and disposed of in disposal areas as directed or approved by the Engineer.

Burning of in-situ vegetation, and/or waste vegetation, rubbish, timber from demolition works, etc. as part of clearing operations will **not** be permitted except when and where specifically approved by the Engineer at the request of the Contractor; and at such locations as approved by the Engineer. If and when such approval is granted the Contractor shall take all special precautions necessary to prevent fire from spreading to beyond the limits of the designated areas and shall have available at all times suitable fire-fighting equipment and supplies for use in preventing and suppressing fires.

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SECTION 02210

OPEN AIR EXCAVATIONS

1. GENERAL

1.1. WORK INCLUDED

This section covers all operations in connection with such excavation methods and to such dimension and depths that allows for proper execution of the Works.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

Excavation as specified under this section shall include manual and mechanical excavation techniques including when necessary use of heavy excavation equipment, ripping, percussion and/or hydraulic breaking, temporary supporting of excavations where required; scaling down and preparation of excavated surfaces for foundations; and, loading, transporting, placing and spreading of all excavated materials in approved stockpile and/or disposal areas.

1.4. DEFINITION

1. According to the dimensions, lines, levels and grade as shown on the drawings or directed by the Engineer:
 - the « elevation » line or neat-line shown on the drawings shall be the line within which no material shall be permitted to remain.
 - all excavations out of « elevation » line shall be classified as over-excavation or overbreak.
 - "geological overbreaks" shall be those due solely to the geology of excavated material. This will not apply to overbreaks due to other reasons such as the method of excavation employed by the Contractor. Classification of over-excavation/overbreak as geological overbreak shall be as decided by the Engineer.

Unless otherwise approved by the Engineer, the Contractor will not be entitled to payment for over-excavation or overbreak outside the excavation line, with the exception of geological overbreaks.

2. Classifications of excavation types

a) Rock excavations

Rock will be defined as sound and solid masses, of such hardness and texture, that it cannot be effectively loosened or broken down by ripping in a single pass with a late model tractor-mounted hydraulic ripper, equipped with one digging point of standard Manufacturer's design adequately sized for use with and propelled by a crawler-type tractor rated minimum 250 kW (335 HP) flywheel operating in low gear.

In the case where the above criterion is not convincing, rock excavation will be defined as sound material with a longitudinal seismic velocity greater than 2000 m/s.

All boulders or detached pieces of solid rock, more than 2.7 tons weight or 1 cubic metre volume will be classified as rock excavation.

b) Common excavations

Common excavation includes all materials other than rock excavation and may also be termed soil excavation. All boulders or detached pieces of solid rock less than 1 cubic metre in volume or 2.7 tons weight will be classed as common excavation.

In the event of a dispute as to classification of a material, the decision of the Engineer shall be final.

1.5. CODES AND STANDARDS

BS 410 Test sieves. Technical requirements and testing.

BS 1377 Methods of test for soils for civil engineering purposes

BS 5930 Code of practice for Site investigations

BS 6031 Code of practice for earthworks

ISO EN 965, 964-1, 12956, 10319 : Test of geotextile

USBR: Earth Manual of "Bureau of reclamation" US Department of the Interior.

LCPC: Laboratoire Central des Ponts et Chaussées.

1.6. SUBMITTALS

1. Mass haul diagram.

Prior to the commencement of any excavation works, the Contractor shall prepare and provide to the Engineer for review and approval a Mass haul diagram.

This diagram shall be submitted to the Engineer as part of the Traffic Management Strategy Plan to be submitted within 14 days after the award of the Contract and shall be updated, as and where necessary, at least 7 days prior to commencement of excavation works for any part of the Permanent Works.

In the planning and preparation of excavation works, the Contractor shall take into due account all available data on site investigations and geotechnical surveys that have been carried out previously (if any), an/or independent investigations carried out by the Contractor.

2. Method of work

Not later than 14 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the methods, sequences and equipment proposed for carrying out the excavation works including the planning of exploitation for quarries and borrow areas. This shall include all provisions for support and safety of the excavation where appropriate.

Within 7 days of receipt of any excavation plan, the Engineer will give in writing to the Contractor, approval or rejection of that plan in whole or in part. If approval is withheld the Contractor shall submit a new plan. No rock excavation shall be started in areas for which the excavation plan has not been approved by the Engineer.

The Contractor shall submit to the Engineer, at least two weeks before commencement of any excavation works, all calculations notes, documents and drawings that he will have produced relating to slope stability. Works shall not begin before the Engineer's agreement concerning the technical solution chosen by the Contractor to ensure slopes stability and safety. If supports and protections are found to be necessary, technical justifications shall be submitted.

No excavation work shall start before the Engineer has notified his complete and unreserved agreement to the relevant Contractor's excavation plan and the Contractor shall not be entitled to claim any compensation in this respect.

3. Topographical survey before any works

At least 14 days before start of any excavation work, a topographical survey - as described in § 3.1 Inspection - shall be submitted to the Engineer.

4. Topographical survey on completion of the excavation work

On completion of each type of excavation and not later than 3 days after a topographical survey, as described in Clause 3.1 hereinafter, shall be submitted to the Engineer.

5. Excavation records

The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work of all excavations works. When applicable the following data shall be recorded for each working face together with such other data as the Engineer may request:

- volume excavated in soil,
- volume excavated in rock,
- location methods used for rock excavation,
- number and classification of men and plant engaged,
- unusual occurrences, such as unstable or soft ground, inflows of water, slope instability, rockfalls or the like.

1.7. TOLERANCES

Excavations shall be made to the dimensions, lines, levels, grades, as shown on the Drawings or directed by the Engineer and shall be finished to tolerances as specified hereinafter.

Any excavation beyond the lines, levels and grades shown on the Drawings or directed by the Engineer which is performed by the Contractor for any purpose (such as for working space) shall be kept within the limits approved by the Engineer. If such excavation should in the opinion of the Engineer, require to be backfilled, such backfilling shall be done to the satisfaction of the Engineer with material approved by the Engineer.

Beneath load bearing structures, foundations and other reinforced concrete work, the filling of any over-excavation or overbreak shall be of the same quality concrete as that required for the associated concrete structure unless the Engineer permits leaner concrete.

For the excavations to be covered by concrete, the tolerances shall be as follows:

- for the levels: +0 / -100 mm
- for the horizontal dimensions: +100 mm / -0

For other excavations the following tolerances shall be required unless otherwise shown on the Drawings or directed by the Engineer:

- for the levels: +0 / -100 mm
- for the horizontal dimensions: +100 mm / -0

2. PRODUCTS

Not applicable.

3. EXECUTION

3.1. INSPECTION

Topographical survey before works

Before the commencement of any excavations or earthworks the sites shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish existing ground levels. These agreed ground levels shall form the basis for the calculation of quantities of any subsequent excavation and/or filling when required.

Topographical survey on completion of excavation works

On completion of each type (common excavation, rock excavation), and section, of excavation work the areas shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish the different volumes excavated.

3.2. GENERAL

The Contractor shall arrange excavation activities with due regard for the safety of the Works and the personnel on site.

Excavated surfaces which will remain permanently exposed shall be finished off in a neat and workmanlike manner and shall be graded to provide adequate drainage.

All necessary precautions shall be taken to preserve the material below and beyond the prescribed lines for excavation in the soundest possible conditions.

Excavations for the Contractor's installations shall be submitted to the approval of the Engineer.

3.3. INVESTIGATIONS

No specific site investigations are required for this contract. However, the Contractor can carry out investigations at his own expenses if he judges it necessary or if required for obtainment of permits (example: excavation permit).

The foregoing notwithstanding the Contractor shall be deemed to have obtained and evaluated all available data and information on site conditions pertaining to the execution of the works under the Contract. If the Contractor deems that such available information is insufficient for the programming and execution of the Works under the Contract, he shall carry such additional investigations and/or testing as he deems necessary at his own expense and risk. The costs of any such additional investigations and testing shall be deemed to be included in the unit rates and prices, or lump sums, in the priced Price Schedule

Investigations carried out by the Contractor at his own expense and risk, and potentially affecting the time for commencement or completion of the works shall be subject to approval by the Engineer.

3.4. SUPPORT AND PROTECTION

All temporary slopes shall be made safe and protected if necessary. Protection measures shall include temporary supports including shoring, sheeting and bracing where necessary; the diversion of water and the provision and maintenance of such protection.

During the works, the Contractor must ensure that the dumping of excavated material and the circulation of machines do not cause landslips.

3.5. COMMON EXCAVATION

Common material shall be excavated to existing rock level or to the lines, levels and grades shown on the Drawings or as required by the Engineer. Excavation for any structure or other permanent works shall include excavation necessary to ensure the stability of slopes associated with such structure or works.

Where the excavation is provided to accommodate structures, such excavation shall allow for the proper placing and bracing of required formwork.

If at any point in excavation the natural foundation material is disturbed or loosened during the excavation process or otherwise, it shall be compacted in place or where directed by the Engineer it shall be removed and replaced with approved suitable material, placed and compacted as directed by the Engineer for the preparation of the structure or embankment foundation as required, and at the expense of the Contractor.

3.6. ROCK EXCAVATION

Rock excavation shall be performed with heavy percussion tools complete with rock bits, or by hydraulic wedges, blasting or other specific methods for rock excavation.

Except as may be specifically approved by the Employer or the Engineer in writing, the Contractor shall not use explosives in the execution of any of the works under the Contract.

When required by the Engineer, concrete structure foundation shall be finished using hand tools for the last 25 cm.

3.7. EXCAVATION IN BORROW AREAS

1. At least two weeks before any borrow area is opened the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit the area until the Engineer has given his approval.
2. All material obtained from borrow areas for use in the permanent works shall be tested by the Contractor and approved by the Engineer.
3. At any time during the exploitation of a borrow area, the Engineer may withdraw approval for the continued utilization of that borrow area.

3.8. EXCAVATION IN QUARRIES

1. At least two weeks before a quarry is opened, the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit it until the Engineer has given his approval.
2. All materials from quarries for use in the permanent works shall be tested by the Contractor as described in these specifications and approved by the Engineer.

3.9. TRENCH EXCAVATIONS

Trenches must be sufficiently wide at all points to lay pipes or ducts and carry out backfilling operations around them. Unless otherwise shown on the Drawings or directed or approved by the Engineer, the bottom width of the trench in metres shall not be less than:

- $1.2 D + 0.70$ for one pipe, and

- $n (D+0.50) + 0.70$ for n pipes of the same type for same network in one trench

in which D = outer diameter of the pipe in metres.

[Note Laying of pipes for different types of network (e.g. stormwater, water supply, etc.) in the same trench will not be permitted.]

- $3 \times n \times D$ for one or more ducts

in which n = number of ducts and D = widest outer diameter of the ducts in metres.

The bottom of the trenches shall be excavated to and levelled at least 0.10 m below the level planned for the outer invert of the pipes. If there are any rocks projecting above this level, they shall be completely excavated and the corresponding cavities filled in if necessary.

Trenches for welded steel pipes shall include recesses for joints. These recesses shall be at least 1 m wide on either side of the trench edge.

The normal depth of the trenches shall be such that the thickness of fill above the outer soffit of the pipe shall not be less than 0.80 m.

The Contractor shall take all necessary measures to avoid cave-ins and ensure safety for staff, if necessary by sloping, shoring, planking or reinforcing the sides of the excavation using all means suited to the nature of the soil and as approved by the Engineer.

All trench excavation for installation of pipework (or other work) of depths greater than 1.5 metres must be continuously supervised by a suitably qualified officer.

Excavated material shall not be deposited less than 3 m from the edge of any trench.

The Contractor shall excavate trenches in such a way that, where required, the pipes installed by the Contractor can be connected to existing pipes previously installed by the Owner.

3.10. DISPOSAL OF EXCAVATED MATERIALS

All excavated materials shall remain the property of the Employer and shall not be used in the works or disposed of without the prior approval of the Engineer.

Excavated material shall be stockpiled or disposed of in disposal areas within the Site as indicated on the Drawings or directed by the Engineer regardless of distance.

Disposal areas shall be well drained and left in tidy, safe and stable conditions.

In-so-far as they may be suitable and comply with the Specifications, materials arising from required excavations shall be used in the Works.

All surplus or unsuitable excavated materials shall be disposed to spoil banks at locations shown on the Drawings or approved by the Engineer subject to the following conditions:

- ☐ all necessary measures shall be taken not to obstruct natural drainage courses with the spoil banks;
- ☐ suitable slopes shall be given to the surface to ensure drainage;
- ☐ maximum heights shall be as determined by the Engineer.

3.11. PREPARATION OF EXCAVATED SURFACES

1. Common excavations for foundations

The surface shall be cleaned of all loose material.

The foundation shall be compacted if necessary to a depth of 0.20 m to a minimum dry density of 95% of the Maximum Dry Density according to the standard proctor test (NF P 94 093).

For foundation on gravel materials, the in situ foundation material to depth 0.20 m shall be compacted in such a manner as to achieve a uniform density throughout of 80% of the relative density.

The surface shall be free from standing or running water.

Where the ground surface under any compacted embankment or structure is not suitable, as determined by the Engineer, after the required excavation or removal of top soil, the Contractor shall further remove the unsuitable material to such depth and in such area as may be directed.

The foundation just after compaction shall receive a layer of blinding concrete.

2. Rock excavations for foundations

After completion of the excavations and other required works, the following operations shall be carried out where relevant.

A first cleaning shall be carried out to allow a geological examination of the foundation surface and to define possible treatment if required.

Any degraded or weathered material located beyond the theoretical excavation lines shall be removed. This includes materials in cracks, seams, faults and cavities, which shall be removed by using hand tools or compressed air water jet to a depth where sound materials is encountered or until the depth cleaned out is at least four times the width of the surface opening.

Rock surfaces shall be thoroughly cleaned by the use of high pressure water air jet. Brushing shall be employed if appropriate and required by the Engineer.

After having been cleaned out, cracks, seams, faults cavities, trenches or pits in rock surfaces shall be filled with concrete, or cement slurry as required or agreed by the Engineer.

After acceptance by the Engineer, a final cleaning of rock surfaces in foundations to structures shall be made not more than 24 hours before concreting and the rock shall be kept wet and protected from the sun up to the time of placement of blinding concrete or structural concrete as the case may be.

3.12. POSSIBLE DMOLITION OF BURIED STRUCTURES.

If masonry or concrete structures are encountered during excavation works, the Contractor shall first inform the Engineer then proceed with the demolition, removal, transport and disposal of the materials as approved by the Engineer. Unless otherwise approved or directed by the Engineer, such material shall be treated as rock for purposes of payment and the required works shall not give the Contractor right to any additional payments.

3.13. RESTORATION OF BORROW AREAS AND QUARRIES

At the end of works, all borrow areas and quarries shall be left in safe conditions as approved by the Engineer.

The surface of borrow areas shall be left in a reasonably smooth and even condition as approved by the Engineer.

Borrow areas shall be drained by the means of open ditches where necessary to prevent the accumulation of standing water.

3.14. SPECIAL REQUIREMENTS

1. Bottom of excavation

Any local pockets of materials that are more compressible than the bottom of the excavation in general shall be removed and replaced by similar material compacted to similar compressibility to that of the sound earth at the same depth.

In particular, before blinding concrete is placed, the bottom of excavations must be carefully inspected in order to check the quality of the foundation.

2. Excavations at the foot of slopes

Care must be taken when excavating at the foot of slopes so as to avoid causing any instability or movement of the slope.

3. Acceptance of excavations for structures

A band of at least 0.80m in width outside the specified limits shall be provided for formworks in excavations for structures.

In the case of foundations to structures the Contractor shall supply the Engineer with:

- working drawings for the excavations and associated earthworks in conformity with the approved design Drawings including tolerances in compliance with Clause 1.7 of this Section,
- bearing capacity checked by plate bearing tests (1 test for 250m² of excavation), EV1 and EV2 being the deformation moduli according to the procedure of LCPC-CT2: $EV2/EV1 < 2$ with $EV2 > 50$ MPa, Westergaard's modulus: $K > 50$ MPa/m.

3.15. KEEPING EXCAVATIONS DRY DURING WORKS

1. General

Except for any special dispensations which might be granted by the Engineer, the Contractor shall protect the excavations from water, at his own expense, so that the works can be performed in dry conditions.

The method used to drain water from the excavation shall be the responsibility of the Contractor and shall be submitted for the Engineer's approval, including, where requested by the Engineer, the recommendations of a geotechnical specialist where the stability of the ground may be involved.

2. Runoff outside the site

The crest of the excavations shall be surrounded by surface interception drains to collect runoff outside the excavation and evacuate it at a suitable distance from the excavations.

3. Water from the walls and bottom of excavations

Any seepage from the walls and bottom of excavations shall be blocked off or intercepted and diverted at the source. The measures used for this purpose shall not cause soil erosion or subsidence.

During the works, the Contractor must ensure that the dumping of excavated material and the circulation of machines do not cause landslips.

4. Water collection and pump sumps

If, because of the site layout, water in the excavations cannot be evacuated by gravity, the water shall be collected in a sump from which it can be pumped. The Contractor shall take all the necessary precautions to prevent wash out of fines.

5. Dewatering or water table drawdown

The Contractor shall take all necessary precautions so as to avoid effects of water table drawdown on existing structures and excavations (stability, wash out of fines, etc.).

Before any operation involving water table drawdown, the Contractor shall submit to the Engineer calculations and notes related to the dewatering measures as established by a

geotechnical specialist, as well as the precautionary measures taken for the existing structures.

oOo

SECTION 02220

EMBANKMENTS, FILLS AND BACKFILLS

1. GENERAL

1.1. WORK INCLUDED

This section covers all operations in connection with:

1. Backfill around all structures.
2. All embankments
3. Road embankments.
4. Backfill of trenches.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

1. Fills and backfills works as specified under this Section shall include filling or backfilling with materials approved by the Engineer and built up in horizontal layers, the thickness of which shall be determined according to trials carried out by the Contractor before the beginning of any filling work.

1.4. REFERENCES

1. BS 1377:1990 Methods of test for soils for civil engineering purposes
2. ASTM: American Society for Testing and Materials.
3. USBR: Earth Manual of "Bureau of Reclamation"
US Department of the Interior.

1.5. SUBMITTALS

1. A mass haul diagram shall be submitted to the Engineer in the form and following the description given in Section 02210 "Open air excavations".

This mass haul diagram shall be drafted and submitted together with the general mass haul diagram of Section 02210.

2. At least one month before starting the filling operations, the Contractor shall submit a complete programme showing the proposed filling program including quantities and origin of materials.
3. At least one month before starting the filling operations, the Contractor shall submit to the Engineer a detailed method statement covering the filling operations and material placement.
4. On a weekly basis, the Contractor shall submit to the Engineer summary sheets giving the results of all controls performed during the week on a format to be agreed with the Engineer.
5. The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work for all fill work including:
 - a) quantities of materials placed with their type,
 - b) location of the material placed,
 - c) number and classification of men and plants engaged,
 - d) weather during the day,
 - e) inflows of water or any other unusual occurrence.

1.6. TOLERANCES

1. All fill and backfill shall be constructed to the lines and dimensions shown on the Drawings or as required by the Engineer.
2. For compacted fill and backfill, the following tolerances shall be required unless otherwise shown on the Drawings or ordered by the Engineer:
 - level (vertical) = ... +0, -5 cm,
 - dimension (horizontal) = ... +15, -0 cm (on the dimension of fill).

1.7. CONTROLS

1. All the controls required in the present Specification shall be performed in the Contractor's laboratory or in a laboratory he will have chosen with the agreement of the Engineer.

2. PRODUCT

2.1. GENERAL

1. Fill and backfill materials shall be derived as much as possible, from required excavations for permanent works to be constructed under the Contract, or from designated on-site borrow areas and quarries, subject to their compliance with the relevant Specifications and approval of the Engineer. Where quantities are insufficient or available materials do not

comply with the Specifications materials shall be obtained by the Contractor from external sources approved by the Engineer.

2. All fill and backfill materials shall be “well graded” in terms of particle size distribution in accordance with the relevant EN, BS, ASTM, USC classification systems.
3. All materials as specified hereinafter shall be subject to the prior approval of the Engineer

2.2. SELECTED COMPACTED FILL

The material shall comply with the following requirements:

- D max = 100 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm standard sieve (square openings) between 5 and 15%.
- Plasticity index IP ≤ 15.

2.3. GRAVEL 20-40 MM

The material shall comply with the following requirements:

- D maxi = 40 mm.
- D min = 20 mm.
- Organic matter content < 0.1%.

2.4. GRAVEL 50-100 MM

The material shall comply with the following requirements:

- D maxi = 100 mm.
- D min = 50 mm.
- Organic matter content < 0.1%.

2.5. SELECTED COMPACTED ROCKFILL

The material shall comply with the following requirements:

- D max = 200 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm standard sieve (square openings) between 0 and 5%.

2.6. RANDOM COMPACTED FILL

The material shall comply with the following requirements:

- D max = 800 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm standard sieve (square openings) between 0 and 5%.
- Maximum particle size of the top layer of embankment shall be 250mm.

2.7. SMALL FILL

The material shall comply with the following requirements:

- D max = 20 mm.
- Gypsum content < 2%.
- CBR test (at 95% of modified Proctor test): > 80.
- Sand equivalent: $40 < SE < 60$.

2.8. SAND LAYER

The material shall comply with the following requirements:

- D max = 4 mm.
- Fraction passing 0.074 mm standard sieve (square openings): $\leq 5\%$.
- Plasticity index: < 6.

3. EXECUTION

3.1. INSPECTION

Before the commencement of any fill works the site shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish a record of existing prepared and/or excavated ground levels and these agreed ground levels shall, when required, form the basis for the calculation of quantities of any subsequent filling.

No fill shall be placed in any section of the Works until the foundation has been inspected and approved by the Engineer.

Placing of any fill layer shall not be done until the preceding layer has been inspected and accepted by the Engineer.

3.2. GENERAL

All fill and backfill operations shall be performed in the dry.

Prior to the commencement of placing backfill materials adjacent to structures, the backfill areas shall be cleared of all remaining concrete forms, other temporary works and unsuitable materials, and shall be subject to the approval of the Engineer.

The backfill materials shall be placed in such manner as to ensure that they can be satisfactorily compacted without damage to the structure.

The sequence of filling behind or around a structure and the maximum difference in height at any time between fill levels shall be approved by the Engineer.

Filling around structure is permitted only if the structure is completely achieved, or if the unachieved part is not necessary to handle earth pressure. In all cases, approbation of the Engineer is required before filling around any structure.

Filling around liquid retaining structure shall begin only after validation of watertightness tests.

Sheeting and timbering supporting the excavations shall be removed, step by step, to prevent any settlement.

Where instructed by the Engineer, timbering and sheeting shall be left in place.

Unless otherwise directed by the Engineer, backfill material shall not be placed and compaction shall not be permitted adjacent to concrete for 14 days after the placing of concrete, and compaction of backfill material placed above buried concrete shall not be permitted to be carried out with vibrating rollers within 100 cm vertically of the surface of the concrete.

Where instructed, selected granular fill material approved by the Engineer shall be placed around the structure.

A special care shall be given to compaction along concrete structures and at all locations where easy access is not possible. At these locations all the required criteria for each type of fill shall be fulfilled.

3.3. SELECTED COMPACTED FILL

1. Placing and compaction

Selected compacted fill shall be placed in layers not exceeding 250 mm and at least 1.5 time D_{maximum} .

Each layer shall be compacted by means of a vibrating smooth drum roller or vibrating plate so as to achieve a dry density:

$$DC = \frac{\gamma_d}{\gamma_{d_{\text{max}}}} \geq 95\%$$

with:

γ_d = field dry density;

$\gamma_{d_{\text{max}}}$ = Standard Proctor maximum dry density in accordance with ASTM D698.

2. Placement moisture content of the material shall be so that:

$$-2 < w - w_{\text{opt}} < +2$$

with:

w: placement moisture content measured on the compacted layer;

w_{opt} : optimum moisture content of the Standard Proctor compaction test in accordance with ASTM D698.

3. Test Pad

Prior to the commencement of Contract Earthworks on site, the Contractor shall propose a methodology for the Compaction of soils in accordance with the requirements of this Specification, for approval by the Engineer.

The Contractor shall demonstrate their methodology consistently achieves the requirements of the Specification by constructing a number of test pads (minimum 20m dimension) and recording the layer thickness, any required drying or moisture conditioning, applicable construction plant (eg 10t vibrating sheeps foot roller) and required number of passes.

The Contractor shall undertake in situ field density tests (and permeability tests as appropriate) in accordance with the testing requirements of this Specification, sufficient to satisfy the Engineer that the required material parameters are achieved.

4. Control

Two controls shall be made on the first layer placed in order to determine the suitability of the equipment used and the number of passes.

If changes occur in the nature or the origin of the fill material used during the works or at the request of the Engineer, new tests shall be performed.

A minimum of one control every 250m³ of material placed shall be performed.

Final acceptance of materials shall only be made after they have been placed, spread and compacted.

3.4. BACKFILLING OF TRENCHES

1. General

Every section of the pipeline shall be covered as soon as possible after being lowered into the trench, but no section of the line shall be covered without pipe surveying and express approval of the Engineer.

Each section shall be backfilled after the pipe has been placed in its final position in the trench and after all welded joints and bends have been coated and all defects in the pipe coating repaired.

Backfilling shall be done carefully to prevent displacement of the pipes or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench sides, without leaving any voids.

Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil. Stones removed during trench excavation may be used in the second stage of backfilling as specified herein.

On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench.

2. Sand layer placement

In all cases and for all types of pipe, a “Sand layer” as described hereinbefore of at least 10cm in thickness shall be laid under the pipe.

3. Small fill placement

The backfill around and up to 40cm above the pipes shall be in accordance with “Small fill” materials as described hereinbefore, placed, compacted and controlled as described in paragraph 3.3.

4. Selected compacted fill placement

Above the “small fill” layer and except otherwise shown on drawings or directed by the Engineer, trenches shall be backfilled using “Selected compacted fill” materials as described hereinbefore, placed, compacted and controlled as described in paragraph 3.3.

SECTION 02232

ROADS

1. GENERAL

1.1. WORK INCLUDED

Roads and related works inside the project boundaries.

The Contractor shall be responsible of the design, the construction, the maintenance and reinstatement of the various access roads to the Site Works.

The Contractor shall in consequence take all necessary arrangements to build the access roads in accordance with local Standards and Regulations.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. STANDARDS AND REGULATIONS

AASHTO	Standard Specifications for Highway Bridges
BS 434 Part 1	Bitumen road emulsions
BS 594	Hot rolled asphalt for roads and other paved areas
BS 598	Sampling and examination of bituminous mixtures for roads and other paved areas
BS 812	Testing aggregates
BS 1377	Methods of test for soils for civil engineering purposes.
BS 4987	Coated macadam for roads and other paved areas
NF P 18561	Aggregates – Measurement of the flakiness index
ASTM Standards as referenced throughout this Section	

1.4. SUBMITTALS

All documents concerning the quality of materials and all the results of routine tests prescribed in the present Section shall be submitted to the Engineer, at the frequency and on the form agreed at the start of the Works.

1.5. TOLERANCES

The surface at each stage during the construction of the roads shall comply with the requirements set out below.

« Specified level » shall be the level shown on the Drawings, or deduced by reference to the finished road level and minimum layer thicknesses.

« Smoothness » shall be measured as the maximum gap beneath a 3.0 m long straight-edge used longitudinally or beneath a template, to suit the specified camber shape of the road, used transversely.

Surface	Tolerance from specified level (mm)	Smoothness (mm)
Sub-grade (formation)	+0 to -25	-
Sub-base course	+0 to -25	-
Base course	+5 to -10	10
Wearing course	+5 to -5	5

In addition, the wearing course shall have no backfall from any drainage point.

Immediately before the construction of any layer, the surface on which it is to be laid shall be tested for accuracy of formation and smoothness, and if any areas are found to be outside the specified tolerances such areas shall be scarified, reshaped, recompact, broken out and replaced, or otherwise treated until the specified smoothness and accuracy are obtained.

Notwithstanding the above requirements, no layer of road construction shall have a thickness less than the thickness shown on Drawings.

2. PRODUCTS

2.1. GENERAL

Fill and backfill shall come, as much as possible, from excavations of nearby structures.

All the hereafter materials shall have the prior agreement of the Engineer.

2.2. GENERAL FILL

The material shall comply with the following requirements:

- Maximum diameter: 200 mm
- Fraction passing 0.074 mm sieve (square opening) $\leq 15\%$
- Plasticity index ≤ 15
- Organic matter content $< 0.1\%$

2.3. SUB-BASE COURSE

It shall be approved material reasonably “well graded” in terms of particle size distribution, complying with the following requirements:

- Maximum diameter: 50 mm.
- Plasticity Index: ≤ 15 .
- Californian Bearing Ratio $\geq 25\%$ at 95% of Proctor optimum density.
- Los Angeles Abrasion Test of mineral aggregates $\geq 2.36\text{mm}$ (BS sieve):..... ≤ 30 .
- Organic matter content $\leq 0.1\%$.

2.4. BASE COURSE

Base course material may be either naturally occurring sound hard gravels or crushed rock obtained from quarries.

The material shall comply with the following grading requirements:

Material size (in millimetres) (square openings)	Per cent finer by weight
20	100
10	50 - 80
5	30 - 60
2	20 - 40
0.2	5 - 20
0.075	2 - 15

In addition, the material shall meet the following test requirements:

- Dry density: $\geq 17.5 \text{ kN/m}^3$.
- Plasticity Index: $6 \leq IP \leq 15$.
- California Bearing Ratio: $\geq 80\%$ at 95% of Proctor optimum density.
- Los Angeles Abrasion Test: ≤ 30 .
- Organic matter content:..... $< 0.1\%$.

Where graded crushed stones are used, the following requirements shall be added:

- Flakiness index (BS EN 933-3:2012) ≤ 30 .

2.5. AGGREGATES FOR READY MIX ASPHALT-CONCRETE WEARING COURSE

The aggregate shall be of crushed gravel conforming to the following gradation:

Sieve size	Per cent passing
25.0 mm	100
20.0 mm	85 - 100
5.0 mm	45 - 65
2.5 mm	30 - 50
315 microns	12 - 23
80 microns	4 - 8

The portion of the total aggregate passing the 400 micron sieve shall have a plasticity index of not more than 6.

2.6. MINERAL FILLER

Mineral filler when separately supplied from an external source shall consist of finely ground mineral matter such as rock dust, hydrated lime, cement or other material which can satisfy the Engineer will produce asphalt mixes of at least equal quality. It shall be free from organic substances and clay, shall be thoroughly dry and free from agglomerations, shall be non-plastic and shall meet the following grading requirements:

<u>BS Sieve (mm)</u>	<u>% Mass Passing</u>
0.600	100
0.300	95-100
0.150	90-100
0.075	70-100

Hydrated lime shall conform to the definitions given in ASTM C51. Sampling, packaging and marking of hydrated lime shall be in accordance with ASTM C50. Storage and use of the hydrated lime shall at all times be such as to protect the material from the weather.

When cement is used as mineral filler, it shall meet the requirements of BS 12.

2.7. BITUMEN

The bitumen specified for use in the asphalt mixes shall be 60-70 penetration grade in accordance with BS 3690 and shall only be obtained from approved sources.

The bitumen shall be prepared by the refining of petroleum. It shall be uniform in character and shall not foam when heated to 175°C. Blending of bitumen materials from different refineries will be permitted only with the written approval of the Engineer.

2.8. TACK COAT

Emulsified asphalt for use in asphalt works shall comply with BS 434: Part 1 class K1-40.

Alternatively emulsified asphalt for use in asphalt works may be CSS-lh or CRS-2 cationic emulsified asphalt in accordance with AASHTO M 208 or SS-lh anionic emulsified asphalt in accordance with AASHTO M 140 unless otherwise designated.

Emulsified asphalt shall be of the slow-setting cationic or anionic type of the CSS-lh or SS-lh grades respectively and shall conform to the designated requirements.

2.9. CONTROLS

The frequency of the tests shall be as required by the Engineer according to the results of previous tests and material variations.

3. EXECUTION

3.1. INSPECTION

No excavation and fill operations shall start without prior agreement of the Engineer.

3.2. GENERAL

All excavation and fill operations shall be performed in accordance with Sections 02210 and 02220 of the Technical Specifications.

3.3. SUB-GRADE PREPARATION

Prior to receiving the base course or sub-base course, the sub-grade shall be graded to the lines and levels shown in the Contractor's approved drawings and the surface shaped to the same profile as the finished surface of the road.

Once the required level is obtained, the sub-grade material shall be compacted to a depth of 300 mm minimum, up to a minimum of 95% of the Maximum Dry Density in accordance with ASTM D698.

Compaction shall be achieved by means of a smooth drum vibrating roller with the following minimum characteristics:

- Minimum static weight 8t
- Drum diameter not less than 1500 mm
- Minimum static weight per metre of drum 3.5t

The number of passes shall be adapted to the material.

- All soft areas shall be cut out and filled with approved material brought to the correct level after compaction.
- The Contractor shall perform all relevant tests in order to prove that compaction depth can be reached as required.

3.4. SUB-BASE COURSE

The sub-base course shall be of a total thickness not less than 300mm in every point.

The sub-base course material shall be spread longitudinally in uniform layers not exceeding 150 mm loose thickness.

Each layer shall be compacted to the following standards:

- a. Dry density:

$$DC = \frac{\gamma_d}{\gamma_{d_{\max}}} \geq 95\%$$

with:

γ_d = field dry density

γ_{dmax} = Standard Proctor maximum dry density in accordance with ASTM D698.

b. Placement moisture content:

$$-2 \leq w - w_{opt} \leq 2$$

with:

w : placement moisture content measured on the compacted layer;

w_{opt} : optimum moisture content of the Standard Proctor compaction test in accordance with ASTM D698.

CBR $\geq$ 25% shall be achieved for the sub-base course to be approved.

3.5. BASE COURSE

The sub-base course shall be of a total thickness not less than 200mm in every point.

The Contractor may propose to add cement to the base course material, in order to:

- reduce moisture content of the material;
- improve the characteristics of the base course and thus diminish the quantities used and/or diminish the maintenance.

The base course material shall be spread longitudinally in uniform layers not exceeding 200 mm loose thickness.

Each layer shall be compacted to the following standards:

a. Dry density:

with:

γ_d = field dry density

γ_{dmax} = Standard Proctor maximum dry density in accordance with ASTM D698

b. Placement moisture content:

$$-2 \leq w - w_{opt} \leq 2$$

with:

w : placement moisture content measured on the compacted layer;

w_{opt} : optimum moisture content of the Standard Proctor compaction test in accordance with ASTM D698.

CBR $\geq$ 80% shall be achieved for the base course to be approved.

3.6. TACK COAT

a. General

This work shall consist of furnishing and applying diluted emulsified asphalt to the previously prepared road base surface, to provide bond for the superimposed wearing course to the full designated width.

Tack coat shall not be applied during rain, fog, dust storms or other unsuitable weather, unless otherwise directed by the Engineer.

Tack coat shall not be applied when the air temperature at the surface on which it is laid is below 10 °C, nor when the wind speed at any temperature exceeds 40 km/h at 2m height unless specifically approved by the engineer.

b. Equipment Required

The equipment used by the Contractor shall include a pressure type asphalt distributor as well as a power broom and a power blower. In addition, the Contractor shall supply and use efficient and approved equipment for diluting the emulsified asphalt with water.

c. Surface Preparation

The full width of the surface to be treated shall be cleaned with a power broom or power blower to remove dust, dirt or other objectionable materials. All faulty or unsuitable patches, excess cracks or joint filler and all surplus bituminous material shall be corrected in accordance with the instructions of the Engineer. The surface shall be dry when treated.

d. Application

Immediately after cleaning the surface, the tack coat shall be applied by means of the distributor in accordance with the respective specification, or as directed by the engineer.

Hand spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

The diluted emulsion shall be applied at a rate between 0.15 to 0.38 kg/m² as specified by the Engineer. The Contractor shall ensure that excessive application of tack coat is avoided.

The application temperature for the diluted emulsified asphalt shall be between 10 °C and 60 °C as directed by the Engineer.

The surface of structures, kerbstones and other fixed objects adjacent to areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

e. Maintenance and Traffic

After application, the surface shall be allowed to dry until it is in a proper condition of tackiness to receive the superimposed wearing course. Tack coat shall be applied only so far in advance of the superimposed course placement as is necessary to obtain this proper condition of tackiness.

Until the superimposed course is placed, the Contractor shall protect the tack coat from damage.

If the tack coat is unavoidably damaged by rain or dust, it shall be allowed to dry, shall be cleaned again by a power broom or power blower and, if required by the Engineer, a

subsequent light application of tack applied to the surface. Where, in the opinion of the Engineer, a tack coat is not necessary between layers of freshly placed courses, he may give instructions in writing to omit the tack coat. Any cleaning required in these areas shall be carried out before the application of the next course.

3.7. ASPHALT-CONCRETE ROADS

Where shown on Drawings or as directed by the Engineer, the roads and platforms shall be built according to the drawings and the following specifications:

1. A 60 mm wearing course shall be made of a ready mix asphalt-concrete spread with a grader or finisher and then compacted; the wearing course shall have the following characteristics:
 - a) Aggregates as specified in section 2.
 - b) Content of asphalt of penetration grade 60/70 (in accordance with ASTM D946) shall be between 4 and 6 percent.
 - c) Marshall Stability test (ASTM D1559) shall not be less than 10 kilonewtons and the flow value less than 4 mm.
 - d) Degree of compaction not less than 97 percent of the Standard Specimen Specific Gravity (ASTM D1074).

3.7.1. HAULING EQUIPMENT

Vehicles used for the transport of aggregates or bituminous mix shall have tight, clean and smooth insulated metal beds and shall be free from dust, screenings, petroleum oil and volatile or other mineral spirits which may affect the material being hauled. The vehicle metal bed shall, if required, be sprayed with a minimum amount of soapy water or lime solution to prevent the bituminous mix from adhering to the bed. After spraying, the truck shall be raised and thoroughly drained and no excess solution shall be permitted. Use of diesel or other solvents to spray in the truck bed is prohibited.

Provision shall be made for covering truck loads with canvas or other suitable material of such size that the bituminous mix is fully covered.

Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall, upon the instruction of the Engineer, be removed from the work until such faults are corrected.

End dump trucks shall be equipped with chains on the tail gates for control when dumping the mix into the paving machine. Hauling trucks shall not be routed over wet or muddy access ways such that tyres accumulate dirt that is deposited on the laying surface.

The Contractor shall provide an adequate number of trucks of such size, speed and condition to ensure orderly and continuous progress of the work all to the approval of the Engineer.

3.7.2. OTHER EQUIPMENT

a. Spreading and Finishing Equipment

The asphaltic mixture shall be fed to the paver by end tipping of the truck or by means of a windrow elevator. The equipment for spreading and finishing the asphaltic mixtures shall be of an approved mechanical, self-powered electronic controlled floating screed type, capable of spreading and finishing the mixture true to line, grade and required crown.

The pavers shall be self propelled and equipped with hoppers and distributing screws of the reversing type to place the mixture uniformly in front of adjustable electronic controlled screeds. The pavers shall be so designed to allow a minimum paving width of 2 m, although paving in widths of less than 3 m will require the approval of the Engineer.

Pavers shall be equipped with such provisions and attachments to suit paving widths specified for road widening as well as to suit paving on sloped sections. They shall be equipped with fast and efficient steering devices and shall have reverse as well as forward travelling speeds. The operational speed of the pavers shall be adjustable from 3 to 6 m/min in accordance with the instructions of the Engineer.

The pavers shall employ mechanical devices as equalising runners, straight edge runners, eveners or other compensating devices to maintain trueness of grade and to confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be designed and operated in such a manner that it will place the material at the required compacted thickness.

Electronic screeds shall include automatic feed controls to maintain a constant level of material along the full length of the screed, automatic grade control and automatic slope control. The grade controller shall be activated by a travelling, articulated averaging beam not less than 9 m in length. The automatic slope control shall be equipped with a proportioning manual override to enable smooth transition of changing slope rate. Automatic screed controls shall be approved by the Engineer before use.

Screeds shall be provided with devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring. Pavers shall also be provided with the standard attachable screed extensions. All screeds shall be of the vibrating type that permit material to be tamped into position.

The term "screed" includes any cutting, crowning or other physical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor.

b. Rolling Equipment

Rolling equipment shall consist of vibratory steel-wheeled rollers, dead weight steel-wheeled rollers and pneumatic-tyred rollers as required for proper compaction and finishing of the asphalt surface. Unless otherwise permitted, rollers shall be equipped with reversible or dual controls to allow operation both forward and backward with the operator always facing in the direction of movement.

Steel-wheeled rollers shall be two-axle tandem rollers or three-axle tandem rollers. These rollers shall be self-propelled and equipped with power units of not less than four cylinders and under working conditions shall develop contact pressures under the compression wheels of 45 to 65 kg/cm of width. Each two-axle roller shall have a minimum weight of 10,000 kg each and three-axle roller shall have a minimum weight of 13,000 kg. Vibrating steel-wheeled rollers shall have dual drums with a minimum weight of 7000 kg. Vibrating frequency shall be between 2000 and 3000 cycles per minute with individual controls for each tandem drum. Rollers shall be in good working condition and shall be equipped with a reversing clutch. Rollers shall be equipped with adjustable scrapers to keep the wheel surface clean and with efficient means of keeping them wet to prevent mixes from sticking. These surfaces shall have no flat areas or projections which will mark the surface of the asphalt courses. The three-axle rollers shall be equipped with a centre axle which may be operated either fixed or floating. The three-axle tandem roller shall be so constructed that when locked in a position for all treads to be in one plane, the roller wheels are held with such rigidity that, if either front or centre wheel is unsupported the other two wheels will not vary from the plane by more than 6 mm. All steel-wheeled rollers shall be in good condition and the Contractor shall furnish to the Engineer the manufacturer's technical data for each roller and no roller shall be used except after approval of the Engineer.

Pneumatic-tyred rollers shall be self-propelled. The rollers shall be equipped with pneumatic tyres of equal size and diameter which are capable of exerting varying average contact pressure. Pneumatic-tyred rollers shall be in good condition and with enough ballast space to provide uniform wheel loading as may be required. The Contractor shall furnish to the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tyre inflation pressures and for the full range of tyre loading for each type and size compactor tyre furnished and used in pneumatic-tyred rollers. The total operating weight and tyre pressure may be varied by the order of the Engineer to obtain contact pressures which will result in the required asphalt course density.

c. Liquid Bitumen Distributor

The liquid bitumen distributor truck shall be of the pressure type with insulated tanks. The use of gravity distributors will not be permitted. The distributor shall have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 100 kg/cm tyre width.

Spray bars shall have a minimum length of 2.4 m and shall be of the full circulating type. Spray bar extensions shall also be of the full circulating type. The spray bar shall be adjustable to maintain a constant height above the surface to be treated.

The spray bar nozzles shall be slotted and shall be of such design so as to provide a uniform unbroken spread of bituminous material on the surface. The valves shall be operated by levers so that one or all valves may be quickly opened or closed in one operation. The distributor shall be equipped with a hose and nozzle attachment to be used for spotting areas inaccessible to the distributor. The distributor and booster tanks shall be so maintained at all times as to prevent dripping of bituminous material from any part of the equipment.

The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous material being applied and with a tachometer of the auxiliary wheel type reading speed in m/min. The spreading equipment shall be provided with a separate power unit for the pump or a variable displacement pump driven by a hydrostatic transmission so that a uniform application of bituminous material, in controlled amounts, may be made ranging from 0.15 to 5.0 kg/m². The distributor shall have satisfactory heating equipment and thermometers in order to provide the full range of application temperatures for the bituminous material being used.

Before commencing the work and as required by the Engineer, the liquid bitumen distributor shall be checked and calibrated such that the rate of transverse spread or longitudinal spread shall not vary more than 10 % from the required rate of application.

3.7.3. PRODUCTION OF ASPHALTIC CONCRETE WEARING COURSES

a. Weather Limitations

Production and spreading of asphaltic Concrete mix shall not be permitted when the ambient temperature is less than 8 °C, nor during rain, fog, dust-storms or other unsuitable weather.

b. Equipment Required

The equipment required for construction of the asphaltic concrete courses shall include but not be limited to the equipment mentioned in Clauses hereinbefore, together with such miscellaneous equipment and tools as required for the satisfactory preparation and performance of the work.

All equipment shall be checked, calibrated and approved by the Engineer before use. The equipment shall be satisfactorily maintained and shall be used in an approved manner.

Adequate equipment and labour shall be used so that there is continual production and distribution of the asphalt course being constructed.

c. Survey and Preparation

The area to be paved shall be true to line and grade and shall have a properly prepared surface before the start of paving operations.

When an asphaltic concrete pavement course is to be placed on top of an existing pavement, the existing pavement surface shall be prepared as designated by the Engineer.

Priming or tacking of surfaces to be paved shall be carried out as designated.

The surface of kerbs, vertical faces of existing pavements and all structures in actual contact with asphalt mixes shall be painted with a thin and complete coating of tack coat as instructed by the Engineer to provide a closely bonded, watertight joint.

All openings or structures in the road for water, drainage and other specified utilities shall be constructed and their positions and levels determined before the start of paving operations.

d. Heating of Bitumen

The 60/70 penetration grade bitumen shall be heated to a temperature of between 150 to 165 degrees centigrade.

Bitumen of other penetration grade shall be heated to yield viscosity's in the range of 150 to 300 centistokes (175 to 150 seconds Saybolt-Furol) when delivered to the mixer, as determined from the Temperature Viscosity Chart of the product used.

Bitumen shall not be used if foaming occurs or shall it be heated above 177 °C at any time.

e. Heating of Mineral Aggregate

When using 60/70 penetration bitumen the materials shall be thoroughly dried and heated so that their temperature is 165 to 180 degrees centigrade.

When using bitumen of other penetration grade the materials shall be thoroughly dried and heated so that their temperature is within ± 8 °C of the temperature needed to satisfy the viscosity requirements of the asphalt cement.

In no case shall the materials be introduced into the pugmill with a temperature, including the 8 °C tolerance permitted, of more than that at which the bitumen has a viscosity of 75 seconds Saybolt-Furol.

The moisture content of the heated and dried materials shall not exceed 1%.

The quantity of materials fed through the drier shall in all cases be held to an amount which can be thoroughly dried and heated within the limits specified.

The heated materials shall be screened into sizes such that they may be combined into a gradation meeting the requirements of the Job Mix Formula and the hot aggregate storage bins shall be such as to minimise segregation and loss of temperature of aggregate.

Hot bins shall be drawn and cleaned of material at the end of each day's operation.

f. Proportioning and Mixing

The heated ingredients together with the mineral filler and bitumen shall be combined in such a manner so as to produce a mixture which complies with the requirements of the Job Mix Formula.

Mineral filler, in a cool dry state, shall be proportioned into the mixer either with the aggregate or after the introduction of the bitumen to avoid loss of fines that may occur in dry mixing as a result of turbulence in the mixer.

In batch type plants a dry mixing period of not less than four seconds shall precede the addition of the bitumen to the mix. Excess wet mixing shall be avoided. Wet mixing shall continue as long as it is necessary to obtain a thoroughly blended mix but shall not exceed 75 seconds nor be less than 30 seconds.

The Contractor shall propose the length of time for both dry and wet mixing for the approval of the Engineer. Approval of the lengths of time for mixing shall not relieve the Contractor of his responsibilities and obligations under the Contract.

Once approved, mixing times shall not be altered unless so ordered or further approved by the Engineer.

3.7.4. DELIVERY, SPREADING AND FINISHING

a. Delivery of Mixes

Sufficient plant capacity, haul vehicles and storage shall be provided so that adequate supplies of mixture are delivered to site to ensure that continuous paving can be achieved.

The dispatching of the hauling vehicles to the job site shall be so scheduled that all material delivered may be placed in daylight, unless the Engineer has approved the use of artificial light. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

All precautions shall be taken to protect the mix from the weather during transit and while waiting to discharge.

Hauling vehicles shall not be permitted to carry out tight turns on the laying surface.

The mixture at delivery to the paver shall be within 14 °C of the Job Mix Formula temperature and above an absolute minimum temperature of 135 °C. Material which has fallen below the minimum temperature of 135 °C before discharge shall be rejected and immediately removed from site. Delivery temperature shall not exceed the maximum temperature specified for mixing at the plant

Should a significant proportion of the mixture delivered to the paver fail to meet this requirement, or should cold lumps be found in the mixture, the Engineer shall order that paving operations be suspended until measures are taken, to the approval of the Engineer, to ensure compliance.

b. Spreading and Finishing

Prior to the commencement of delivery of the mix the Contractor shall erect and maintain an approved reference guide wire for controlling the levels of the laid mix. The reference guide wire shall be supported at intervals of not less than 10m.

The mix shall be laid upon an approved surface and only when weather conditions are suitable and as designated. Upon arrival at the point of use, the asphalt mix shall be spread and struck off to the grade, elevation and cross-section shape intended, either over the entire width or over such partial width as may be required. If the material does not conform to the requirements, it shall not be used and shall be discarded.

The laid material shall be compacted as soon as rolling can be effected without causing undue displacement and while the temperature does not fall below 120 °C. Materials still uncompacted and below this temperature shall be rejected.

The Contractor shall supply accurate calibrated thermometers suitable for measuring the inner and surface temperature of the material. The material temperature shall be checked immediately before rolling and at least every 30 minutes thereafter during forward progress. A record of these temperatures shall be passed to the Engineer at the end of each days work.

While paving is in progress, the output of the batching plant shall be exclusively reserved for the operations and no mixture shall be supplied to other sites or projects.

If during laying, the paver is repeatedly delayed because of lack of mixture or if the paver stands at one location for more than thirty minutes (for any reason), a transverse joint shall be constructed. Paving shall not recommence until the Engineer is satisfied that paving will proceed uninterrupted and until at least four loaded vehicles have arrived at the paving site.

The asphalt course shall be constructed to proposed levels and shall be homogeneous, providing after compaction an even surface free from undulations, rises or depressions and within the tolerances stipulated.

In no case shall construction of a new asphaltic concrete course begin until the previously laid course has been tested and approved.

When the same asphalt course is to be laid in more than one layer the second layer shall be placed as soon as practicable after the first layer has been finished, rolled and cooled, and the Engineer may at his discretion request cleaning of the first layer and the application of a tack coat thereon if he so deems necessary.

Transverse joints in succeeding layers shall be offset at least 2 m. Longitudinal joints shall be offset at least 300 mm.

The use of motor grader or hand spreading of the asphalt mix shall not be permitted except in places where it is impractical to use pavers and shall be only with the specific permission of the Engineer. The asphalt mix shall comply with all conditions regarding trueness of level, thickness, and homogeneity of the mix.

Automatic electronic screed controls shall be required on all pavers and shall be used with a 9 m long articulated averaging beam or grade wire control as approved by the Engineer.

c. Compaction of Mixes

At least three rollers shall be required at all times, one self-propelled pneumatic-tyred and two self-propelled steel-wheeled. As many additional rollers shall be used by the Contractor as necessary to provide specified asphalt course density and surface characteristics in an orderly, efficient and continuous manner.

Before beginning construction of the permanent works, unless otherwise agreed with the Engineer, the Contractor shall carry out compaction trials for each type and thickness of asphaltic course to establish an approved compaction procedure which shall then be used as a minimum requirement for the compaction of the permanent works unless otherwise directed or agreed by the Engineer.

The compaction trials shall involve all procedures specified for the permanent works including testing as specified for the asphaltic course under consideration and any equipment, processes or procedures proposed by the Contractor which are not designated. Construction of the permanent works shall not commence until a compaction procedure has been approved in writing by the Engineer. Such approval shall in no way relieve the Contractor of his responsibilities and obligations stipulated in the Contract.

Immediately after the asphalt mix has been spread and struck off, the surface shall be checked and any irregularities adjusted and then compacted thoroughly and uniformly by rolling.

To prevent adhesion of the mix to steel-wheeled rollers, the wheels shall be kept properly moistened but excess water shall not be permitted.

After the longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides of the road and shall gradually progress towards the centre. On superelevated sections, rolling shall begin on the low side and progress to the high side, overlapping on successive trips by at least one-half the width of tandem rollers and uniformly lapping each proceeding track. The rollers shall move at a slow but uniform speed with the drive wheels nearest the paver. The speed shall not exceed 4-5 km/h for steel-wheeled rollers or 8 km/h for Pneumatic-tyred rollers. The operating speed shall be approved by the Engineer.

The line of rolling shall not be changed suddenly or the direction of rolling reversed suddenly. If rolling causes displacement of the material, the affected areas shall be loosened at once with hand tools and restored to the original grade of the loose material before being rerolled. Heavy equipment or rollers shall not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled.

When paving in a single width, the first lane placed shall be rolled in the following order:

- (a) transverse joints
- (b) longitudinal joints
- (c) outside edge
- (d) initial or breakdown rolling, beginning on the low side and progressing towards the high side second rolling
- (e) finish rolling.

When paving in echelon, 50 mm to 100 mm of the edge which the second paver is following shall be left unrolled. Edges shall not be exposed more than 15 minutes without being rolled. Particular attention shall be given to the construction of the transverse and longitudinal joints in all courses.

d. Transverse Joints

Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be checked with a straightedge to assure smoothness and true alignment. Joints shall be formed with a bulkhead, such as a board, to provide a straight line and vertical face.

If the joint has been distorted by traffic or by other means, it shall be trimmed to line and the face shall be painted with thin coating of emulsified asphalt before the fresh material is placed against it. To obtain thorough compaction of these joints the material placed against the joint shall be tightly pushed against the vertical face with a steel-wheeled roller.

The roller shall be placed on the previously compacted material transversely so that not more than 150 mm of the rear rolling wheel rides on the edge of the joint. The roller shall be operated to pinch and press the mix into place at the transverse joint. The roller shall continue to roll along this line, shifting its position gradually across the joint, in 150 to 200 mm increments, until the joint has been rolled with the entire width of the roller wheel. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

e. Longitudinal Joints

Longitudinal joints shall be rolled directly behind the paving operations. The first lane placed shall be true to line and grade and have a vertical face. The material being placed in the abutting lane shall then be tightly pushed against the face of the previously placed lane. Rolling shall be done with a steel-wheeled roller.

The roller shall be shifted over onto the previously placed lane so that not more than 150 mm of the roller wheel rides on the edges of the newly laid lane. The rollers shall then be operated to pinch and press the fine material gradually across the joint. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

When the abutting lane is not placed in the same day, or the joint is distorted during the day's work by traffic or by other means, the edge of the lane shall be carefully trimmed to line, cleaned and painted with a thin coating of emulsified asphalt before the adjacent lane is placed.

The longitudinal joints in the surface course shall be along the same line as the traffic lane markers.

f. Paving Edges

The edges of the asphalt course shall be rolled concurrently with or immediately after rolling the longitudinal joint.

Care shall be exercised in consolidating the course along the entire length of the edges. Before it is compacted, the material along the unsupported edges shall be slightly elevated with hand tools. This will permit the full weight of the roller wheel to bear on the material to the extreme edges of the mat.

g. Breakdown Rolling

Breakdown rolling shall immediately follow the rolling of the longitudinal joints and edges. Rollers shall be operated as close to the paver as possible to obtain adequate density without

causing undue displacement. In no case shall the mix temperature be allowed to drop below 120 °C before breakdown rolling.

If the breakdown roller is steel wheeled, it shall be operated with the drive wheel nearest the finishing machine. Pneumatic-tyred rollers may be used as breakdown rollers.

h. Intermediate Rolling

Pneumatic-tyred rollers or Steel wheeled rollers shall be used for the intermediate rolling.

The intermediate rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still hot. Rollers shall be used continuously after the initial rolling until all of the mix placed has been thoroughly compacted. Turning of rollers on the hot paving mix which causes undue displacement shall not be permitted.

i. Finish Rolling

The finish rolling shall be performed with three-axle tandem rollers unless otherwise permitted by the Engineer. Finish rolling shall be accomplished while the material is still warm enough for the removal of roller marks.

All rolling operations shall be conducted in close sequence.

In places inaccessible for the operation of standard rollers as specified, compaction shall be performed by manual or mechanical tampers of such design as to give the desired density.

After final rolling, the smoothness, levels, crossfalls, density and thickness shall be checked and any irregularity of the surface exceeding the specified limits and any areas defective in texture, density or composition shall be corrected as directed by the Engineer, including removal and replacement as directed by the Engineer.

j. Protection of Laid Courses

Sections of the newly finished work shall be protected from traffic of any kind until the mix has been properly compacted and cooled. In no case shall traffic be permitted less than 24 h after completion of the asphalt course unless a shorter period is authorised by the Engineer.

3.7.5. SAMPLING, TESTING AND ACCEPTANCE

a. General

Each completed asphalt concrete course shall be tested and approved in accordance with the following requirements before placing any subsequent asphalt concrete course.

In addition to the following requirements one set of three laboratory compacted specimens and one uncompacted coated sample for each mix type and mixer plant for each day's production shall be delivered to the Central Materials Laboratory no later than 12 h after compaction of the specimens. Details of compaction date, time and temperature of mix shall be provided with the specimens together with mix type and project details.

b. Sampling

The Contractor shall cut samples from each completed asphalt course during the progress of the work and before final acceptance as directed by the Engineer. The Engineer shall determine the location of the samples.

When testing for compaction at joints the edge of the core shall not be more than 50 mm or less than 25 mm from the joint.

Compacted samples shall be taken by coring in accordance with BS 598, for testing by an approved laboratory. The core diameter shall be 150 mm. Where the Contractor fails to provide cores as required by the Engineer, the Engineer may arrange for the taking of cores on behalf of the Contractor at his cost. Samples shall be taken of the asphalt mix for the full depth of the course from the location directed by the Engineer at a rate of not less than one sample per 100 m run of road or 1000 m² of paving whichever is less. A sample shall comprise a pair of adjacent cores and the average density of these shall be the density of the sample.

Whenever deficiencies are noted in loose mix samples or core samples, the Engineer may direct the taking of additional cores at the Contractor's expense in order to define the area of pavement involved.

Hot asphalt mix of the same type shall be placed and compacted in holes left by sampling. The mixture shall be compacted to the % compaction required for the layer using a vibrating hammer such as a Kango hammer.

c. Compaction

The degree of compaction determined in accordance with BS 598: Part 104 is the ratio of the bulk density of the pavement sample to the bulk density of the laboratory Marshall specimens prepared in accordance with the Job Mix Formula.

The field density, as determined from each core sample, shall be a minimum of 98% of the job standard density of the mix for the wearing and intermediate courses and a minimum of 97% for the base course.

The field density, as determined from each core sample, shall not exceed 101.8% of the job standard density of the mix.

d. Mix Composition

Loose samples of mixed material shall be taken at the rate of one for each 1,000 m² laid or at least twice per day from the paving machine for testing of the mix gradation and bitumen content.

If it appears from the analysis of samples of loose mix or cores that the asphalt content or aggregate gradation are beyond the permissible tolerances specified for the Job Mix Formula (established for each respective asphalt course mix) and that, such variation affects the characteristics of the asphalt mix conformity to the designated requirements is concerned, this shall be considered a major defect in the work. The portion of the asphalt course represented by these samples shall be rejected.

e. Thickness and Level

Cores shall be taken to determine the thickness of asphaltic paving courses. As determined from each core, the thickness of a paving course shall not be less than that specified by more than 5 mm in the case of a single – layer construction. Furthermore, the thickness of the wearing course shall not be less than that specified by more than 5 mm and the total thickness of all asphaltic paving courses combined shall not be less than that specified by more than 10 mm.

In addition, the variations in the falls to cross sections of the road shall not vary from the required value by more than 0.3%. Any asphalt paving course containing deviations or

variations exceeding these tolerances shall be corrected or removed and replaced by the Contractor, in accordance with the instructions and to the satisfaction of the Engineer.

Where any individual course is marginally out of tolerance on the low side, the Engineer may allow adjustment in the succeeding course to correct the overall thickness of the pavement.

The tolerances herein specified shall not invalidate the tolerances set forth for the evenness of surface of the asphalt paving course.

f. Evenness of Surface

The Engineer shall test the evenness of surface for each course of the various asphalt paving courses to determine compliance.

The Contractor shall put at the disposal of the Engineer a 3 m long straightedge and a crown template of sturdy and approved design and enough labour to assist in the checking operations.

Any layer containing deviations or variations exceeding the tolerances specified here shall be corrected or removed and replaced in accordance with the instructions of the Engineer and to his satisfaction.

3.8. RELATED WORKS

1.3.1. KERB KEYING

Edges shall be of type T4 according to EN 1340 and NFP 98 340/CN, with mass concrete and standard grey facing. They shall be made of prefabricated concrete sections 1.00 m and exceptionally 0.33 m long.

Precast concrete kerbs shall be laid true to lines, grades and levels and any kerb found to be more than 5 mm out of lines, grades or levels at either end shall be removed and relaid.

Kerbs shall be laid on a concrete foundation with concrete Class B according to Section 03300, 20 cm thick, and shall be backed with concrete shaped up to the required cross-section, all as detailed on the Drawings.

Specially cast radiused kerbs shall be used on curves of 12 m radius or less.

Kerbs shall be jointed with cement mortar except at expansion joints which shall be made with performed joint filler 13 mm thick. Expansion joints shall be carried through the concrete backing and foundation.

Kerbs shall be made with concrete class B according to Section 03300.

1.3.1. ROAD MARKINGS

Where directed by the Engineer, the Contractor shall paint markings on the completed road surfaces.

Before paint is applied, the road surface shall be thoroughly cleaned and dried to remove all dust and other deleterious matter.

Except where otherwise specified all lines shall be 100 mm wide. All lines shall be premarked with dots at approximately 3 m centres on straight lines and 1 m centres on curves. Lines on curves shall not be formed by a series of straight sections around the curve. The alignment shall

not deviate more than 20 mm in 25 m. The width of the lines shall not be varied more than plus or minus 6 mm from the specified width.

The paint shall be applied with due regard to the Manufacturer's instructions. Lines and other road marking shall be applied uniformly and shall have sharply defined edges without runs or spatters.

3.9. CONTROLS

The following controls shall be made on materials either placed or in situ, after compaction:

Test	Sub-grade	Sub-base	Base
Californian Bearing Ratio (in situ)	1 per 300 m ²	1 per 100 m ³	1 per 100 m ³
Density (in situ)	-	1 per 200 m ³	1 per 200 m ³

Nuclear method may be used for testing density of soil in place.

The frequency and nature of the tests may be amended as required by the Engineer depending on the results of previous tests, material variations or climatic conditions.

3.10. MAINTENANCE WORKS

The Contractor shall properly maintain all roads, both permanent and temporary to the Engineer's satisfaction.

Such maintenance shall include all measures necessary to maintain the roads in an operational and safe condition for the vehicle and weather condition for which the particular road is designed, and shall include, but not be limited to, repairs to foundation and road surface, clearing of drains, repairing or supplementing signs, and clearing and stabilizing batter and fill slips.

Upon completion of the Contract and before the issue of Taking Over Certificate, all roads constructed, upgraded and/or used by the Contractor shall be left in good condition to the satisfaction of the Engineer.

The asphalt works for the required permanent roads shall be done at the end of works, when the circulation of heavy trucks is not likely to occur. If the Sub-base or Base courses are damaged during construction works, the Contractor shall repair such according to the specifications and to the satisfaction of the Engineer before asphalt sealing works. For temporary roads, the Contractor can propose a design different from the specifications, provided he demolishes it at the end of works to build the permanent roads according to the specifications. In all cases, the price items for roads in the Price Schedule include all temporary, maintenance and permanent road works.

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SECTION 02240

GEOTEXTILE

1. GENERAL

1.1. SCOPE

This specification is applicable to placing geotextile at locations indicated on Drawings.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. REFERENCED DOCUMENTS

ASTM Standards :

D 123	Standard Terminology Relating to Textiles
D 276	Test Methods for Identification of Fibers in Textiles
D 3786	Test Method for Hydraulic Burst Strength of Knitted Goods and Nonwoven Fabrics, Diaphragm Bursting Strength Tester Method
D 4354	Practice for Sampling of Geosynthetics for Testing
D 4355	Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon Arc Type Apparatus)
D 4439	Terminology for Geosynthetics
D 4491	Test Methods for Water Permeability of Geotextiles by Permittivity
D 4632	Test Method for Grab Breaking Load and Elongation of Geotextiles
D 4751	Test Method for Determining Apparent Opening Size of a Geotextile
D 4759	Practice for Determining the Specification Conformance of Geosynthetics
D 4833	Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 4873	Guide for Identification, Storage, and Handling of Geotextiles
D 5141	Test Method to Determine Filtering Efficiency and Flow Rate for Silt Fence Applications Using Site Specific Soil

1.4. SCHEDULE

In addition to the general schedule, the Contractor shall hand the Engineer a precise schedule for laying the various geotextiles with the corresponding layout drawing.

2. PRODUCTS

2.1. PHYSICAL AND CHEMICAL REQUIREMENTS

- A. Fibers used in the manufacture of geotextiles and the threads used in joining geotextiles by sewing, shall consist of long chain synthetic polymers, composed of at least 95% by weight polyolefins or polyesters. They shall be formed into a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.
- B. Geotextile Requirements. The geotextile shall meet the requirements of following List. Woven geotextiles shall not be allowed. All numeric values in the following table, except AOS, represent minimum average roll values (MARV) in the weakest principal direction (i.e., average test results of any roll in a lot sampled for conformance or quality assurance testing shall meet or exceed the minimum values). Values for AOS represent maximum average roll values.

The geotextile should comply with the following characteristics:

- - Non-Woven geotextile
- - Mass per unit area : at least 600 g/m²
- - Thickness (standard NF EN 964-1): ≥ 4mm
- - AOS (Apparent Opening Size) as per ASTM D 4751 : 0.42 mm (±10%)
- - POA (Percent Open Area) : at least 10%
- - Permeability > 0.09 m/s
- - Grab tensile strength : 1500 N
- - Trapezoidal tear strength : 750 N
- - Puncture strength : 750 N
- - Gradient Ratio test (ASTM D5101). Ratio should be <2.5.

2.2. CERTIFICATION

- A. The Contractor shall provide to the Engineer a certificate stating the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns and other pertinent information to fully describe the geotextile.
- B. The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available upon request.

- C. The Manufacturer's certificate shall state that the furnished geotextile meets MARV requirements of the specification as evaluated under the Manufacturer's quality control program. The certificate shall be attested to be a person having legal authority to bind the Manufacturer.
- D. Either mislabeling or misrepresentation of materials shall be reason to reject those geotextile products.

2.3. SAMPLING, TESTING AND ACCEPTANCE

- A. Geotextiles shall be subject to sampling and testing to verify conformance with this specification. Sampling for testing shall be in accordance with ASTM D 4354. Acceptance shall be based on testing of either conformance samples obtained using Procedure A of ASTM D 4354, or based on manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D 4354. A lot size for conformance or quality assurance sampling shall be considered to be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.
- B. Testing shall be performed in accordance with the methods referenced in this specification for the indicated application. The number of specimens to test per sample is specified by each test method. Geotextile product acceptance shall be based on ASTM D 4759. Product acceptance is determined by comparing the average test results of all specimens within a given sample to the specification MARV. Refer to ASTM D 4759 for more details regarding geotextile acceptance procedures.

2.4. SHIPMENT AND STORAGE

- A. Geotextile labeling, shipment, and storage shall follow ASTM D 4873. Product labels shall clearly show the manufacturer or supplier name, style number, and roll number. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.
- B. Each geotextile roll shall be wrapped with a material that protect the geotextile from any damage due to shipment, water, sunlight, and contaminants. The protective wrapping shall be maintained during periods of shipment and storage.
- C. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 71EC (160EF), and any other environmental condition that may damage the physical property values of the geotextile.

3. EXECUTION

3.1. GENERAL

Atmospheric exposure of geotextiles to the elements following lay down shall be a maximum of 7 days to minimize damage potential.

3.2. SEAMING

- A. If a sewn seam is to be used for the seaming of the geotextile, the thread used shall consist of high strength polypropylene, or polyester. Nylon thread shall not be used. For erosion control applications, the thread shall also be resistant to ultraviolet radiation. The thread shall be of contrasting color to that of the geotextile itself.
- B. For seams which are sewn in the field, the Contractor shall provide at least a 2 m length of sewn seam for sampling by the Engineer before the geotextile is installed. For seams which are sewn in the factory, the Engineer shall obtain samples of the factory seams at random from any roll of geotextile which is to be used on the project.
1. For seams that are field sewn, the seams sewn for sampling shall be sewn using the same equipment and procedures as will be used for the production of seams. If seams are to be sewn in both the machine and cross machine directions, samples of seams from both directions shall be provided.
 2. The seam assembly description shall be submitted by the Contractor along with the sample of the seam. The description shall include the seam type, stitch type, sewing thread, and stitch density.

3.3. PREPARATION OF FORMATION LEVEL

Before installing the geotextile, the following points shall be checked:

- The area shall be cleaned and compacted so that it is free of any vegetation, irregularity, depression or sudden change in elevation.
- The surface shall be cleared of all roots, rocks more than 50 mm in diameter and other debris.
- No surface shall have suffered excessive erosion due to water or wind.
- The water content shall not be excessive at any point on the surface.
- The surface shall not display any shrinkage cracks beyond the project specifications.

At each stage, the Geotextile Installer shall confirm in writing that the state of the formation level on which the geotextile are placed is acceptable. The acceptance certificate shall be sent to the Engineer before any geotextile is deployed on the surface in question.

The acceptance certificate report concerning the foundation levels shall include at least the following information:

- - Date and time,
- - Description of the accepted area(s),
- - Sketch indicating the accepted area(s),
- - Partial or complete acceptance,
- - Comments,
- - Name and signature of the Geotextile Installer's representative.

In case the surface to be laid is a trench, the excavation shall be done in accordance with details of the Drawings. Excavation shall be done in such a way so as to prevent large voids from

occurring in the sides and bottom of the trench. The graded surface shall be smooth and free of debris.

3.4. GEOTEXTILE PLACEMENT

- A.** The geotextile shall be placed loosely with no wrinkles or folds, and with not void spaces between the geotextile and the ground surface. Successive sheets of geotextiles shall be overlapped to a minimum of 300 mm, with the upstream sheet overlapping the downstream sheet.
 - 1. When required in trenches equal to or greater than 300 mm in width, after placing the drainage aggregate the geotextile shall be folded over the top of the backfill material in a manner to produce a minimum overlap of 300 mm. In trenches less than 300 mm but greater than 100 mm wide, the overlap shall be equal to the width of the trench. Where required in trench less than 100 mm the geotextile overlap shall be sewn or otherwise bonded. All seams shall be subject to the approval of the Engineer.
 - 2. Should the geotextile be damaged during installation, or drainage aggregate placement, a geotextile patch shall be placed over the damaged area extending beyond the damaged area a distance of 300 mm, or the specified seam overlap, whichever is greater.
- B.** At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacturer, transportation or storage.
- C.** Unless for placement in trench, geotextile shall not be placed during strong wind events (wind velocity ≥ 4 m/s).
- D.** The geotextile shall be free of tensile stresses folds, and wrinkles.
- E.** The geotextile shall be ballasted after positioning. The Contractor shall choose the most appropriate ballasting method for site conditions and the expected winds. The Contractor may use bags of soil or tires. The Contractor shall be responsible for the supply, placement and removal of the ballasting used.
- F.** The deployed geotextile should not be exposed over the maximum allowable exposure time specified by the Manufacturer. If the allowable exposure time has been exceeded, a joint inspection shall determine if the geotextile has been damaged. If needed, additional CQA tests will be requested in order to verify that the physical properties of the geotextile have not been diminished due to inappropriate exposure.

3.5. DRAINAGE AGGREGATE AS BACKFILL FOR TRENCH APPLICATION

When applicable (as shown on Drawings), placement of drainage aggregate should proceed immediately following placement of the geotextile. The geotextile should be covered with a minimum of 300 mm of loosely placed aggregate prior to compaction. If a perforated collector pipe is to be installed in the trench, a bedding layer of drainage aggregate should be placed below the pipe, with the remainder of the aggregate placed to the minimum required construction depth.

3.6. SITE VERIFICATION

- A.** The installation of the geotextile shall be inspected by the Contractor's representative in presence of the Engineer: visual inspection of the placement and aspect, measurement of the overlap, ballasting.

- B.** If the installation does not comply with the specifications and rules of the art, the Contractor shall be responsible to make necessary arrangements at no cost for the Employer.

SECTION 02346

BOLTING

1. GENERAL

1.1 WORK INCLUDED

The section covers the requirements for:

1. the supply bolts and dowels,
2. the installation of bolts and dowels,
3. the testing of bolts and dowels,
4. the supply and placement of wire mesh fabric for temporary protection.

The specifications for the bolts cover resin grouted and cement grouted bolts.

The works will be carried out with the Engineer' approval for particular case only.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DEFINITIONS AND DESCRIPTIONS

1. A bolt is a high yield deformed bar of specified diameter and length which is end anchored with resin grout, fully column bounded with either resin or cement grout, equipped with a faceplate, hemispherical washer and nut and tensioned to a specific load. The use of resin or cement grout for the column grout shall be at the contractor's discretion.
2. Alternative materials with equivalent service characteristics may be proposed to the agreement of the Engineer.
3. A **dowel** is a high yield deformed bar of specified diameter and length for which the protruding portion may be either straight or bent, which is fully grouted with either resin or cement grout. Dowels will not be fitted with accessories nor will they be tensioned. The use of resin or cement grout shall be at the Contractor's discretion.

Bolts and dowels shall be installed in portions of the work where anchorage of concrete or steel structures are required or where the stability of soil faces exposed by the excavations will not be maintained naturally.

It is intended that in general treated soils reinforcement will be provided mainly by dowels.

1.4 CODES AND STANDARDS

1.3.1. GENERAL

The work including in this Section shall comply with the requirements of the following standards and codes, except where this Specification differs from these standards and codes, in which case the requirements of the Specification shall take precedence.

International Society of Rock Mechanics (ISRM).

ISRM Suggested method for Rock Anchorage Testing (ref. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, v. 22, n2, p 714-83, 1985).

1.4.2 AMERICAN CONCRETE INSTITUTE

ACI 318-77 Building code requirements for pre stressed concrete.

1.3.1. AMERICAN SOCIETY FOR TESTING MATERIALS (ASTM)

ASTM A 185 Steel welded Wire Fabric, for Concrete Reinforcement

ASTM C150 Portland Cement

ASTM D4435 Standard method for rockbolt anchor pull test

ASTM F432 Standard specification for roof and rock bolts and accessories

1.4. QUALITY ASSURANCE

1.3.1. TESTS AND CONTROLS

1. The Contractor shall make trial tests of bolts and dowels before any installation proceeds.
2. The trial programme shall include sufficient pull-out tests to failure, or to such lesser load as the Engineer may approve, and dowels anchored in suitable rock to determine the adequacy of the anchorage used and the correct torque or tension where appropriate to apply to the bolts. The trial assemblies shall show that the bolt, the anchorage system and the tensioning system proposed by the Contractor will be suitable for the work.
3. the effectiveness of the installation procedure shall be checked by testing to yield load a minimum of 1 bolt in 100 installed.

1.5.2 TOLERANCES

4. Position ± 150 mm
5. Alignment $\pm 5^\circ$

1.5. SUBMITTALS AND APPROVALS

1. Not later than 45 das prior to commencement of excavation, the Contractor shall submit to the agreement of the Engineer.

The different types and characteristics of dowels, bolts and accessories he intends to use.

For exposed bolts and accessories, the protective coating compound the Contractor intends to have applied at the factory with possibility of recoating at site if required.

Grouting equipment and method.

2. Schedule for grouting bolts and dowels

Prior to grouting the Contractor shall submit a schedule for grouting for the Engineer's approval.

All granted bolts shall be grouted in place immediately prior to backfilling or concreting or in the case of permanently exposed faces, upon completion of the work in any area, unless otherwise required by the Engineer.

2. MATERIALS

2.1. TENSIONED BOLTS

1. Bolts shall be manufactured from hot rolled deformed bars with a minimum tensile strength of not less than 415 Mpa complying with ASTM F432, in various lengths and diameters as specified.
2. The bar length specified shall be the required length of bar to be bonded to the soil and due extra allowance in the cutting length shall be made for any length including the threaded portion protruding from the rock as required for installation. One end shall be threaded for at least 150 mm with coarse cut thread which shall not reduce the overall specified bar diameter by more than 3 mm. The other end shall be chamfered to facilitate installation.
3. Bolts shall be provided with face plate, hard steel flat and hemispherical washers and nuts.
4. The face plate shall be domed load indicating type and fitted with hemispherical washer to permit seating of the plate at inclinations up to 30° from normal to the bolt, with the following minimum dimension characteristics:
 - for 20 mm dia rockbolt, diameter 120 mm and 8 mm thick plate,
 - for 25 mm ida rockbolt, diameter 150 mm and 8 mm thick plate.
5. Couplings for connecting adjacent sections of a bolt shank and bolt extensions shall have a center stop so that each section is connected by an equal length of thread. Such threads shall be capable of transferring the yield load of the bolt from one section to the other

without, in any way, overstressing the coupling or the threads of the bolt shank or extension. Couplings for hollow core bolts shall be such as not to interfere in any way with the flow of grout through the core of the bolt.

6. Cement grouted bolts shall be supplied with suitable tubes for injecting grout and permitting release of air from the hole. Bearing plates for bolts to be grouted shall be supplied with holes to accommodate the grouting and venting tubes. Alternatively, groutable bolts having a hollow core may be used, in which case the bearing plates shall have one hole for the grouting or air venting tube.
7. For all bolts which be permanently exposed, all portions of the bolts, the bearing plates and accessories which will be permanently exposed shall be coated after installation with an approved protective coating compound. The engineer may nevertheless require grouting to be used for protection of the shank.

2.2 DOWELS

Dowels shall be manufactured from hot rolled deformed bars with a minimum tensile strength of not less than 415 Mpa, in various lengths and diameters as specified.

Dowels shall be either straight bars or shall have the protruding end bent to facilitate the specified connection between the rock and surrounding concrete or shotcrete when so detailed on the drawings.

Dowels for installation with resin or cement cartridge shall be threaded at one end sufficiently for attachment of the installation equipment. The other end shall be chamfered to facilitate installation.

2.2. WIRE MESH

1. Wire mesh shall be of a standard approved by the Engineer.
2. Welded wire mesh shall comply with ASTM A 185.

2.3. GROUT

1. Resin grout shall be a commercially produced epoxy product in capsule form with both fast and slow setting times as applicable especially formulated for use with rockbolts or dowels, and transported, stored and utilised in accordance with the manufacturer's recommendations.
2. Cement grout shall be a commercially prepared product in capsule form especially produced for use with rockbolts or dowels. The product shall not contain any material which could corrode the bolts or dowels.

2.5 RESERVE SUPPLY

3. To be able to perform the excavation work without delay, the Contractor shall always have a reserve inventory of bolts and dowels of various types and length, wire mesh and other accessories. Such inventory shall be adequate to meet the requirement for the following month as well as provision for unforeseen conditions. The inventory status shall be reported to the Engineer on a monthly basis.

4. As the work progresses the Contractor shall supply additional bolts to site as instructed by the Engineer.

2.4. TORQUE WRENCH

The Contractor shall a standard torque wrench for calibrating impact and torque wrenches used in the work. This controlled torque impact wrench shall have a control device that can be set to cut off over the required range of torques. This wrench shall not be used for any other purpose. All impact and torque wrenches shall be calibrated at least once every month.

2.5. PULLOUT TEST EQUIPMENT

The Contractor shall provide two sets of approved pullout test equipment for use in making tests, to comprise of a suitable hydraulic jack, having a center bore in the ram for installation of the jack concentrically over the longitudinal axis at the bolt, hydraulic pump, and all other required accessories.

3. EXECUTION

3.1. GENERAL

1. Bolting shall be carried out in the pattern and sequences as indicated on the drawings or as directed or as proposed by the Contractor and agreed by the Engineer.
2. Before grouting, the Contractor shall check the tension of all tensioned bolts and retorque where necessary.
3. Where opencut excavation is carried out in successive lifts or benches, support of each newly exposed soil face shall be completed prior to blasting of the next bench unless otherwise authorized by the Engineer.
4. Bolts required to support the underground excavation shall be set and tensioned at agreed locations, as soon as practicable after each round is excavated and before the face is further advanced. Any bolt, which is damaged by blasting or other operations to the extent that it can no longer be effectively retensioned, shall be replaced as required by the Engineer.

3.2 DRILLING

5. Standard percussion drilling equipment may be used for drilling bolts or dowels.
6. Holes for bolts shall be drilled to the depths and at locations and orientation shown on the drawings, directed or as agreed by the Engineer.
7. Unless otherwise proven acceptable by site trials, the bolts shall be installed in holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the bolt, and will be such that, for the anchorage used, the load capacity of the bolt at the yield point of the steel can be developed. In cases where it is necessary to couple lengths of grouted bolts to achieve the total length of bolt required, the diameter of the hole around and above the coupling shall be sufficient to allow the free passage of grout.

8. The holes shall not be more than 100 mm longer than the grouted length of the bolt unless otherwise proven acceptable by site trial.
9. Immediately prior to installation of any bolt, the hole shall be flushed with water and cleaned of all drill cuttings and debris to the satisfaction of the Engineer.

3.3 INSTALLATION AND TENSIONING OF BOLTS

3.3.1 INSTALLATION AND TENSIONING OF BOLTS

10. Installation

The method of installation and tensioning of bolts shall be to the approval to the Engineer, Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

Bolts shall be inserted in the hole and the anchorage firmly seated and tightened. No damage shall be caused to the thread of the protecting end of the bolt.

Prior to installing the bolts, the soil surface shall be prepared to provide uniform bearing at right angles to the longitudinal axis of the bolts.

For resin grouted rockbolts a sufficient number of cartridges shall be used to ensure the annulus around the bolt is completely filled over the full length of the hole.

End cartridges for the anchorage zone shall be of fast setting resin whilst the column shall be filled with slow setting resin or cement cartridges. Tensioning shall be carefully controlled to ensure that it takes place after setting of the end cartridges but prior to commencement of setting of the column grout.

11. Tensioning

The hexagonal nut of the tensining end of the bolt shall be free running on the thread of the bolt and shall be tightened to a torque required to cause a load in the bolt equal to 50 kN for the 20 mm dia rockbolt and 100 kN for the 25 mm dia rockbolt. The requisite torque for the bolts shall be determined by in place testing of the bolts in accordance with the bolt Manufacturer's directions. Bolts which are damaged or overstressed by over torquing shall be replaced by the Contractor.

All necessary preparation of a bolt for grouting shall be made during the initial installation of the bolts. After the bolt has been tensioned, the tension shall not be relaxed for grouting or any other purpose.

If it is found that any bolt will not take the required torque without anchorage slip, another bolt shall be installed in a new hole drilled in the immediate vicinity of the unsatisfactory bolt.

If, at any time, the Engineer or Contractor finds that any bolts have become loose or have lost their tension, the Contractor shall retension all such bolts by reapplying the specified torque.

3.3.2 INSTALLATION OF DOWELS

The method of installation of dowels shall be to the approval of the Engineer. Manufacturer's instructions for the use of proprietary components shall be followed wherever appropriate.

Holes of diameter from 10 mm to 15 mm greater than the maximum diameter of the dowel shall be drilled and cleaned to the approval of the Engineer. The gauged amount of cement grout or cartridges of resin or cement grout shall then be inserted and the bar driven firmly into the hole (by spinning in the case of resin cartridges). If cement grout is used, the grout shall be inserted using a tremie pipe pushed down to the bottom of the hole and withdrawn slowly as the grout is placed. After installation the bar shall be vibrated for a short period to ensure the complete distribution of the grout around the full length of the bar. Additional grout shall be added to make up any shortfall.

3.4 TESTING OF ROCK BOLTS AND DOWELS

3.4.1 GENERAL

Prior to the installation of bolts in the Works the Contractor shall carry out a series of tests as agreed with the Engineer to prove the capacity of the system and the Contractor's capability to correctly install and tension the bolts.

12. for the purpose of these tests, anchorage slip shall be deemed significant if an outward movement of the bolt anchorage occurs and continues without increase in the hydraulic jack loading, or with a decrease in the hydraulic jack loading.
13. If a bolt fails to meet the pullout test requirement, another bolt shall be installed in a new hole drilled as close as practicable to the unsatisfactory bolt.

14. The tests shall demonstrate:

The number of resin cartridges required to provide the end anchorage with an applied load equal to the bars characteristic yield strength and taking into account the overlength variation of holes.

The number of resin or cement cartridges to fill the annulus around the rockbolt over the length of the hole between the anchorage and collar of the hole.

The strength of the resin grout to fully anchor the bars up to the characteristic strength of the bolts.

The composition of the cement grout.

The capacity of the equipment to install the longest fully grouted bolts.

The equipment for tensioning the bolts to the specified loads.

The capability of each crew to correctly install and tension the bolts.

The Contractor shall undertake the tests with the equipment to be used on the Works and shall install the test bolts in a suitable rock face in a steeply upward direction.

The Contractor shall provide a suitably calibrated direct tensioning jack and/or load cell of capacities in excess of the characteristic strength of the rockbolts. Loads and deformations shall be recorded during the tests.

3.4.2 TENSIONED BOLTS

15. A final torque test of bolts shall be made in the presence of the Engineer during the final inspection of the work, and immediately prior to any grouting of bolts. The number of bolts

to be tested will be determined by the Engineer, with consideration given to the total number of bolts installed and the results of such tests.

16. The Contractor shall make a pullout test of each bolt that does not retain the applied torque, as determined by the Engineer. All pullout tests shall be made in the presence of the Engineer. A pullout test result which indicates that the anchorage will take a tension equal to 90 percent of the yield strength of the bolt shank as determined by trial tests, without significant anchorage slip; will be acceptable.
17. All bolts which are installed and tensioned within 15 metres of subsequent blasting work shall be tested after each blast within such longer period as may be approved by the Engineer.

3.4.3 DOWELS

As locations designated by the Engineer, the Contractor shall conduct pullout tests in the presence of the Engineer. A pullout test which indicates that the dowel will take a tension equal to 90 per cent of its yield strength without significant slip will be acceptable.

3.5 CEMENT GROUTING OF BOLTS

18. The grouting shall be performed in accordance with a method approved by the Engineer.
19. The Contractor shall supply all plant and materials required to grout the bolts in place after installation.
20. Where a tube system is proposed by the Contractor, such system shall be subject to the Engineer's approval, and the Contractor shall demonstrate to satisfaction of the Engineer that the proposed system will provide complete filling of the annular space around the bolt.
21. The water/cement ratio by weight shall be between 0.30 to 0.44. Special agreed admixture shall be added to the grout to prevent shrinkage. This non shrink admixture shall be added strictly as recommended by the Manufacturer. Calcium chloride will not be permitted. Grout shall be forced into the drill hole at the appropriate point to completely fill the space all around the rock bolts. All air shall be vented from the drill hole adequately. If during the grouting of any bolt, grout is found to flow from points in the rock surfaces adjacent to the bolts, such leak shall be plugged or caulked. Grout which has not been injected into a hole within 1 hour of mixing shall not be used.
22. The Contractor shall ensure that grouted bolts are neither loosened nor disturbed in any way until at least 7 days after completion of grouting.

3.6 WIRE MESH

23. Where wire mesh will be placed for temporary protection for safety of person and equipment, it shall be securely fastened to the bearing plates or bolts.
24. Overlaps in the wire mesh shall not be less than 300 mm and shall be secured with wire clips.
25. Additional wire mesh anchors shall be used to secure wire mesh to the soil surface between bolts and to secure the edges of wire mesh and provide anchorage at overlaps

and where sagging may occur. There wire mesh anchors patterns shall be approved by the Engineer.

SECTION 02432

DEWATERING AND CARE OF WATER

1 GENERAL

1.1 WORK INCLUDED

This section covers the requirements for dewatering and maintaining the surface and underground work areas in a dewatered state.

Unless otherwise instructed by the Engineer during construction, the Contractor shall investigate, design, construct, maintain and operate temporary drainage facilities as are necessary for controlling all water entering the work areas which includes seepage of ground water, surface runoff. Water removed from the work areas shall be disposed of in such a manner as will not harm the environment, the stability of existing and constructed slopes, the works and the public health.

Dewatering shall mean works required to pump ground water out of surface or underground excavations.

1.2 RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3 CODES AND STANDARDS

Not used.

1.4 QUALITY ASSURANCE

Not used.

1.5 SUBMITTALS AND APPROVALS

The Contractor's schemes for dewatering the surface and underground works shall be submitted for approval not less than 14 days prior to commencement of related excavation.

2 MATERIALS

2.1 GENERAL

All materials required by the Contractor to ensure effective drainage of the Works shall be approved by Engineer.

2.2 COFFERDAM FILL

Fill materials for cofferdams shall be obtained from required excavations, quarries, borrow pits or stockpiles as required. Fill materials shall be free of objectionable quantities of roots, organic and other foreign objects, as determined by the Engineer, and shall comply with the requirements of Section 02223 - Fills, Backfills and Embankment Construction.

2.3 CONCRETE

Materials for concrete shall comply with the requirements of Section 03301.

2.4 GROUT

Materials for grout shall comply with the requirements of Section 02398.

3 EXECUTION

3.1 DEALING WITH SURFACE WATER

Excavations and platforms shall at all times be maintained in a well-drained condition and free of ponded water from whatever source including precipitation run-off, groundwater percolation, water back-up, or water for construction operations.

After having served their purpose, all temporary protective works shall be removed or leveled so as not to interfere in any way with the operation of the project works, and to give a tidy appearance at the satisfaction of the Engineer.

The Contractor shall be responsible for, and shall repair at his own expense, damage to any part of the work caused by floods, water back-up, or failure of protective works.

Excavated borrow pits shall be developed with regular profiles and graded to drain, via ditches to the nearest water course. Measures shall be taken when necessary to prevent watercourses from backing up into the borrow areas.

The Contractor shall do whatever is necessary to prevent water from entering excavations or from flowing over excavated slopes in overburden or rock.

Unless otherwise directed by the Engineer, gravity drainage will be preferred to dewatering by pumping wherever feasible.

3.2 DEWATERING OF UNDERGROUND WORKS

The underground works shall be maintained in a dewatering state. Ponding of water shall be avoided.

Water from underground works shall be treated in a silt and oil trap before release to any watercourse.

3.3 DEWATERING OF SURFACE WORKS FOUNDATIONS

The Contractor shall provide and maintain all temporary stoplogs, cofferdams, dykes and other protective works and shall provide, operate and maintain any channels, flumes, drains, sumps, pumps and other drainage facilities and equipment required to dewater the areas required for the Work and maintain them free from water and ponding for such periods as are necessary for satisfactory completion of the Work.

The Contractor's methods shall be such that they do not interfere with the progress or safety of the Work.

Where existing minor streams are to be diverted, the Contractor's arrangements shall be subject to the approval of the Engineer.

Subject to the approval of the Engineer, the Contractor will be permitted to leave in place sumps and pipes which form part of the dewatering system, provided they are backfilled and give a tidy appearance, to the satisfaction of the Engineer.

3.3 CARE OF WATER

Excavation and platforms shall at all times be maintained in a well-drained condition and free of ponded water from whatever source including precipitation run-off, groundwater percolation, water back-up, or water for construction operations.

Water removed from any excavations shall be treated if necessary and disposed of in such a manner as will not endanger public health, the environment, the stability of existing slopes, or the Works.

Drains, ditches, sumps and other facilities shall be lined as required or directed to prevent erosion of the underlying soil or rock.

The Contractor shall be responsible for, and shall repair at his own expenses, damage to any part of the work caused by floods, run-off, water back-up, or failure of protective works.

3.5 SPOIL AREAS

The Contractor shall do whatever is necessary to prevent water from flowing over spoil areas and adequate measures shall be taken to prevent erosion of the material by surface runoff and watercourses.

Pipes and conduits through spoil dumps shall be solid and continuous and will require specifically formed inlets and outlets in impermeable and non erodible headwalls. Pipes or conduits shall have a minimum dimension of 1000 mm regardless of discharge requirement. Pipe or conduit shall be suitably constructed to prevent erosion.

If necessary, and upon request by the Engineer, a surface drainage system will be installed on the completed spoil dump.

3.6 SHAFT

The shafts will be excavated with care of water.

A pumping installation with high capacity ($> 200 \text{ m}^3/\text{h}$) shall be installed in the shafts and regularly relocated in accordance with the progress of the works.

Any permanent pond will be authorized by the Engineer at the bottom of the excavation.

The Contractor will always have on site a supply equipment to replace if necessary the equipment in duty.

A permanent water level measuring device shall be installed in the shafts; the records will be submitted to the Engineer every day.

SECTION 03100 FORMWORKS

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply, installation and execution of formwork for concrete structures.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

Formwork shall be designed supplied and installed in order to produce concrete parts meeting specified shape, dimensional and position requirements, without defects or irregularities and within the prescribed tolerance limits.

1.4. DEFINITIONS

A. Abrupt irregularities

Any local irregularity resulting from incorrect alignment or relative displacement of the formwork, unsatisfactory condition of formwork or any other cause.

Abrupt irregularities will be measured directly or using a rule or a template of 20 cm long.

B. Gradual irregularities

Refer to any other difference between the theoretical and actual lines of the concrete faces. They shall be measured with a straight rule for plane surfaces and with an appropriate template for curved surfaces of 1.50 m long.

C. Honey combs, grout losses and surface plucking shall not be considered as irregularities but as defects.

1.5. STANDARDS AND REGULATIONS

The following Standards shall be used, in this order of priority:

1. British Standards

2. European Standards.

1.6. STANDARDS OF FINISH

A. Class 1

This is a very high quality finish where formwork shall ensure a particularly accurate line of finish: surfaces in contact with hydraulic flow and surfaces exposed to view:

1. The surfaces delineated by panel joints shall be regular.
2. Unless otherwise indicated, panel joints shall be vertical or horizontal, perpendicular or in alignment with the water flow.
3. Construction joints shall match architectural design details where necessary and shall be submitted for the Engineer's approval.
4. Formwork linking systems shall not be permitted unless otherwise approved by the Engineer.
5. All abrupt irregularities shall be ground to obtain chamfers of 1-over-50.

For surfaces that will be subjected to flowing water at a rate of more than 10 m/s, no smoothing will be tolerated and any irregularity outside specified limits which cannot be repaired by bush hammering or grinding shall be repaired with epoxy resins or any other product approved by the Engineer. Such resins or products shall be applied by approved specialists.

B. Class 2

Formwork for structure surfaces and joints and, in general, all structures not requiring a special finish, i.e. surfaces not exposed to the view:

1. The surfaces delineated by joints between formwork panels shall be regular.
2. Unless otherwise indicated, joints shall be vertical or horizontal or parallel to the overall lines of the structure.
3. Construction joints positions shall be submitted for the Engineer's approval.
4. If accepted, formwork linking systems shall be placed uniformly with aligned joints as to achieve a symmetrical pattern in the finish concrete surface.

C. Class 3

1. Surfaces designed for construction joints between different construction stages with, where applicable, steel bars passing through them.
2. Surfaces designed to be coated at a later stage.

D. Class 4

Surfaces contained by formwork but which will be permanently concealed in the completed work.

E. Surface state tolerances in millimetres

Formwork class	Abrupt irregularities	Gradual irregularities
Class 1	2	6
Class 2	4	8
Class 3	8	15
Class 4	nil	40

N.B.: The clauses of this article are also applicable to concrete surfaces not effectively shuttered.

1.7. DESIGN

- A. Formwork and falsework shall support without appreciable deformation the weight of the fresh concrete, reinforcement and embedded parts as well as the forces induced by falling concrete, with vibration, impacts of handling equipment, personnel, temperature variations and climatic agents.**
- B. Joints between panels shall be grout-tight and shall provide satisfactory continuity of concrete surfaces.**

1.8. CURVED FORMWORK

- A. Curved surfaces of radius less than or equal to 2 m shall conform strictly to the theoretical curve.**
- B. Curved surfaces shall be given by curved formworks, even for 2D curved ones:**
 - a. Either by plywood built on site,
 - b. Either by industrial curvable iron formworks.

1.9. SUBMITTALS

- A. Working drawings of formwork with props, stays, spacers and fastening systems shall be submitted to the Engineer for information.**
- B. The specifications and manufacturer's instructions for the following items and products shall be submitted for the Engineer's approval:**
 - 1. Sheathings or liners.
 - 2. Spacers and falsework.
 - 3. Special supports embedded in the concrete if agreed on principle.
 - 4. Dressing material for stripping.
 - 5. Slip forms where applicable.

1.10. LAYOUT TOLERANCES

- A. Layout deviations of concrete facings shall be compatible with the functions of the structure considered and with related structural functions, especially with regard to mechanical supplies.**

For electromechanical works, tolerances shall be indicated on the drawings.

- B. Unless otherwise indicated, the positive and negative tolerances are as follows:**

1. On any linear dimension L (in m), measured between opposing facings, edges or intersecting edges:

$$T \text{ (cm)} = \frac{1}{4} \sqrt[3]{L}$$

with a minimum of 0.5 cm and a maximum of:

- a) 1 cm for class 1 formwork
- b) 3 cm for other classes of formwork

2. On vertical dimensions:

$$T(\text{cm}) = 0.0005 \times H$$

where:

H = height of the item in cm

Upper limits: 0.05 x E or 3 cm

E = thickness of the item in cm

3. On alignments or gradients:

$$T(\text{cm}) = 0.0005 \times L$$

where:

L = length in cm

For the curved parts, the tolerances are fixed by analogy

4. On the layout with respect to the reference marks indicated to the Contractor: planimetry and altimetry:

$$T \text{ (cm)} = \frac{1}{2} \sqrt[3]{D}$$

where:

D = distance in metre between the control point and the reference mark with an upper tolerance limit of 3 cm and a lower limit of 0.5 cm.

2. PRODUCTS

2.1. FORMWORK MATERIALS

- A. Generally speaking, forms shall be made of wood or metal. Unless specified to the contrary, they shall be made of plywood for wood or exposed surfaces where the visual impact is particularly important.

All panels other than metal panels shall be new when they are first used on site.

- B. Panels may be reused on site on condition that they are carefully cleaned, reconditioned or surfaced from time to time and if they will be capable of producing concrete surfaces conforming to the specifications. After repeated use, the Engineer may require the Contractor to scrub the form or to provide new ones.
- C. Spacers and fasteners shall be designed in such a manner that, after stripping, no metal part will be closer to the surface of the facing than the minimum concrete cover agreed for the reinforcement.
- D. For water retaining concrete structure, a plate of 50 mm minimum diameter shall be welded in the middle of spacers and fasteners to avoid leakages.

2.2. DRESSING MATERIALS FOR STRIPPING

- A. Surfaces exposed to concrete must be coated with form oil or other approved dressing material.
- B. Dressing material shall facilitate wetting of the form surface, reduce bubble formation, leave no notable trace on concrete surfaces and protect the form surface from any damage such as corrosion.
- C. They shall be compatible with the treatment that may be applied to the concrete surfaces (painting, coating, etc.).

2.3. EXCAVATED SURFACES USED AS FORMS

- A. At the Contractor's request, and after the Engineer has given his approval, the lateral forms of buried parts of concrete structures may be omitted with the concrete being placed directly the excavated surfaces.
- B. In cases where the omission of formwork is accepted, the dimensions of the concrete parts shall be increased by 3 cm on each face in contact with the excavated surfaces.
- C. At the Engineer's instruction, a layer of blinding concrete shall be spread or projected over the excavated surface before placing the concrete.

3. EXECUTION

3.1. INSPECTION

Reference levels and alignments, levels and positions of previous concrete lifts and the position of previously placed reinforcement bars shall be checked before installing the formwork.

3.2. PREPARATION

- A. After cleaning, the forms shall be coated with a dressing material in accordance with the manufacturer's instructions.**
- B. The forms shall be protected from dust and dirt, after the above treatment.**

3.3. INSTALLATION

- A. The forms shall be installed and securely braced in such a manner that the concrete surfaces produced come within the tolerance limits defined in Part I herein.**
- B. If necessary, forms shall be installed with a counter-deflection.**
- C. Unless otherwise indicated, exposed corners shall be provided with 25 x 25 mm chamfers by mean of moulding strip placed in the formwork.**
- D. Construction joints levels shall be provided with battens defining the limits between two concrete lifts, where directed by the Engineer.**
- E. Formwork for successive vertical lifts must make good contact with the concrete in the preceding lift, such that there will be no excrescences, bulges, tears or other outward signs of a faulty junction such as grout leakage.**
- F. Blockouts, inserts and embedded items should be properly identified, positioned and secured.**

3.4. STRIPPING OF FORMS

- A. Formwork shall not be removed without the approval of the Engineer. Notwithstanding this approval, the forms shall not be moved or removed until the concrete has acquired sufficient strength to support its weight and the construction or design loads that it may be required to bear.**
- B. Stripping shall take place without impact or vibration to the concrete and care shall be taken not to damage the concrete surfaces.**
- C. Stripping operations may be decided in relation to the results of compression tests on specimens kept under conditions similar to those of the structure considered. These test specimens shall be taken in addition to the test pieces specified in section on concrete.**
- D. Concrete compressive strength tests may be replaced by sclerometer measurements.**

- E. Generally speaking, the forms and supports of suspended structures shall not be removed until the ratio of the compressive strength of test specimens kept under similar conditions to those of the structure considered to the specified strength is greater than the ratio of the deadweight plus construction loads to the design load, with a minimum value of 0.50.**
- F. In general, formwork shall be left in place for the following period after the concrete is cast:**
1. minimum of 36 hours: vertical surfaces of piers and columns,
 2. minimum of 36 hours: vertical surfaces of footings, walls and dams,
 3. minimum of 20 days: suspended beams and slabs,
 4. minimum of 12 hours: tunnel linings,
 5. minimum of 7 days: arch roof of underground chambers.

The times above specified shall have elapsed from the end of concreting. According to the results of the laboratory tests and site trials, the aforesaid minimum times may be reconsidered by the Engineer. In all cases, the Contractor shall demonstrate that removal of formwork will not in any way adversely affect the concrete of permanent work.

3.5. REPAIR OF SURFACE DEFECTS

- A. If the concrete surfaces after stripping have certain local defects (such as honey combs or surface defects) or irregularities, the Contractor shall advise the Engineer before undertaking any repairs so that the said defects and irregularities can be inspected and notified in a jointly-signed report.**
- B. If in the Engineer's opinion that the defects will not have any significant impact on the quality of the structure, the Contractor shall propose the necessary repair work prior to any repairs.**
- C. In case of serious defects, the Engineer may order the whole lift concerned to be removed and replaced.**
- D. Repairs of local defects and holes left by form fasteners and spacers shall be carried out using cement mortar containing an adhesive and an additive mixture to prevent shrinkage.**
- E. Holes left by form fasteners and spacers may, for certain concrete facings not in contact with water, be left as they are, with the Engineer's approval.**
- F. Spalling, burrs and irregularities not compatible with specified type of finish shall be repaired by smoothing as specified for defects, or ground.**
- G. Within 24 Hours after form removal all fins and loose materials shall be removed and surface defects including the holes shall be remedied unless otherwise required by the Engineer.**

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SECTION 03200

REINFORCEMENT

1. GENERAL

1.1. WORK INCLUDED

This section covers the supply and installation of steel bars or steel fabrics used for reinforcement in concrete works, either for permanent or for temporary structures.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. QUALITY ASSURANCE

1.3.1. CODES AND STANDARDS

The following Standards shall be used, in this order of priority:

1. British Standards.
2. European Standards.

1.3.1. TESTS AND INSPECTION

- A. If the Contractor does not have the Supplier's Certificate or mill certificates, or if the reinforcement appears to be in a deteriorated condition in the Engineer's opinion, the Contractor shall bear the cost of arranging for tests to be carried out in an approved laboratory.
- B. The tests will cover the following characteristics:
 1. Diameter (determined by weighing)
 2. Tensile strength
 3. Bending tests
- C. Six samples per diameter shall be taken for determining each of the above-mentioned characteristics.
- D. If two tests of a given characteristic give unsatisfactory results, the reinforcement bars concerned shall be considered defective.
- E. If one test of a given characteristic gives an unsatisfactory result, a new sampling of six samples from the same batch shall be taken for a new series of tests on the characteristic in question. If

the results of the new tests are all satisfactory, the reinforcement bars will be accepted. If this is not the case, the bars shall be considered defective.

1.4. SUBMITTALS

A. Supply of steel bars

Manufacturer's test certificates or mill certificates including details of physical and chemical properties.

B. Welding of reinforcement bars will not be allowed

Nevertheless in particular cases, the Engineer could agree with bars welding; in such cases the following documents will be submitted to the approval of the Engineer.

1. A welding programme.
2. Certificates of steel reinforcement weldability.

C. Spacers shall be submitted to the approval of the Engineer.

1.5. TOLERANCES

A. Tolerance on the distance (d) between reinforcement bars in walls, slabs or beams:

1. 0.5 cm for d less than 15 cm
2. 1.0 cm for d between 15 and 80 cm
3. 2.0 cm for d greater than 80 cm

B. Tolerance on length of bars: + 4 cm except when these bars are in a discontinuity zone (support surface, etc.) where the tolerance will be + 1.5 cm.

C. Tolerance on concrete covering thickness:

1. Minus 15% with a maximum of 10 mm
2. Plus 30%

2. PRODUCTS

2.1. STEEL GRADES

The following types of steel shall be used for reinforcement:

1. Plain round mild steel or High yield steel bars conforming to BS 4449.
2. Cold worked steel bars conforming to BS 4461.
3. Fabric reinforcements made of cold drawn high tensile bars conforming to BS 4483.

Reinforcement shall be High yield steel bars conforming to BS 4449 as well as BS EN 1992-1 and BS EN 1992-3, with a minimum yield strength (noted f_{yk} in BS EN 1992-1) of 460 MPa and a minimum characteristic strain (ϵ_{uk}) of 5%, which corresponds to a class B of ductility in BS EN 1992-1.

2.2. REINFORCEMENT SPACERS

- A. Spacers may be made of metal, concrete, cement mortar or plastic.
- B. Metal spacers or metal chairs shall not come into contact with the formwork.
- C. Concrete or cement mortar spacers shall be of sufficient size to remain stable and shall be of equivalent quality to that of the concrete.
- D. Unless their actual shape makes them perfectly stable, all spacers shall be provided with systems for attaching them to the reinforcement.

2.3. DELIVERY OF STEEL REINFORCEMENT

- A. When the steel bars for concrete reinforcement are delivered on site, they must be straight, without bends or windings, without stains or other damage. Bars accidentally bent will be rejected; however, after removal of the bent parts, the remaining straight sections could be accepted if the available length is sufficient.
- B. When the steel reinforcement is delivered already shaped and assembled, it will be transported to the place of use with great care to ensure that no parts will not be permanently deformed.

2.4. STORAGE OF STEEL REINFORCEMENT

- A. The steel reinforcement bars shall be stored in such a manner that different diameters cannot be mixed.
- B. Storage yards shall be clean and designed in such a manner that none of the steel reinforcement is in contact with the ground or subject to damp conditions.

2.5. WELDING OF BARS

- A. The Engineer may authorise end-to-end welding of steel bars and spot welds on bars as a replacement for binding, depending on the steel bar weldability certificates.

- B.** The Engineer will prescribe tensile and bending tests on welded parts in order to check the quality of welds and prove that the procedure will produce adequate strength and other necessary properties in the splice.
- C.** Where agreed, welding of bars shall be carried out in strict accordance with the steel Manufacturer's instructions.

2.6. BENDING OF REINFORCEMENTS

1. Steel reinforcement for reinforced concrete shall be fixed in accordance with the detailed Drawings to be prepared by the Contractor and approved by the Engineer. The Contractor shall provide bending schedules and shall be responsible for checking them and ensuring their accuracy before ordering and bending the reinforcement.
2. The bars shall be bent cold in a manner that will not injure the metal and in accordance with BS 4466. No bar exempt links and stirrups shall be bent to a smaller radius than twice its diameter. All bars which are lapped to secure continuity shall, unless otherwise stated to the contrary, overlap not less than the values given in BS 8110. Reinforcement projecting from partly finished work shall not be bent unless permitted by the Engineer and shall be protected from damage.

3. EXECUTION

3.1. PREPARATION

Firm rust on steel reinforcement will be permitted but rust which is loose or flaky shall be wiped off firmly with burlap or wire-brushed.

3.2. PLACING OF REINFORCEMENT

1. Before being fixed in position all reinforcing bars shall be cleaned of all mill scale, rust, dried grout, paint, oil, grease, earth or any other substance which may impair the bond between the reinforcement and the concrete.
2. The reinforcement shall be placed and securely fixed in the exact position required and the Engineer's approval obtained before concreting is commenced. On walls the horizontal and vertical bars shall be securely bound together with 16 s.w.g annealed soft iron wire at intervals not exceeding 400 mm and at all intersection.
3. The ends of links and bindings shall be bent around the bars for at least 225 degrees so as to fit tightly.
4. Fabric reinforcement when laid adjacent to other sections of reinforcement or when lapped shall have a minimum lap of 300 mm for the main wires and 150 mm for transverse wires.
5. Anchorage length and overlap length shall not be inferior to 60 times bar diameter, unless stated otherwise.
6. Reinforcement in angles shall be placed taking into account the unwanted thrust effect from curved rebars in tension.

3.3. COVERING OF REINFORCEMENT BARS

Unless otherwise indicated, the minimum thickness of concrete covering the steel reinforcement shall be as follows:

1. For concrete cast directly against earth: 7,5 cm

2. Concrete in contact with water and atmospheric or aggressive agents: 5 cm (protection such as coating or painting shall be neglected, unless if approved by the Engineer)
3. Concrete in dry rooms: 3 cm
4. The covering over all reinforcement is to be at least equal to:
 - a) its diameter (Φ) if it is a single bar,
 - b) $\Phi \times n^{0.5}$ if it is a group of n bars, with a maximum of 55 mm
5. The concrete cover of the horizontal bars of a vertical layer of reinforcement shall exceed 4/3 of the maximum nominal aggregate diameter.

3.4. MINIMUM REINFORCEMENT FOR RESERVOIRS

In addition to BS EN 1992-1 and BS EN 1992-3, the following criteria apply for reservoirs:

For reservoir walls, the steel section of reinforcement (in m^2) shall not be inferior to 0,125 % of wall width (in m) on each face and both vertically and horizontally.

For reservoir raft, the steel section of reinforcement (in m^2) shall not be inferior to 0,25 % of raft thickness (in m) in each direction. This section shall be spread on the top and bottom layer of reinforcement.

3.5. PROTECTION

As the concrete sets, after it has lost its plasticity, the steel reinforcement shall not be subjected to shocks or any external force (bending or use of bars for moving personnel) for a period of 48 hours.

SECTION 03250

CONCRETE STRUCTURE JOINTS AND NEOPRENE BEARING PAD

1. GENERAL

1.1. WORKS INCLUDED

This section covers the supply, installation or execution of different types of joints in all concrete structures and neoprene bearing pads.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DEFINITION AND DESCRIPTION

A. Contraction joint

1. It is a contact between 2 elements generally without continuity of reinforcement, or half continuity of reinforcement.
2. Such joints will enable concrete cracks to be localized and construction phases to be localized.
3. They shall have no filler material (concrete cast against concrete).

B. Expansion joint

1. An expansion joint is formed by creating complete discontinuity with clear gap between 2 elements.
2. The purpose of expansion joints is to prevent structural disruptions as a result of temperature variations or differential movements, including earthquake effects in seismic regions.
3. The joints shall be filled with preformed joint filler.

C. Construction joint

1. The continuity of both concrete, by special preparation, and reinforcement shall be assured.
2. These joints localize construction phases.

D. Sealing strip (or waterstop)

1. Watertight sealing is achieved by a natural rubber or PVC strip held in the two parts of structures in contact.
2. Strips are fitted to contraction and expansion joints.

E. Joint sealing compound

Joints may be sealed with an elastomer joint-sealing compound.

F. Neoprene bearing pads:

These elements shall provide vertical support and allow small horizontal displacements. They can be used for example between roof slabs and supporting water retaining walls under temperature shrinkage or during earthquake.

G. Preformed gap filler:

For the remaining part of gap in expansion joint and around neoprene bearing pad.

1.4. QUALITY ASSURANCE

All the products used in joint work shall be of proven quality and shall be obtained from reputable manufacturers and approved by the Engineer.

1.5. STANDARDS AND CODES

The following Standards shall be used, in this order of priority:

1. ASTM D1751
2. British Standards.
3. European Standards.

1.6. SUBMITTALS

A. Technical data sheets giving the physical, chemical and mechanical characteristics of:

1. Sealing strips and special connection parts
2. Preformed joint fillers
3. Joint sealing compound
4. Neoprene bearing pads

B. A sample of all the products to be used in joint construction.

- C. Results of quality control tests carried out in the factory on sealing strips and joint sealing compound.
- D. Manufacturer's instructions for the storage and use of products.

1.7. TOLERANCES

A. Sealing strips

- 1. With respect to the formwork before pouring of concrete: 5 mm in all directions.
- 2. With respect to the final faces of the structure after pouring of concrete: 20 mm in all directions.

B. Joint sealing

After making the joint, the surface of the facing shall be continuous and smooth and shall not have any local irregularity greater than 5 mm.

C. Bridge joints

- 1. The level difference between the top carriage way surface of the bridge joint and the finished surface of the bridge deck shall be less than 5 mm.
- 2. The level difference between the 2 sectional irons forming the built-in part of the joint shall be less than 2 mm.

D. Neoprene bearings

1 mm in flatness and horizontality for lower surface (head of water retaining wall) and upper surface (roof slab).

2. PRODUCTS

2.1. SEALING STRIPS AND CONNECTION PARTS

A. Material

Sealing strips shall be of rubber sections for type 1 and polyvinyl chloride (PVC) for type 2 waterstop.

Type 1 will be used for expansion joints or contraction joints in structures bearing a water pressure more than 5 mwc.

Type 2 will be used for contraction joints.

B. Rubber Material Characteristics

	At 25°C	After aging (48h at 70°C under 2 MPa of Oxygen)
Tensile strength greater than	20 MPa	15 MPa

Elongation on rupture greater than Percentage of cinders less than Shore hardness	450% 4% 60 to 70	350% 4%

C. PVC material characteristics

	At 25°C	After aging (48h at 70°C under 2 MPa of Oxygen)
Tensile strength greater than Elongation on rupture greater than Maximum water absorption after 48 h immersion at 50°C Shore hardness	12 MPa 250 % 3 % 50 to 60	15 MPa 350 %

D. Range of dimensions (in mm)

Type	Width	Centre bulb	Outer flanges
1	300-350	45-55	23-27
2	200-230	No	18-22

E. Protection

During storage, sealing strips shall be protected from UV light.

2.2. PREFORMED JOINT FILLER

The preformed expansion joint fillers shall consist of a compressible, rot-proof and elastic material of the Flexcell or equivalent type conforming to ASTM D1751.

2.3. JOINT SEALING COMPOUND

A. The joint sealing compound will be an elastic, adhesive, waterproof elastomer capable of stopping the intrusion of foreign materials in the joint.

B. The product shall not have any chemical action on the materials with which it will come into contact (concrete, preformed joint filler).

C. Characteristics

1. Density:..... 1700 kg/m³ minimum
2. Shore hardness: 25-30
3. Consistency after polymerization: Rubbery
4. Proportion of solvent: Nil
5. Shrinkage: Nil
6. Vertical creep:..... Nil

7. Minimum deformation: 25 %
8. Minimum deformation in compression and traction without bond breaking, creep or cracking in the temperature range of 0-70°C.

2.4. BRIDGE JOINTS

- A. Bridge joints shall be formed by steel and neoprene rubber.
- B. Bridge joints shall be of the medium-heavy type capable of accommodating movements of 20-30 mm.

2.5. NEOPRENE BEARING PADS

Same quality as for bridge joints but without reinforcement of steel plates. Sticking with approved glue on its sub-surface.

3. EXECUTION

3.1. INSPECTION

All the products making up the joints (sealing strips, special parts, preformed joint filler, joint sealing compound, bridge joints) will be inspected and checked by the Engineer before installation.

3.2. SEALING STRIPS AND SPECIAL PARTS

- A.** Sealing strips as well as special intersection or connection parts, shall be fastened to the formwork or the reinforcement so as to keep them in the correct position as defined on the drawings during concreting operation.
- B.** Under no circumstances shall sealing strips fastening devices compromise watertightness (nailing for example).
- C.** Sealing strips as well as special intersection or connection parts shall be interconnected in order to guarantee total continuous sealing. The method of connection shall be of an approved type such as hot-vulcanized connection using an electric vulcanizer, or cold connection using a preformed rubber sleeve, and special solvent, as specified by the manufacturer of the strips.
- D.** The Contractor shall take particular care when concreting around the sealing strips. The consistency, particle size distribution, placing and internal vibration of the concrete shall be such that encasing is obtained. Large aggregates shall in all cases be removed from the strip encasing zone.
- E.** Restarting parts of sealing strips or special parts shall be protected from the risk of mechanical accidents and, if necessary, from the effects of solar radiation if the exposure time were to exceed one month.
- F.** All sealing strips or special parts incorrectly installed or connected, punctured or damaged, will be rejected and replaced.

3.3. PREFORMED JOINT FILLER

- A.** The preformed joint fillers shall be installed in the positions defined on the drawings against the first concreted face of the joint.
- B.** The method of fixing the preformed joint filler (copper or bronze nailing or bonding with an adhesive compatible with the filler material) shall ensure proper stability of the joint filler before and during concreting.
- C.** Joints between preformed joint filler panels shall be made watertight in order to prevent the penetration of underlying cement grout.

3.4. JOINT SEALING

- A.** The edges of joints shall not show any signs of spalling or beading. Any repairs that may be required on the joint lips shall be carried out using epoxy resins approved by the Engineer.
- B.** Before filling with the joint sealing compound, the joint faces shall be cleaned of any loose laitance by sand-blasting or grinding or brushing. The faces shall be clean and dry when the mastic compound is applied.
- C.** The joint sealing compound shall be applied in strict accordance with the manufacturer's recommendations.

3.5. BRIDGE JOINT

- A.** Anchor bars of bridge joint shall be welded to the reinforcement bars.
- B.** The two parts of the bridge joint shall form an integral part during concreting of the second part of the joint and shall be separated as soon as concrete setting is done.

3.6. NEOPRENE BEARINGS

- A.** The reinforced neoprene pads shall be settled on perfectly flat and horizontal surfaces.
- B.** The performances (ashlar) of the bearing surfaces shall be slightly larger than the neoprene pad. The ashlar shall be refilled on pointed surface with a mortar dosed at 500 kg of cement per cubic metre of sand. The neoprene bearings shall be placed on green mortar. For case in-situ structures the Contractor shall design a formwork system allowing for an easy stripping around the bearing.

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SECTION 03300

CONCRETE

1. GENERAL

1.1. WORK INCLUDED

This section covers the execution of concrete works for all structures.

1.2. RELATED SECTIONS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. STANDARDS AND REGULATIONS

A. Local Standards

HHSN – Seismic Code of the Republic of Armenia

SNiP – Construction rules and regulations

B. British Standard

BS EN 1992-1 Eurocode 2 - design of concrete structures - part 1-1: general rules and rules for buildings

BS EN 1992-3 Eurocode 2 - Design of concrete structures - Part 3: Liquid retaining and containment structures

BS EN 1998-1 Design of structures for earthquake resistance – General rules, seismic actions and rules for buildings

BS EN 1998-4 Design of structures for earthquake resistance – Silo, tanks and pipelines

BS EN 1998-5 Design of structures for earthquake resistance – Foundations, retaining walls and geotechnical aspects

BS EN 206-1 Concrete - part 1: specification, performance, production and conformity

BS EN 197-1 Cement - Part 1: composition, specifications and conformity criteria for common cements

BS 12 Specification for ordinary and rapid hardening Portland cement

BS 146: Part 2 Specification for Portland blast furnace cement (Metric units)

BS 340	Specification for precast concrete kerbs, channels, edgings and quadrants
BS 368	Precast concrete flags
BS 812	Grading of aggregates
BS 1200	Building sands from natural sources
BS 1881	Testing Concrete
BS 3148	Methods of tests for water for making concrete
BS 4027	Specification for sulfate-resisting Portland cement
BS 4246	Low heat Portland blast furnace cement
BS 5328	Methods for specify concrete
BS 5896	Specification for high tensile steel wire strand for the prestressing of concrete
BS 6073	Specification for precast concrete masonry units
BS EN 933-3	Tests for geomtrical properties of aggregates
BSI 6089	Guide to assessment of concrete strength in existing structures

C. American Concrete Institute (ACI)

ACI 121R	Quality Assurance Systems for Concrete Construction
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 305	Hot Weather Concreting

D. American Society for Testing and Materials (ASTM)

ASTM A 416	Specification for Uncoated Seven-Wire Stress-Relieved Steel Strand for Prestressed Concrete
ASTM A 421	Specification for Uncoated Stress-Relieved Wire for Prestressed Concrete
ASTM A 615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C 31	Test Method of Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Specification for Concrete Aggregates
ASTM C 39	Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 40	Test Method for Organic Impurities in Fine Aggregates for Concrete
ASTM C 42	Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 70	Test Method for Surface Moisture in Fine Aggregate
ASTM C 88	Test Method for Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate

ASTM C 94	Specification for Ready-Mixed Concrete
ASTM C 114	Methods for Chemical Analysis of Hydraulic Cement
ASTM C 177	Test Method for Material Finer than 0.075 mm Sieve in Mineral Aggregates by Washing
ASTM C 125	Definition of Terms Relating to Concrete and Concrete Aggregates
ASTM C 127	Test Method for Specific Gravity and Absorption of Coarse Aggregate
ASTM C 128	Test Method for Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C 142	Test Method for Clay Lumps and Friable Particles in Aggregate
ASTM C 143	Test Method for Slump of Portland Cement Concrete
ASTM C 150	Specification for Air-Entraining Admixtures for Concrete
ASTM C 151	Test Method for Autoclave Expansion of Portland Cement
ASTM C 172	Method of Sampling Freshly Mixed Concrete
ASTM C 191	Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
ASTM C 192	Method of Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 204	Test Method for Fineness of Portland Cement by Air Permeability Apparatus
ASTM C 231	Test Method for Air Content of Freshly Mixed Concrete by the pressure Method
ASTM C 309	Specification for Liquid Membrane - Forcing Compounds for Lining Concrete
ASTM C 348	Test Method for Flexural Strength of Hydraulic Cement Mortars
ASTM C 349	Test Method for Compressive Strength of Hydraulic Cement Mortars (Using Portions of Prisms Broken in Flexure)
ASTM C 360	Test Method for Ball Penetration in Fresh Portland Cement Concrete
ASTM C 403	Test Method for time of setting of concrete mixtures by Penetrations Resistance
ASTM C 451	Test Method for Early Stiffening of Portland Cement (Paste Method)
ASTM C 469	Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C 494	Specification for Chemical admixture for concrete
ASTM C 496	Test for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C 535	Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 566	Test Method for Total Moisture Content of Aggregate by Drying
ASTM C 595	Specification for Blended Hydraulic Cements
ASTM C 596	Test Method for Drying Shrinkage of Mortar Containing Portland Cement

- ASTM C 618 Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
- ASTM D 75 Practices for Sampling Aggregates
- ASTM D 2419 Test Method for Sand Equivalent Value of Soils and Fine Aggregate
- ASTM D 2487 Classification of Soils for Engineering Purpose.

E. Association Française de Normalisation (AFNOR)

- NF P 15-436 Binders - Measuring of hydration heat of cement by means of semi-adiabatic calorimetry (Langavant method)
- NF P 18-561 Aggregates - Measurement of the Flattening coefficient
- NF P 15-317 Hydraulic binders – sea-water resisting cements
- NF P 15-319 Hydraulic binders – sulphate resisting cements

F. Deutsches Institut Fur Normung

- DIN 1048 Testing Method for concrete; fresh concrete.

1.4. SUBMITTALS

- A. The Contractor shall advise the Engineer not later than 2 months after the commencement date, by means of a detailed memorandum, of the arrangements he proposes to adopt regarding the production of sand and aggregates and the manufacture of concrete, as well as for casting of the concrete.**
- B. Documents on concrete manufacturing**
- C. The Contractor shall submit to the Engineer's approval detailed drawings of the phases of concreting, specifying the locations of the various construction joints, any particular arrangements which may be required, and the order of implementation of the different phases.**
- D. Test results**
- The results of the tests shall generally indicate:
1. Identification number of sample.
 2. Origin of sample.
 3. Part of structures represented by the sample.
 4. Drawing date of the sample.
 5. Description of test with reference to a given standard.
 6. Test result.
 7. Date of test.
- E. Cement**
1. Test report for approval of cement before use.
 2. Chemical and physical analyses for each make.

3. Copy of the cement storage record-book submitted at the end of each week.

F. Aggregates

Test report for approval of aggregate before any use.

G. Water

Detailed memorandum for approval.

H. Additives

Test results.

I. Concrete

1. Results of tests on mix design studies.
2. Results of concrete suitability tests.
3. Results of control tests.
4. Complete records shall be kept by the Contractor of all concreting. The records shall include the time of mixing and casting, weather conditions, quantity, mixture proportions, amount of additives, slump and water content of each cast, as well as the results of any tests made on the concrete.

1.5. DESCRIPTION

- A. The major part of the concrete may be considered as medium reinforced concrete except in volume with some embedded items. In consideration of the behaviour of massive concrete blocks (setting temperature, shrinkage) and for reasons of construction (concreting or/and equipment erection schedules, etc.) concrete shall be placed in a number of planned pours or lifts (a lift being defined as a volume of concrete poured without any interruption).
- B. Except as otherwise specified or shown on the drawings or directed by the Engineer the extent of any horizontal length of a lift shall not exceed 15 m. The height shall in general not exceed 2.5 m, in some exceptional cases (with at least one small horizontal dimension) higher.
- C. In the building parts such as service rooms, staircases, etc.. reinforced concrete works with a medium to high percentage of reinforcement shall be involved. In principle, the above mentioned provision concerning the massive concreting sections remains valid.
- D. Finally, concreting sections will be provided such as second phase concrete for pockets or around embedded items. In these cases, relatively small quantities of concrete will be placed under confined conditions.
- E. All concreting of contiguous lifts are separated by construction or expansion joints. In general, the reinforcement will be continued over the construction joints.
- F. Pouring of lifts of limited dimensions does not exclude other means to avoid cracking such as the use of low heat of hydration cement, low cement ratio and refrigeration of concrete constituents.
- G. All concrete shall be “hydraulic type concrete”, watertight by its own media.

2. PRODUCTS

2.1. CEMENT QUALITY

- A. Unless otherwise specified, the cement shall be Portland Cement type CEM I or CEM III according to EN 197-1, and resisting to sulphate according to NFP 15-319**

The cement shall meet the following specifications:

Characteristics	Value	Test Method
Minimum compressive strength at 28 days	30 MPa	ASTM C 349
Initial setting time (Vicat needle) more than	90 mm	ASTM C 191
Initial setting time less than	180 mm	
Le Chatelier stability - cold and hot expansion less than	3 mm	NFP 15-432
Shrinkage at 28 days of mortar less than	0.08 %	ASTM C 596
+ chemical characteristics S03 less than	5 %	ASTM C 114
Hydration heat at 5 days (Langavant bottle) less than	260 J/g	NFP 15-436
+ equivalent sodium oxide ($Na_2O+0.658 K_2O$) less than	0.6 %	ASTM C 114
Potential alkali reactivity of cement - aggregate		
Combination - expansion at:		
6 months less than	0.075 %	ASTM C 227
12 months less than	0.1 %	ASTM C 227

+ for cement only.

- B. The mixing of cements or cement and mineral admixtures, such as milled slag, fly ash, pozzolan or fillers shall be authorised provided the effect of such blends made before mixing in the batching plant or during mixing be tested in accordance with the Engineer's instructions and the result submitted to the Engineer.**

2.2. APPROVAL OF CEMENT BEFORE ANY USE

- A. Each make of cement shall be constituted by cement from a homogeneous source (same factory, same fabrication process and same basic material).**
- B. The delivery of any make of cement to the primary silos at site shall not take place until written approval has been given by the Engineer, after examination of the test report. This test report shall be the result of tests carried out in the cement works or in a laboratory approved by the Engineer.**
- C. The tests shall include:**
- Flexural and compressive strength at 2,7, 28 and 90 days.
 - Initial and final setting time on pure paste.
 - Cold and hot expansion.
 - Shrinkage of cement mortar.
 - Chemical analysis.

6. Hydration heat (measured at 12 hours 1, 2, 3, 5 and 7 days) by the insulated. Langavant bottle method. (NF P 15-436) which is a semi-adiabatic measurement.
 7. Potential alkali reactivity of cement - aggregate combination (test duration: at least 2 years: the 6 months test will be extended for at least six additional months).
 8. Blaine's specific surface (ASTM C 204).
- D. Each characteristic shall be taken as equal to the average of three measurements made under each test (except for the compressive strength which shall be the average of 6 measurements).**

2.3. VERIFICATION OF CEMENT DELIVERED

- A. Control sampling shall be effected on each supply before the cement is delivered to the primary silos at site and when required by the Engineer.**
- B. Every 1000 t or not less than once a month, the following control tests shall be carried out:**
1. Hot and cold expansion
 2. Flexural and compression strength at 2 and 28 days
 3. Initial and final setting time on pure paste
 4. Blaine's specific surface
- C. Every 5000 t or not less than once a month, the following control tests shall be carried out:**
1. Heat of hydration (measured at 12 hours, 1, 2, 3, 5 and 7 days).
 2. Chemical analysis.
- D. Every 1000 t, and not less than once a month, a sample shall be taken at the silo of the batching plant and shall be kept in the laboratory for a minimum duration of 6 months (conservation samples). These samples (5 kg) are designed to allow the performance of tests a posteriori, in case of dispute or for information.**
- E. No cement shall be used before the flexural and compression strength at 2 days, the initial and final setting times, and the Blaine specific surface are known.**

2.4. CEMENT DELIVERY

- A. The cement shall be delivered in bulk or in bags, with the exception of cement for grouting, repair or finishing works or any other particular works, which will be delivered exclusively in bags.**
- B. Transport from the factory to the site shall be effected in watertight containers specially designed for this purpose.**
- C. The installations for transport from the container to the silo and from the silo to the mixer shall be watertight.**

- D. Once the supply in bags has been approved, the cement shall be delivered in bags of standard dimensions. The identification of the cement, the name of the manufacturer and the weight of the bags shall be clearly marked on each bag. Cement from damaged bags shall be neither used nor replaced in the bag without the prior approval of the Engineer.

2.5. CEMENT STORAGE

- A. The cement supplied in bulk shall be stored in watertight silos designed to ensure that there is no loss in storage. The silos shall be emptied and cleaned every 6 months and whenever there is a change in the type or origin of the cement.
- B. The cement supplied in bags shall be stored in a dry place, fully enclosed and covered, isolating them from the soil and from atmospheric agents. The store shall be of sufficient dimensions to allow easy access for identification, removal of samples, counting and moving the bags. The bags shall not be stored in piles exceeding 2.5 m in height.
- C. The cement shall be used in chronological order of its arrival. The temperature of the cement at the time of its use shall not exceed 70°C.
- D. The total storage capacity of the primary silos at site shall be sufficient to guarantee normal progress of works on site for a duration of 20 calendar days.
- E. The use of any cement that has remained in storage on site for more than 4 months shall be subject to a complete series of physical tests to ensure that the specifications are complied with.
- F. Any cement which has been exposed to the elements or which has set, even partially, or which has been rejected in compliance with the specifications shall not be used for the permanent Works and shall be removed from the silos or stores.

2.6. CEMENT STORAGE RECORD-BOOK

The Contractor shall keep for every silo a cement storage record-book in which the following will be noted:

1. The quantity of cement in store at the end of the week.
2. The quantities, origin and location of storage of the various batches delivered during the week.
3. The quantities used daily and the structures in which the cement is used.

2.7. OVERALL QUALITY OF AGGREGATES

- A. The aggregates shall be crushed material originating from rock that is neither sensitive to the environment nor likely to have any harmful effect with regard to the other concrete ingredients. Fine aggregates for concrete may consist of natural sand. Provenance of aggregates after washing, screening and possibly crushing is subject to prior Engineer's approval with evidence of their suitability as regards to the requirements of the present specification.
- B. The aggregates shall meet the requirements of ASTM C 33.

- C. The density of the aggregates shall be greater than 2.55 t/m³.

2.8. GRADING OF FINE AGGREGATES

- A. The fine aggregate shall be made up of two separate categories, which shall be:

1. Fine sand 0 - 0.630 mm
2. Coarse sand 0.630 mm - 5.0 mm

- B. The grain size characteristics of the fine aggregate after mixing the two categories shall be within the following range:

Sieve Designation	Per cent passing by weight
4.8 mm (N°4)	95 to 100
2.4 mm (N°8)	85 to 95
1.2 mm (N°16)	60 to 85
0.595 mm (N°30)	30 to 65
0.297 mm (N°50)	15 to 40
0.149 mm (N°100)	5 to 20
0.074 mm (N°200)	0 to 5

- C.

1. The fineness modulus shall be within the range of 2.2 to 3.1.
2. Continuity, that is the percentage in mass retained between two successive sievings, shall not be greater than 40%.

2.9. GRADING OF COARSE AGGREGATES

- A. The coarse aggregates shall be divided into 3 categories:

1. 5/12.5
2. 12.5/25
3. 25/50

- B. Coarse aggregates will be divided into classes defined by d/D, and shall meet the following conditions:

US Standard Sieve Designation	Per cent passing by weight		
	5 /12.5 mm	12.5 /25 mm	25 /50 mm
76.2 mm (3 inches)	-	-	100
50.8 mm (2 inches)	-	-	90-100
38.1 mm (1 1/2 inch)	-	100	35-65
25.4 mm (1 inch)	-	90-100	3-10
19.1 mm (3/4 inch)	100	35-65	0-3
12.7 mm (1/2 inch)	90-100	3-10	-
9.5 mm (3/8 inch)	35-65	0-3	-
4.8 mm (No. 4)	3-10	-	-
2.4 mm (No. 8)	0-3	-	-

2.10. NOT USED.

2.11. PROPERTIES OF AGGREGATES

A. General

Characteristic	Value	Test Method	Field of application
Water absorption, Ab	< 5	ASTM C 127 ASTM C 128	Coarse aggregate Fine aggregate
Los Angeles, LA	< 40	ASTM C 131 ASTM C 535	Aggregates > 2.5 mm Coarse aggregates
Flattening coefficient	< 30	NF P 18-561	Aggregates > 4 mm
Sand equivalent ESV	> 75	ASTM C 2419	Fine aggregate mixtures of sands

B. Sand equivalent

Fine aggregates having an equivalent sand value (ESV) which is less than the specified value may be accepted if the blue value (BV) measured according to standard NFP 18-595 is less than 1 g per 100 g of fines passing through the 80 micron sieve.

2.12. TRANSPORT AND STORAGE OF AGGREGATES

- A. The transport and storage methods shall be such as to guarantee a stable and uniform water content and to avoid any segregation.**
- B. The different classes of aggregates shall be stored separately in silos or on a concrete platform or by any other means guaranteeing an equivalent level of cleanliness. The storage area must be designed to ensure effective drainage of the aggregates. The aggregates shall be stored sheltered from rain and protected from solar radiation.**
- C. The capacity of the storage specified in para. B for each class of aggregates shall be sufficient to ensure progress of work on the site for a duration of 8 days.**

2.13. VERIFICATION OF AGGREGATES

A. Normal frequency N

- 1. Every week or every 500 m³ of concrete if the volume of concrete manufactured is less than 500 m³ per week.
- 2. For every new delivery of a material of different origin or obtained by a different process.

B. Frequency xN

- 1. Every x tests carried out at the normal frequency.
- 2. For every new delivery.

C. Tests to be performed on the aggregates:

Characteristics	Method ASTM	Field of application	Frequency
Grain size analysis	C 136	All aggregates	N
Water content	C 566	Fine aggregates	N
Water content	C 566	Coarse aggregates	N
Fineness modulus diagram	C 136	All aggregates	10 N
Water absorption	C 127	Coarse aggregates	5 N
Water absorption	C 128	Fine aggregates	5 N
Los Angeles	C 131-C535	Aggregates > 2.5 mm	15 N

Organic matter	C 40	Fine aggregates	10 N
Sand equivalent	D 2419	Fine aggregates	N
Soundness	C 88	All aggregates	15 N
Flattening Coefficient	NF P 18-561	Aggregates > 4 mm	5 N

D. The tests shall be performed on samples taken in accordance with the Engineer's instructions.

E. Diagram of fineness modulus

At the specified frequency, a series of 10 sieve analyses will be made at intervals of about 1 hour. The following will be noted on a diagram: the 10 results, the average of the 10 results, the straight lines situated at 0.10 and 0.20 unit above and below the mean value. The results of the fineness modulus determined by the normal sieve analyses shall also be shown on this diagram.

F. Blue value

Measurement of the blue value shall be made where the equivalent sand value (ESV) is less than the specified value.

2.14. WATER

A. The mixing and curing water shall be free of any impurities which might significantly affect the duration of setting, the strength or durability of the concrete or which might affect the appearance of the concrete by discolouration, coloration or efflorescence.

B. The mixing and curing water shall meet the following specifications:

Impurity	Maximum content (part per million - ppm)
Suspended matter	2000
Carbonates and bicarbonates	1000
Sulphate (SO ₃)	1000
Dissolved salts	2000

C. Where the dissolved salt concentration exceeds the specified value, or where the water quality is doubtful in the Engineer's opinion, comparative tests of compressive strength and setting time will be performed on two cement pastes with the same cement, one with the water in question and the other the reference paste, with distilled water in the same proportions. The water will be acceptable if the test results comply with the following values:

Test	Limit	Standard
Compressive strength at 7 days minimum result compared to reference paste	90 %	ASTM C 349
Start of setting: maximum difference from time of reference paste	1 h	ASTM C 191

D. Control tests shall be carried out:

- For approval of the water.
- For any change in the source of supply.
- In any event, once every three months.

2.15. ADDITIVES

- A. Additives shall comply with ASTM C 494.
- B. The use of additives containing calcium chloride is forbidden.
- C. All additives shall be in liquid form.
- D. Provision shall obligatorily be made for the automatic addition of any additive.
- E. The concrete shall be made with addition of a water-reducing plasticizer, with the exception of blinding concrete.
- F. The Contractor shall submit, for approval of any proposed additive, a memorandum demonstrating, on the basis of test results, the compatibility of the additive with the other concrete ingredients, its influence on the proportion of water for equal consistency, its effect on consistency for equal proportions of water, the times of beginning and end of setting of the neat cement paste, and the mechanical strengths of the concrete obtained. These tests are performed for the optimum proportion proposed and for half and double of this optimum proportion.
- G. Where specified, the following additives shall be used:
 - 1. Air entrainer.
 - 2. Shrinkage reducer for certain sealing grout or mortars; this additive shall be free of iron.
 - 3. Setting accelerator for shotcrete.

2.16. CLASSES OF CONCRETE

- A. The concrete classes are defined by their characteristic strength f_c in MPa, followed by the specified coarser aggregate dimensions in mm.
- B. The characteristic strength f_{ck} is the compressive strength at 28 days on 150 mm dia cylinder for all concrete classes A, B, C, D, below which less than 5% of the tested samples should be found.
- C. Classification table:

Class	Class according to BS EN 206-1	Definition	f_{ck} (MPa)	Coarser aggregate dimension (mm)	Cement content kg/m ³		Max water/ Cement ratio max W/C
					min	max	
A	C35/45	Reinforced concrete Precast concrete	35	25	350		0.45
B	C20/25	Unreinforced and lightly reinforced concrete	20	40	250	320	0.55
C		Shotcrete	25	-	350	400	-
D		Blinding concrete	15	25	180	250	-
E		Porous concrete	10	40	200	250	-

2.17. CONCRETE COMPOSITION

For each class of concrete, a memorandum shall be submitted to the Engineer demonstrating that for the design consistency, the proposed composition and the installations on site will produce concrete satisfying the specifications.

If the proposed concrete has not been made previously from materials of the same type and origin and with equivalent site installations, a concrete design study shall be made for testing, with the exception of blinding concrete.

2.18. CONCRETE DESIGN STUDY (CONCRETE CLASSES A, B, C)

A. Purpose

1. Check that the nominal composition of the concrete proposed by the Contractor enables the specification to be met.
2. Check that the concrete specifications are still respected if the quality of the ingredients reaches the specified limits or the probable limits of the ingredients used.
3. Check that the concrete specifications are still respected if the proportions of the ingredients reach the specified limits or the probable limits resulting from the site installation (the design limits may also be chosen so as to study several nominal compositions simultaneously).

B. The design test will involve the following operations:

1. Three batches meeting the nominal formula.
2. Eight batches varying from the nominal formula as follows:
 - a) Two batches by modifying the proportions of aggregates (for example variation of the ratio of the mass of coarse aggregates to that of finer aggregates by 10% in either direction).
 - b) Two batches by altering the quantity of mixing water (10 l/m³ more and less).
 - c) Two batches by altering the quantity of cement (25 kg/m³ more and less).
 - d) If an additive or additives are used, two batches by altering the quantity or quantities of additives (half and double the optimum quantities).

C. Measurements made for concrete classes A, B and C:

1. Each batch shall be the subject of the following measurements:
2. consistency;
3. density and air content within the fresh concrete;
4. density of concrete at 28 days;
5. compressive strength at 7 days on three samples;
6. compressive strength at 28 days on three samples and static modulus of elasticity and Poisson's ratio (in addition to ASTM C 469 strains shall be measured for stresses of 3, 5, 7, 9, 11 MPa).
7. The components shall be subject to the control measurements specified elsewhere.
8. Also to be noted are the following factors:

- Temperature of the components and of the concrete during the tests.
- Aspect of the fresh concrete during performance of the consistency test and of the preparation of the specimens.
- Aspect of breakage during the mechanical tests.

D. Not used.

E. Interpretation of the design test:

1. The design test shall be considered valid and the composition of the concrete accepted if all the following conditions are met:
 - e) All consistency results are within the specified ranges.
 - f) The arithmetic mean (f_{cE}) of the 9 measurements (3 tests on each of 3 batches) of compressive strength in MPa measured at 28 days is greater than:
$$f_c + (C_E - C_{min})$$
and greater than $1.1 f_c$,
formula in which C_E is the compressive strength at 28 days of the cement used for the design test and C_{min} is the minimum guaranteed value of the cement's compressive strength at 28 days.
 - g) The arithmetic mean of the 3 compressive strength tests on each of the complementary batches is within the range of $f_{cE} \pm 0.15 f_{cE}$.
2. If the above conditions are not totally satisfied but the concrete is close to the required values or well in excess of these values, the Engineer will, if the Contractor submits a proposal to this effect, fix the nominal composition of the concrete without any further design test.

F. Not used.

2.19. CONCRETE SUITABILITY TESTS (CONCRETE CLASSES A AND B)

A. The suitability test, to be performed on the site at least 40 days before making any concrete for the permanent Works, shall be aimed at verifying the following:

1. that the concrete made by applying the nominal composition, using the materials and constructional plant delivered to the site, satisfies the specifications,
2. that the concrete composition, considering the installations it is envisaged to use, will enable the structures to be built in a satisfactory manner,
3. that the characteristics of the plant are in conformity with those submitted to the Engineer's approval.

B. The suitability test, performed under conditions representative of the site (transport, installations and plant used, temperature, etc) implies the making of three batches to the nominal composition and will involve:

1. Casting of a reference concrete sample in representative formwork, where required by the Engineer.
2. Casting of a volume of 1 m^3 of concrete.
3. Performance of the same sampling and tests as for the design test.
4. Verification of the characteristics of the site installations or the materials supplied.

C. The test shall be interpreted on the same basis as the design test.

2.20. NOT USED

2.21. CONCRETE CONSISTENCY (CONCRETE CLASSES A AND B)

- A. The consistency of the concrete shall be such that it can be placed using the site facilities and compacted so as to enclose completely the reinforcement bars and embedded parts and completely fill the formwork, with neither voids nor segregation.**
- B. Consistency shall be checked by measuring the slumps test (ASTM C 143).**
- C. For concrete with aggregate larger than 40 mm, the test shall be performed on the fraction of concrete passing 40 mm sieve (the larger aggregate being removed in accordance with ASTM C 172).**
- D. The consistency classes are as follows:**

Consistency Class	Nominal slump (in cm)	Nominal Tolerance
Very stiff	1	0 - 2
Stiff	3	2 - 4
Semi-plastic	5	3 - 7
Plastic	8	6 - 10
Fluid	15	12 - 20

- E. The consistency classes shall be applied in the following manner:**
 - 1. 3 cm for mass concrete without embedded parts.
 - 2. 5 cm for slabs and lightly reinforced parts of the structures, for the main structures and the upper sections of walls and columns.
 - 3. 8 cm for narrow walls (< 40cm), columns, beams and heavily reinforced parts of the structures, and for lining concrete in underground excavations.
 - 4. Fluid conditions (slump of 15 cm or higher) shall be exceptionally applied when required by Engineer (around steel lining penstock for instance).
- F. The Engineer reserves the right to specify different consistencies where required by the nature of the works.**
- G. The concrete consistency shall be measured at the time it is used at the Engineer's discretion. If the measurement made falls outside the specified limits, two control measurements shall be made immediately, and the result shall be taken as the average of the three measurements, rounded off to the nearest centimetre.**
- H. In case of sampling for testing the strength of the concrete, 3 measurements shall always be made.**

2.22. PARTICULAR SPECIFICATIONS FOR SHOTCRETE

The composition of shotcrete shall be defined according to the recommendations of the AFTES (Association Française des Travaux en Souterrain i.e. French Association for Underground Works) relating to the technology and application of shotcrete.

The Contractor shall propose to the Engineer the composition of the shotcrete in terms of sieving of the aggregates alone and of the aggregate-cement mix. The particle size curves shall fall within the reference ranges recommended by AFTES. The Contractor shall also communicate to the Engineer the results of the tests carried out in laboratory in accordance with the same recommendations, depending on which concrete projection technique is adopted.

A. Suitability test

Forty days before commencing any shotcrete works, the Contractor shall perform suitability tests in the Engineer's presence, which shall cover, depending on the observed characteristics of the concrete ingredients:

1. Operation of the cement-mixers, of the control devices and the sprayed installations, under normal site operating conditions.
2. The quality of the shotcrete:
 - simple compressive strength at 8 h, 24 h, 7 days and 28 days,
 - adherence of the shotcrete to the terrain (minimum adherence on the most critical fissures or joints: 50% of the maximum adherence obtained on sound surfaces),
 - continuity of the shotcrete (no voids between the terrain and the shotcrete nor within the shotcrete itself),
 - apparent density of the shotcrete,
 - effective composition of the concrete,
 - consistency measurement (without additives).

These tests shall be carried out on not less than three tests panels for each mix for testing. Sets of test panels shall comprise one shot downwards on to a horizontal surface, one shot on to a vertical surface and one shot on to a overhead horizontal surface.

2.23. SPECIAL SPECIFICATIONS FOR POROUS CONCRETE

- A. Porous concrete is one containing no sand, used for drainage purposes under structures.**

The Engineer shall be responsible for defining whether or not it is to be used.

B. Composition

No sand shall be used.

2.24. PARTICULAR SPECIFICATION FOR BLINDING CONCRETE

- A. The blinding concrete is designed to be placed in the structure foundations on common soil; the layer of blinding concrete must be impermeable.**

- B. The concrete shall be obtained from a mix of sand, aggregates in the 5-12.5 and 12.5-25 size categories and cement at 275 kg minimum per m³ of concrete. The exact composition shall be proposed by the Contractor.

2.25. PARTICULAR SPECIFICATIONS FOR FLUIDIFIED CONCRETE

- A. Fluidified concrete will be used only when required by the Engineer.
- B. The concrete composition shall be the composition of a pumpable concrete and the amount of material finer than 0.250 mm (fine sand and cement) shall be at least 450 kg per cubic metre of concrete.

This concrete shall have a consistency measured by the slump test of 6 cm with the tolerance specified above, before addition of the fluidizer.

- C. The fluidizer shall be added to the concrete mixture already transported to the concreting site in a liquid form by means of an automatic control system. The fluidizer addition shall be followed by an additional mixing of the concrete-fluidizer mixture in a special concrete mixer (minimum mixing time: 3 mn) or in the truck mixer itself (minimum mixing time: 5 mn).
- D. The amount of fluidizer added shall be such that the slump of the mixture after the additional mixing is 15 cm. However this amount shall not be less than 0.5 % of the cement in weight.
- E. The setting retarder effect of the fluidizer may be compensated by use of an approved combined setting accelerator if required.
- F. **Suitability test**

Forty days before commencing any concrete works, the Contractor shall perform suitability tests in the Engineer's presence, which shall cover, depending on the observed characteristics of the concrete ingredients:

1. Operation of the cement mixers, of the control devices for fluidizer addition, of the additional mixing and of the final transport of fluidified concrete to the site (pipes, channels...).
2. The quality of the fluidified concrete:
 - a) Consistency measurement (before and after the fluidizer addition).
 - b) Simple compressive strength at 1, 3, 7 and 28 days.

The strength shall be at least 90 % of the corresponding strength of the same concrete without addition of the fluidizer.
 - c) Measurement of air content of fresh concrete after the additional mixing.
 - d) The compatibility of the fluidizer with any other additive possibly used, as requested above for any additive proposed.
 - e) Suitability of the concrete mix as regards to segregation.
 - f) Suitability of the concrete mix as regards to pumpability.
 - g) Effect of the variations in the quantity of fluidizer added, as described above for the submittal of any additive to the approval of the Engineer.

2.26. CONCRETE MIXING

- A. The aggregates, water, cement and additives shall be mixed in an automatic concrete-mixer with batching by weight, equipped with:**
 - 1. a wattmeter (slumpmeter or any other approved concrete workability meter),
 - 2. a printed register for recording the date and time of batching, the weight of cement and aggregates and the water-cement ratio.
 - 3. A continuous moisture measuring device for sand.
- B. The output of the plant shall be adapted to the programme of work and shall be at least 100 m³/hour.**
- C. After the concrete has been mixed, no subsequent addition of water in the course of concreting will be tolerated.**
- D. The mixing operation shall be under the control of a suitably experienced supervisor.**
- E. The sequence of filling a mixer with the concrete ingredients shall be studied during the suitability tests and subject to the approval of the Engineer and unless otherwise authorized, the same sequence of filling shall be followed throughout the work.**
- F. The quantity of mixed materials per batch shall not exceed the manufacturer's rated capacity of the mixer, and shall be further reduced for fluid concrete.**
- G. An automatic timing device shall be used to set the duration of mixing.**
- H. Mixing time shall be adjusted according to mix compositions and the mixers used and shall be at least 45 s after all components have been added. In the case of concrete containing admixtures, a minimum mixing time of 60 s shall be observed.**
- I. At intervals decided by the Engineer, but which normally be once per day for coarse aggregates and at some other interval depending on the operation of the continuous moisture measuring device for sand, the Contractor shall carry out tests by an approved method to determine the free moisture content of the aggregates. Based on these tests, adjustments shall be made to the quantity of water added to the mix to maintain the specified water cement ratio.**
- J. On commencing work with a clean mixer, the first batch shall contain only half of the normal quantity of the coarsest aggregate category and 10 % extra cement so as to compensate for the fine material and cement which is left sticking to the drum. This batch shall be mixed for at least one minute longer than normal.**
- K. The mixer shall be completely emptied before being charged with the materials for the succeeding batch.**
- L. Weight tolerances:**
 - 1. Cement and water:± 2%
 - 2. Aggregates:
 - Sand..... ± 3%
 - Coarse aggregate ± 5%
 - Total of the aggregate..... ± 3%
 - 3. Admixture: ± 5%
- M. Checking of weighing scales**

The precision of the weighing scales of the batching plant shall be checked at the beginning of each month.

If the precision falls outside the specified tolerances, the batching plant shall not be used again until the scales have been adjusted or repaired as necessary.

N. Mixer performance

Mixer performance shall be determined in accordance with ASTM C 94 to determine the uniformity of the mixture.

3. EXECUTION

3.2. INSPECTION

- A. No concreting shall start until issue by the Engineer of a 'concrete permit'.**
- B. The Contractor shall request this permit at least 24 hours before the presumed start of concreting and after checking that the parts designed to be embedded in the concrete (reinforcement bars, waterstop joints, tie-rods, etc) and the formwork are correctly placed and fixed and that all surfaces designed to be in contact with the concrete have been prepared. The checking before concreting will also include for the dam, water circulation through the watertight coiled pipes, as well as the resistance of these pipes to pressure in excess of the maximum service pressure.**

3.3. PREPARATION

- A. Before casting any concrete layer, the surface of the previously cast concrete shall have been subjected to treatment consisting of the following operations:**
 - 1. Grout shall be removed from the surface, so as to reveal the mosaic of the concrete, without dislodging the coarser aggregates, nor the reinforcement bars or other embedded parts. Where possible, treatment shall be effected after the concrete has set but before hardening, using either a water jet under pressure or a mixture of air and water under pressure, alternatively by brushing the surface with a wire brush. Where this treatment is precluded by the hardening of the concrete, the surface shall be treated either by high-pressure water jet or by sand blasting, or by scabbling the surface. In case of scabbling, the fissured or loosened pieces shall be removed
 - 2. Cleaning with water and air under pressure.
 - 3. Moistening for a minimum duration of 24 hours before concreting.
 - 4. Elimination of excess water and final cleaning.
- B. Before placing concrete on the rock or common soil, the foundation surfaces shall be prepared as indicated under Section 02210.**

3.4. CONCRETE PLACING

- A. Concrete shall be transported from the mixer to its final position in such a manner that the concrete as placed shall not have lost excessive moisture or grout, nor become segregated.
- B. The concrete shall be placed and compacted in a such a manner as to avoid any movement of formwork, reinforcement bars, embedded parts or parts to be embedded.
- C. If required by the Engineer, the first layer of fresh concrete placed on hardened concrete shall consist of a mix which is the same as that of the new lift but without the larger nominal category of coarse aggregates. This layer shall be between 4 and 10 cm thick as directed and shall be covered before it has started setting.
- D. On rocky surfaces, immediately before concreting, a 5 cm thick layer of concrete class A shall be placed over the entire surface and in any fracture joints, so as to ensure an effective rock-concrete bond. The necessary arrangements shall be adopted to cover this mortar with concrete before it has started setting.
- E. The necessary arrangements shall be taken to ensure that all waterstop and other embedded items are effectively well covered by concrete and that they are not subject to any movement compared to their theoretical position.
- F. Qualified personnel shall be included in the concreting team to apply the appropriate remedial action in case of any incident such as movement of forms, steel bars, joints, drains, ducts, grouting valves, grouting groove protection, etc.
- G. The Contractor shall provide a means of direct communication between the concrete batching plant and the location of concreting (telephone or radio-telephone).
- H. In case of simultaneous placing of different classes of concrete, the Contractor shall provide a system of identification which will follow each concrete until it is placed.
- I. The concrete shall be poured as close as possible to its final position. The concrete shall be moved within the formwork by shovel and not simply by flow induced by vibration which is forbidden. Any accumulation of gravel shall be dispersed within the mass of the concrete. Any water shall be removed as and when it appears.
- J. Within each lift, concreting shall be effected in successive layers not exceeding 50 cm in thickness, unless otherwise stipulated by the Engineer.
- K. For massive concrete structures, the lifts shall not exceed 2.50 m in height. The time interval between completion of one lift and starting the next shall be at least 72 hours. The height of these lifts and the time elapsed between successive lifts may be modified depending on temperature changes recorded in the concrete already cast, as compared to the specified temperatures.
- L. Before it is covered by a new layer, each layer shall be fully compacted but shall not have begun to set.
- M. All concrete shall be compacted by internal high frequency vibrators except the fluidified concrete. The number, size, frequency and power rating of the vibrators shall at all times be adequate to obtain appropriate and rapid compaction of the entire volume of concrete to be placed. A third of the required number shall be kept available for use no more than 15 min from the location of compaction.

- N. The vibrators shall be introduced vertically at regular intervals within the concrete to be compacted. If the layer being placed covers a freshly compacted layer, the vibrators shall be introduced to a depth of about 10 cm in the preceding layer. The vibrators shall be withdrawn slowly, so as not to allow the formation of any void.
- O. Vibration shall continue until the rise of air bubbles has practically stopped, and shall be stopped as soon as laitance or excess water appears.
- P. The vibrators shall not be inserted into the concrete hazardly or irregularly, nor used to move the concrete from one point to another within the formwork. The vibrators shall not enter into contact with the reinforcement bars nor with the formwork.
- Q. Where use of external vibrators is agreed, they shall be securely clamped to the shutters to ensure maximum efficiency.
- R. Where the presence of air bubbles is prejudicial to the structure, the thickness of the layers shall be reduced, and additional compaction shall be effected along the formwork, after the regular compaction of the overall concreted area.
- S. If in the course of placing concrete, it may become necessary by reason of an unavoidable breakdown of plant or for other reasons accepted by the Engineer, to interrupt concreting and if the concrete has taken its initial set, the surface of the concrete shall be treated as a construction joint.

3.5. CONCRETING IN HOT WEATHER

- A. When the daily maximum temperature exceeds 35°C, concreting shall take place at night-time, unless special arrangements are adopted for mixing, transport and placing of the concrete.
- B. These particular arrangements could include:
 - 1. Spraying of gravel and pebbles.
 - 2. Cooling of water.
 - 3. Spraying of formwork.
 - 4. Protection of the concrete during transport and placing against solar radiation.
 - 5. Use of ice in mixing water.
 - 6. Painting water tanks with reflecting paint.
- C. In all cases, the temperature of the concrete when it is placed shall be less than:
 - 1. 28°C for massive structures, i.e. structures with a thickness more than 0.60 m.
 - 2. 32°C for other structures of which the thickness is less than 0.60 m.

3.6. CONCRETING IN COLD WEATHER

- 1. In cold weather concreting may take place only if the following precautions and provisions are rigorously observed.
- 2. Suitable means shall be provided to warm the aggregate and/or mixing water, or otherwise to ensure that the temperature of the concrete leaving the mixer shall not be lower than

100C. Aggregates, cement and mixing water bearing or containing ice shall not be used and no ice shall be present in any mixer, hopper, skip, vibration or other apparatus in contact with the concrete. Mixing water shall not be heated above 60oC. Salt or chemicals including proprietary accelerators or hardeners shall not be mixed with the concrete for the purpose of preventing freezing or accelerating hardening unless permitted by the Engineer.

3. Concrete when deposited shall have a temperature of not less than 5oC. Suitable precautions shall be taken to ensure that the temperature of the concrete after placing does not fall below this temperature until it has thoroughly hardened.
4. In putting forward his proposals for concreting in cold weather, the Contractor shall have regard to the recommendation contained in “Winter Concreting” as published by the Cement and Concrete Association, 52 Grosvenor Gardens, London SW1, UK.
5. If the Engineer is not fully satisfied with the Contractor’s arrangements, no concreting shall take place when the shade temperature is below 20C or if there is any prospect of frost within 24 hours (i.e. if the shade temperature is below 30C and falling).
6. The Contractor shall provide and keep available for the Engineer’s use a thermometer suitable for measuring the temperature of aggregate and a maximum and minimum thermometer which shall be hung in a position approved by the Engineer.

3.7. CONCRETING IN WET WEATHER

During wet weather, all necessary tarpaulins, baffles, diversion channels, etc., shall be laid to protect areas prepared for concreting and/or newly placed concrete from heavy rain and run-off. Surfaces on or against which concrete is to be placed shall be protected from becoming excessively wet prior to concreting.

3.8. CURING OF CONCRETE

- A. Exposed concrete surfaces shall be kept damp by one of the following methods:**
 1. Covering horizontal surfaces with a layer of sand, hessian or other absorbent material maintained in a damp condition.
 2. Continuous watering, maintaining a flow of water over the concrete.
 3. After watering, covering of the surface with an impermeable membrane.
 4. Application of a curing compound.
- B. The use of a curing compound will not be permitted for surfaces which will receive a further concrete lift without any further preparation and for surfaces whose aspect may be affected by the curing compound.**
- C. Curing shall commence as soon as possible after placing of the concrete for unshuttered parts and immediately after removal of formwork in other cases.**
- D. Curing shall be continued for a period of 14 days unless otherwise agreed by the Engineer.**
- E. Underground concrete shall not require curing when the relative humidity of the air is higher than 75%.**

3.9. SECOND STAGE CONCRETE FOR SEALING EMBEDDED PARTS OF EQUIPMENT

- A. Placing of second stage concrete shall not proceed until embedded parts have been completely assembled, aligned and secured.**
- B. Constant caution shall be exercised in placing concrete to avoid distortion and displacement of parts being embedded.**
- C. The workability shall be sufficient to achieve satisfactory pouring in the interstices of the first stage concrete.**
- D. A controlled expansive admixture from an approved manufacturer shall be added. The admixture shall be mixed in accordance with the manufacturer's instructions. Prior tests shall be conducted before final approval can be given by the Engineer to adjust the amount of admixture to obtain. Cast iron powder admixture shall not be used in contact with high-tensile steel nor in direct contact with water.**
- E. For small holes (section less than 1 dm²), mortar shall be used. The mix shall be 450 kg of cement per cubic metre of sand with the addition of an approved controlled expansive admixture.**
- F. Interface between the first and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.**
- G. Interface between the equipment and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.**
- H. Formwork shall be perfectly connected with the first stage concrete; irregularities shall be made good by means of grinding.**

3.10. PRECAST CONCRETE

- A. The working drawings may provide for certain parts of structures to be made from precast elements but, for ease of execution, the Contractor may ask to precast other parts of structures not initially indicated as such.**
- B. The Contractor shall submit clear details of the casting and placing procedures that he intends using as well as his planned arrangements for the precasting yard. Precasting work can start as soon as the Engineer has given his approval of the foregoing details and arrangements.**
- C. Precasting shall be organised in such a manner that:**
 - 1. Precast parts are always kept away from sunlight.**
 - 2. Precast parts are not handled for a period of 8 days after casting, unless concrete strength tests indicate the possibility of handling the parts within a shorter time.**
 - 3. All parts from the same mould are stored together.**
 - 4. No stored part shall be subjected to any load other than its deadweight.**
 - 5. Precast parts are installed in their final positions no earlier than 21 days after casting, unless concrete strength tests indicate the possibility of reducing this time.**

- D. The casting date and part references (or mould number) shall be written on each part in the fresh concrete.
- E. Faces in contact with covering concrete after placing shall, if necessary, be treated as concrete construction joints; this clause shall be especially applicable in cases where intermediate slabs are used, the restarting surface of which must be treated accordingly.

3.11. CONCRETE SHUTTERING UNDERGROUND

- A. Such concrete shall be placed mechanically unless otherwise approved by the Engineer.
- B. Inflowing water shall be collected and piped to a dewatering system before executing any lining concrete.
- C. Arch keying shall be carried out as accurately as possible and, in any case, shall meet the minimum lining thickness requirements. Unless otherwise specified on drawings or approved by the Engineer, the minimum thickness requirements is the thickness of the concrete between the 'A' line and the exposed surface of the concrete. Keying shall be checked by exploratory drillings made at the Engineer's request.
- D. With the exception of fluidified concrete (refer to the particular specification), the concrete shall be compacted using external vibrators and completed using internal vibrators inserted inside the formwork through windows. The number and size of these windows shall be sufficient to vibrate the concrete under optimum conditions.
- E. Closure of these windows shall be made watertight.
- F. Unless explicitly authorised by the Engineer, no timber supports shall be incorporated in the final lining.

3.12. BLINDING CONCRETE

- A. Blinding concrete shall be used when the structural concrete is in contact with a non-rock foundation.
- B. The final mean thickness shall be 10 cm and never less than 5 cm.
- C. Blinding concrete shall cover the entire area to be concreted.
- D. The Contractor shall arrange for the recovery and elimination of all infiltrating water so that there is no risk of the concrete being washed out.

3.13. SHOTCRETE

- A. Shotcrete shall be used for permanent work structures only as directed by the Engineer.
- B. In so far as is possible and after scaling and cleaning, walls shall be wetted before placing shotcrete. The same precautions shall be taken in the case of shotcrete placed in several layers.
- C. There shall be no significant inclusion of rebound in the finish work, no hollow areas, good adherence to the rock and reasonably smooth surface finish.
- D. The final thickness of shotcrete shall never be less than 5 cm.

- E. The Contractor shall provide for all inflowing water to be collected and diverted through drilled drains or surface pipes in order to prevent the shotcrete from being washed out and uplift pressures from forming on the treated surfaces.
- F. Mesh reinforcement must be fixed to the rock or to a preliminary layer of shotcrete at several points. The concrete covering on the reinforcement shall be of 20 mm minimum thickness.
- G. After placing the shotcrete, any movement of the steel reinforcement shall be prohibited.
- H. The profile after shotcreting shall be considered in the same manner as an excavation profile and shall not therefore have any part projecting inside the line as defined by the Engineer.

3.14. WEAR-RESISTANT CONCRETE

- A. The Contractor shall propose special micro-concrete of the Lafarge "Alag" type or similar with high adherence, abrasion-resistance and shock-resistance characteristics at places where this is necessary as defined on the drawings.
- B. A complete file containing the characteristics of the products and details of the procedure to be used shall be submitted to the Engineer for approval.
- C. In all cases, the following minimum procedure shall be followed:
 - 1. Floor reinforcements shall be placed at a minimum of 10 cm from the finished surface with a tolerance of +2 cm and -0 cm.
 - 2. Pouring of primary concrete shall take into account the thickness of the wear-resistant concrete, i.e. 8-10 cm from the finished level (rebars must be embedded by at least 2 cm).
 - 3. The top surface must be cleaned with air and water under pressure before it has completely set, or by high-pressure cleaning after it has set.
 - 4. The support must be completely saturated (24-48 hours).
 - 5. Wear-resistant concrete is poured and thoroughly vibrated in chequerboard 2 m x 2 m slabs during stage 1 (class 1 surface quality).
 - 6. The concrete is kept moist after it has begun to set (by spraying or by using a curing agent).
 - 7. The stage 2 slabs are cast after a minimum period of 24 hours.

3.15. CONCRETE FOR DIAPHRAGM WALL COATING

Not used

3.16. DEPOSITION OF CONCRETE ON FOUNDATIONS

- A. The Contractor should keep free of running water and pools the surface of rock upon or against which concrete is to be deposited. Fissures or seams in the rock shall be cleaned out to a depth satisfactory to the Engineer and if necessary stemmed with cement mortar of an approved mix. The rock surface will be inspected by the Engineer before concreting starts.
- B. For deposition of concrete on earth foundations the surface of foundation shall be levelled out before concreting, a layer of blinding concrete shall be disposed on all the surface in contact with the concrete structure and the concreting may start after approval by the Engineer.

- C. The blinding concrete layer shall not be less than 5 cm thick. Blinding concrete specified on the drawings shall be measured and paid at the rate tendered.
- D. For hydraulic structures the concrete foundations shall be placed over and/or aside an adequate filter sufficiently drained, as shown in the drawings or as specified by the Engineer.

3.17. CONCRETING CONSTRUCTION JOINTS

- A. The location of concrete construction joints, other than joints shown of the Drawings or specified, shall be approved by the Engineer; concrete shall be placed continuously between joints.
- B. Duration between the two stages of concrete for a construction joint shall be approved by the Engineer.
- C. All construction joints shall terminate against firm shuttering. All necessary steps shall be taken by means of timber edgings, etc. to ensure an exact finish to edges of joints which are exposed to view.
- D. Before placing concrete against concrete which has already set at a construction joint, the surface of the previous concrete shall be prepared by the following methods. If the preparation is carried out before the previously placed concrete has hardened, the surface shall be cleaned with water and air at 5 kg/cm² pressure to expose the coarse aggregate. If the concrete has hardened the surface shall be scabbled at least 2 cm deep and cleaned in such manner that no loose particles of aggregate or damaged concrete remain on the surface. In all cases the surface shall be thoroughly cleaned with an air and water jet at 5 kg/cm² pressure to remove all laitance, scum and foreign matter. The surface shall be wetted before placing new concrete against it.
- E. Construction joints shall be so located and the amount of concrete placed at any one time shall be so limited in size and shape as to minimise shrinkage and temperature effects.

3.18. CONCRETING MOVEMENT JOINTS

- A. Joints between concrete surface are not intended to bond together (contraction joints) shall have the first formed surface painted with two coats of bituminous paint, the second applied after the first has thoroughly dried or according to the instructions of the Engineer.
- B. Waterstops shall be fixed with at least 5 cm clearance from any reinforcement bar, accurately positioned as shown on the Drawings and tightly fixed in the shutters before concreting starts. Connections shall be made to ensure watertightness and all precautions taken for careful concreting around the waterstop.
- C. No nail shall be driven through any part of a waterstop for fixing. Any waterstop punctured or torn to any extent shall be replaced before concreting.
- D. Shuttering of the first concreted surface of the joint shall be placed carefully perpendicular to the surface of the structure. Waterstops shall be placed carefully on a straight line and perpendicular to the surface of the joints, and/or according to the shape shown on the Drawings or instructions of the Engineer.

- E. Particular care shall be taken with the protection of the outer part of waterstops half embedded in the structure and awaiting completion.
- F. In the event of excavation in the vicinity of the waterstop or when more than one month elapses before completion of the structure, a protection device such as a wooden box shall be provided by the Contractor. Rubber waterstops shall be stored in as cool a place as practicable and in no case shall they be exposed to the direct rays of the sun.
- G. All joint implements such as waterstops, joint fillers, sealing compounds, etc. shall be handled and settled in accordance with the instructions given by the Manufacturer. All related notices and instructions shall be furnished to the Engineer prior to any approval being given.
- H. Compressive filler (flexcell) when placed against concrete faces shall be fastened with adhesive before concreting of the next element.
- I. When required, the joints shall be sealed with concrete mortar containing 400 kg of cement per cubic metre of mortar containing admixture if requested by the Engineer. The edges of the grooves shall be previously carefully watered and cleaned with a brush to remove any foreign bodies. Then the grooves shall be filled with mortar, compacted and surfaced and dressed by handwork. Immediately after completion, the joint shall be protected against the sun and regularly sprinkled with water as requested by the Engineer.

3.19. FINISHING OF NON-SHUTTERED CONCRETE SURFACES

- A. The Contractor shall be responsible for finishing non-shuttered concrete surfaces as soon as concrete placing has been completed and before hardening.
- B. Surfaces shall be finished using a simple screed, a vibrating screed, a float, etc. or by any other means enabling the required quality to be obtained. Screed guiding devices and supports shall be submitted for the Engineer's prior approval.
- C. Surfaces shall be provided with a slope to allow water to drain off, as provided for on the drawings or as instructed by the Engineer.

3.20. FLUIDIFIED CONCRETE

- A. The fluidified concrete shall not be poured from more than 1 metre in height and where required channels or pipes for the concrete transport shall be used.
- B. The fluidified concrete shall be poured within the time for which the fluidizer has a real effect. No addition of fluidizer or water or any other additive in order to prolong this effect will be tolerated after the initial addition of the fluidizer.
- C. Shuttering and forms shall be designed to withstand the full load exerted by the liquid concrete. In addition they shall be fully watertight in order to prevent any loss of the mix.
- D. Where required by the Engineer, the fluidified concrete will be slightly compacted by use of low frequency vibrators.

3.21. INSPECTION TEST AND ACCEPTANCE OF CONCRETES CLASSES (A, B AND C)

- A. Definitions

1. Lot: a lot of concrete is a structure or part thereof or set of structures or parts of similar structures cast in a single lift using concrete of the same class.
2. Sampling: a given sampling is effected on a single batch and one batch can give rise to only one sampling.
3. Result: a result is the average of the measurements made on all the samples taken for a given sampling (generally three).

B. Sampling frequency

1. The number of samplings made shall be as follows:
 - h) Mass concrete (Class B)
 1. one for a lot of less than 500 m³
 2. two for a lot of more than 500 m³
 - i) Other concrete (Class A)
 1. one for a lot of less than 50 m³
 2. two for a lot of 50 to 250 m³
 3. three for a lot of more than 250 m³
2. The sampling frequency shall be greater at the beginning of the works in order to make sure of quality levels as quickly as possible, and during periods when, in the Engineer's opinion, quality is considered doubtful.

C. Tests to be carried out

1. The following tests shall be carried out for each sampling:
 - j) Three samples 160 mm dia cylinder for determination of compressive strength after 28 days (ASTM C 39).
 - k) One measurement of air content (ASTM C 231).
 - l) One consistency measurement (ASTM C 143).
 - m) One temperature measurement.

Additional tests may be required by the Engineer, especially when the concrete consistency varies to a significant extent.

2. On average every three samplings and in accordance with instructions given by the Engineer:
 - n) Three samples for determination of the compressive strength after 7 days.
 - o) Three samples for determination of the tensile strength after 28 days (ASTM C 496).
3. On average every 30 samplings and in accordance with instructions given by the Engineer, 12 samples for determination of modulus of elasticity, compressive and tensile strength after 90 and 365 days (six after 90 days and six after 365 days).
4. All samples shall be taken at the time and on the site of concrete placing.

D. Concrete acceptance criteria

1. A lot shall be deemed to conform to specifications when the following conditions are satisfied:

- p) Consistency: the test result(s) come within the specified tolerances.
- q) Compressive strength after 28 days:
 - 1. Each result is higher than 0.85 f_c
 - 2. In the event of three or more samplings from a lot, the average of the results is greater than f_c .
- 2. A concrete of a given class shall be deemed to conform to the specification when the average of any 3 consecutive results (not necessarily from the same lot) is higher than f_c .

E. Use of 7-day and 28-day test results

For each class of concrete, the results of all the tests shall be used to establish a "least-square" line of best fit to define the relationship between test results and the age of the concrete. The relationships shall be continuously updated during the period of the Contract, and shall be used for the initial assessment of 90-day strength from 7-day and 28-day strengths, or the initial assessment of 28-day strength from 7-day strength.

F. Ready-mix lorries

The concrete in each ready-mix lorry shall be checked for uniformity within the context of the concrete suitability tests and then every quarter according to ASTM C 94. If concrete uniformity is not satisfactory, one of the following measures will be taken until the specifications are met:

- 1. Increase in mixing time.
- 2. Reduction in quantity of concrete transported.
- 3. Modification of ready-mix lorry.

3.22. TESTING FOR WATERTIGHTNESS OF REINFORCED CONCRETE RESERVOIRS

On completion of the works, the reservoirs shall be tested for watertightness when filled with water, before backfilling around the reservoirs and before applying coating or facing on external face of walls.

Each reservoir shall be filled slowly with a rate of 1.50 m (rise of water level in 24 hours, up to top water level). Before testing a period of 10 days will be necessary for the initial soakage and every day water will be added to raise the water level to its initial level. It will have to make clear that the level drop decreases each day.

Water for tests shall be provided by the Contractor. The Contractor shall provide all necessary equipment to transfer the water used for tests from one reservoir to another to be tested.

When the soakage period has been completed, the test shall be started by refilling the reservoir to top water level and accurately recording the level each day over a period of seven days. The evaporation shall be checked by fixed in the reservoir a steel tank filled with water. Any drop in level in the steel tank will then be considered as evaporation loss. The structure will be deemed to be watertight if the total loss of water does not exceed 0.5 l per day and per square meter of wet concrete face.

The reservoir shall not be finally accepted as satisfactory until all leakages exceeding this value have been eliminated by treatment with appropriate products and with pressure grouting

techniques. In this eventually, the treatment shall be approved by the Engineer and the Contractor shall repair at his own expense any leak involved.

From the time a reservoir is accepted, the Contractor shall keep the interior in wet conditions until commissioning of reservoir. This can be assessed by keeping a minimum water level inside each accepted reservoir, or any other mean approved by the Engineer.

Just before commissioning, each reservoir shall be emptied and disinfected according to a methodology proposed by the Contractor and approved by the Engineer.

3.23. ACTION IN THE EVENT OF NON CONFORMANCE (FOR CONCRETE CLASSES A, B AND C)

- A. If the consistency of the concrete is outside the nominal tolerance by inside the maximum tolerance, the composition of the fresh concrete shall be checked immediately, in particular the water content of the aggregates and quantity of water in the concrete. The Contractor shall make all necessary adjustments to recover the right consistency.**
- B. If the consistency of the concrete is outside the maximum tolerance, the concrete shall be rejected.**
- C. If the 28-day test results assessed from 7-day test results is abnormally low the Contractor shall stop concreting, establish the reasons for the strength decrease and take the necessary remedial action.**
- D. If the 28-day test confirm the assessment from 7-day test that the characteristics of concrete do not conform to the Specifications the volume of concrete represented by the samples shall at the discretion of the Engineer be subject to one or more of the following provisions:**
 - 1. Cores from the suspected portions of the structure shall be drilled and tested in accordance with BS 6089 to determine whether the equivalent cylinder strength of the in situ concrete satisfies the specified strength requirements.
 - 2. If the results of test on the cores taken in terms of (1) indicate that the concrete does not satisfy the specified requirements, the Engineer will decide whether or not full scale load tests or an ultrasonic pulse velocity investigation may be carried out.
 - 3. If in the opinion of the Engineer, the load tests are impracticable, or if a tested portion of the structure fails to pass the tests the Contractor shall, on the instructions and directions of the Engineer, and if possible, strengthen by approved means each section that failed or which contains concrete that failed, as relevant and also any other section, irrespective of strength requirements, the functional purpose of which is affected.
 - 4. The works shall be demolished and reconstructed at the Contractor's expense, if the reinforcement or strengthening of the structure is not possible.
- E. If it is found during concreting that the coefficient of variation of 28-day test results for a particular class of concrete is less or more than 14 percent, the Contractor and the Engineer shall meet to decide on the necessary reduction or increase respectively in cement content required to maintain the nominal strength of the concrete with the specified rate of failure. The reduction or increase in cement content shall be to the Contractor's account if this is attributable to him.**

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SECTION 03350

CONCRETE REPAIR

1. GENERAL

1.1. WORKS INCLUDED

This Section covers all operations in connection with concrete repair works to existing concrete structures.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DEFINITIONS AND DESCRIPTION

For the purpose of repairs to existing concrete the following types of defects shall be distinguished:

- Cracks 1 up to 3 mm wide
- Leaking Cracks 1 up to 3 mm wide
- Cracks 3 up to 20 mm wide
- Defective Concrete as loose, broken or honeycombed concrete
- Deteriorated Joints
- Voids under Concrete Slabs

1.4. SUBMITTALS

The Contractor shall furnish the Engineer with three (3) signed copies of the inventory of proposed works for approval to the Engineer. No works shall start until the Contractor has received the written approval from the Engineer.

2. PRODUCTS

2.1. GENERAL

For all mortars, grouts, resins and other products described in this section, the Contractor shall propose the products he intends to use in the Works and shall submit to the Engineer for

approval full information on these products. All products shall have no adverse effects on potable water.

Products named elsewhere in this section are an indication of the standard type and workmanship of goods which are satisfactory to the Engineer. The Contractor may use named products or equivalent other products after the approval of the Engineer in accordance with the Specifications, Conditions of Contract and with the manufacturers specifications.

2.2. WATER, STEEL AND AGGREGATE

Water for use in mortars and concrete shall be clean, fresh, water free from all deleterious matter, silt, organic matter, alkali, slate and other impurities. It shall preferably be from a potable water source (from the public water supply network) or from other approved sources.

Reinforcement steel shall in all aspects comply with the requirements described in *Section 03200 – “Reinforcement”*.

Sand or other aggregate for mixing with grout shall comply with the requirements for fine aggregate described in *Section 03300 – “Concrete”*.

3. EXECUTION

3.1. DEWATERING AND CLEANING

All repair work to existing concrete shall be carried out in the dry. The Contractor shall therefore dewater the concerned structures and clean the surfaces from all sediment, algae, bushes, stones, trash and all other foreign matter to the satisfaction of the Engineer.

3.2. IDENTIFICATION OF REPAIRS

After cleaning the concrete from any foreign matter the Contractor shall survey the exposed surfaces and make an inventory of the work to be done distinguishing the types of defects as described in this Section and submit the inventory of proposed work to the Engineer for approval. In a joint survey of the Engineer and the Contractor the inventory will be discussed and the Engineer may instruct the Contractor to make modifications in the inventory of proposed work after which modifications the Engineer shall approve the inventory for execution. The Contractor shall furnish the Engineer with three (3) signed copies of the inventory of proposed work for approval to the Engineer and after approval the Engineer shall sign these copies and return one (1) signed copy to the Contractor. The Contractor will execute the work accordingly and in accordance with these Specifications.

3.3. REPAIR OF CRACKS 1 UP TO 3 MM WIDE

The Contractor shall repair cracks in structural concrete by injection with an appropriate injection resin.

When the cracks are dry an epoxy resin of low viscosity shall be used. In other cases injection shall be done with a low viscosity polyurethane resin.

The Contractor shall first blow, clean, oil free compressed air through the crack before any resin is injected in order to remove as much as possible any dust or grit that may obstruct the flow.

When the crack is cleaned, a superficial seal will be applied at the surface of the member by using a fast setting material such as any appropriate polyester resin, in which injection nipples are fixed at intervals. The most satisfactory spacing of the injection nipples shall be found by experience, but is usually less than the estimated depth of the crack. The most suitable pressure for injection the resin shall also be found by experience. The spacing and pressure are to be to the satisfaction of the Engineer.

Injection shall be done by an approved and established epoxy resin injection system. Epoxy injection resin of low viscosity shall be subject to the approval of the Engineer. No injection shall be done without the approval of the Engineer.

3.4. REPAIR OF LEAKING CRACKS 1 UP TO 3 MM WIDE

3.3.1. REPAIR BY INJECTION

The Contractor shall inject leaking joints with waterstops in structures with a suitable polyurethane injection resin.

The polyurethane injection resin shall be of low viscosity and reacting with water as to fill all cavities in and adjacent to the joint. Injection shall continue until all leaks are stopped.

To relieve the water pressure if necessary, drain pipes shall be fixed into the remaining concrete so that the water can discharge freely. After the injection material has hardened, the drain pipes shall be cut off or removed and the remaining holes will be plugged one by one with a very quick-setting material that can be held in place by hand until it has set.

The Contractor shall submit for approval to the Engineer the method of injection, material and equipment he proposes to use. The Engineer may at his discretion instruct the Contractor to modify his proposal in accordance with the instructions of the Engineer. No injection will be done without the approval of the Engineer.

3.3.1. REPAIR BY LINING

Concrete slabs featuring many leaks due to cracks and other small porosities of the concrete shall be waterproofed by application of a internal lining. Slabs subjected to variable direction of water pressure shall not be repaired with this method but only via the method as described in Clause "Repair by Injection".

The lining shall be applied only on the inside of water retaining structures so that the lining is compressed between water and concrete.

The lining shall be an epoxy resin and or cement based sealant. The material shall have a durability of 25 years or more and provide a watertight and easy to clean surface. The material shall be capable of bridging and filling 3 mm wide cracks under the existing water pressures.

Particular care shall be taken to ensure all concrete surfaces are completely free from algae, oil, dust, grease, corrosion and any other deleterious matter before application of the lining.

3.5. REPAIR OF CRACKS 3 UP TO 20 MM WIDE

The Contractor shall clean the crack from all dirt and other foreign matter and roughen the surfaces mechanically. After cleaning the crack with oil free compressed air the surfaces will be primed with an approved and established primer.

All exposed reinforcement shall be thoroughly cleaned from any loose rust or other foreign matter. Exposed reinforcement shall be primed with an approved and established primer, to prevent further corrosion.

If the reinforcement has broken or deteriorated too far the crack must be repaired as described in Clause "Repair of Defective Concrete". Then the crack shall be filled with a suitable, approved and established watertight non shrink grout and cured directly after application with a curing agent.

3.6. REPAIR OF DEFECTIVE CONCRETE

When concrete has broken out, has become loose, shows honeycombing or any other similar defects, it shall be removed and the affected member reconstructed to its original section.

The Contractor shall remove all loose or deteriorated concrete until only sound material is encountered. Concrete shall in any case be removed to 25 mm behind any exposed reinforcement.

All exposed reinforcement shall be thoroughly cleaned from any loose rust or other foreign matter. Exposed reinforcement shall be primed with an approved and established primer, to prevent further corrosion.

If the reinforcement has broken or deteriorated too far, new reinforcement shall be placed. To accommodate this reinforcement, holes shall be drilled in which the new bars are fixed with an epoxy resin. As an alternative the surrounding sound concrete can be broken out until sufficient lap length has been acquired to accommodate the new bars. If neither option is suitable, an external steel or concrete bracing shall be constructed. The final solution to be applied shall be approved by the Engineer.

Particular care shall be taken to ensure all exposed concrete surfaces are completely free from laitance, oil, dust, grease, corrosion and any other deleterious matter. Laitance shall be mechanically removed by high pressure water blasting, grit blasting or a combination of both.

The edges of the repair area shall be sawn or cut to a depth of 10 mm to avoid feather edging.

All concrete surfaces shall be in a saturated surface dry condition prior to priming.

Priming shall be done with an approved and established primer after which the broken out area will be repaired with a suitable watertight non-shrink grout approved by the Engineer. Immediately after finishing the repair the mortar shall be cured with a curing agent.

3.7. REPAIR OF DETERIORATED JOINTS

At contraction, construction or movement joints where the filler and or sealant has deteriorated, replacement is required. Hereto the Contractor shall replace both the joint filler and or the sealant. He shall cut out and remove the existing joint filler and or sealant and clean the joint from vegetation, sediment and other foreign matter. The edges of the concrete shall be square. If edges have broken up to 10 mm deep the new joint filler shall be placed deeper. Broken edges from 10 to 30 mm shall be cut square to give a square but wider joint. At edges broken deeper than 30 mm the concrete shall be broken back till 25 mm behind the nearest reinforcement and repaired in accordance with the clause "Repair of defective concrete".

After clearing and squaring up the recess in the concrete the joints shall be filled with flexible filler and or sealant. This shall comply with the requirements as described in sub-clauses "Movement Joint Filler" and "Joint sealer".

Only in movement joints the following alternative construction may be used; a vacuum tube of butyl rubber shall be placed in the joint and the voids left over shall be filled with butyl putty. The vacuum tube and butyl putty shall be of an established type and approved by the Engineer.

3.8. REPAIR OF VOIDS UNDER CONCRETE

During reparation of cracks or joints in otherwise sound slabs, hollow spaces may be found behind the slabs. In such cases and where indicated by the Engineer the Contractor shall fill the hollow spaces with a suitable cement based grout.

Depending on the type of joint, grouting shall be done either before or after completing other repair works on the joints or cracks.

If the voids are not accessible through at least 10 mm wide joint rebates then holes shall then be drilled through the concrete slab, with a maximum distance between successive holes of 700 mm centre to centre. Through the holes the hollow spaces shall be grouted.

The grout will be subject to the approval of the Engineer and shall be of a suitable viscosity.

The area to be grouted and working method will be proposed by the Contractor to the approval of the Engineer; or as instructed by the Engineer. No grouting or drilling shall be done without the approval of the Engineer.

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SECTION 04000

MASONRY WORKS

1. GENERAL

1.1. WORK INCLUDED

This section covers masonry works as required for:

- Internal positions.
- Other small structures according to Drawings and description of the works.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. QUALITY ASSURANCE

Finished rendered work shall be true, plumb, or levelled and straight to a maximum tolerance of 3 mm in a 1 m.

Finished surface shall be free of waves or distortions, square with adjoining work, flush with casings, and free of any defect detrimental to appearance or performance.

All masonry works will be rendered (see 2.5) on both internal and external walls.

1.4. CODES AND STANDARDS

A. British standards

BS EN 1745 Masonry and masonry products - Methods for determining design thermal values

BS EN 772 Methods of test for masonry units

BS EN 845-2 Specification for ancillary components for masonry - Part 2: lintels

BS EN 1015 Methods of test for mortar for masonry.

BS EN 13139 Aggregates for mortar

BS EN 998-2 Specification for mortar for masonry - Part 2: masonry mortar

B. French standards

NF P 13-301 Hollow terra cotta bricks.

NF P 13-304 Facing clay bricks.

XP P 13-305 Clay masonry units. Common solid or perforated clay bricks and perforated clay blocks. Requirements and test methods.

2. PRODUCT

2.1. CONCRETE BLOCKS

The blocks shall be 20 cm thick for outside walls and 10 cm for partitions.

No overall dimension (width, height or length) shall differ by more than 3 mm from the specified dimensions.

The minimum compressive strength shall be:

- a. for individual unit: 15 MPa,
- b. for the average of 3 units taken as a sample: 17 MPa.

The maximum water absorption shall be 250 kg/m³, when soaked for one hour in water.

All units shall be sound and free of cracks or other defects, and shall have uniform colour, texture and appearance.

2.2. CONCRETE LINTELS

Lintels for doors, windows and other openings left in the concrete block walls and partitions shall be reinforced concrete designed according to the span of the opening, but never less than 10 x 15 cm. Each lintel shall be reinforced with a minimum of four 10 mm dia. bars.

2.3. MORTAR FOR PLACING BLOCKS

General requirement for sand used in concrete (Section 03300) applies except that the sand for mortar shall contain no particle greater than 2 mm.

The mix shall be 400 kg cement per m³ of sand.

The mortar is to be mixed dry in a mechanically operated drum type mixer and water shall be added after the constituents have been thoroughly mixed.

Mortar which has begun to set or which has been mixed for more than 30 minutes shall not be used or remixed.

The mixer shall be operated at the speed recommended by the manufacturer and the total quantity of materials mixed in each batch shall not exceed the rated capacity of the mixer.

The entire content of the drum shall be discharged before a new cycle of batching is started and at all times the inside of the drum shall be kept free from a build-up of materials. The mixer drum shall be thoroughly cleaned prior to change of mix or on cessation of mixing.

2.4. METAL WALL TIES

Cavity walls and wall facing shall be provided with galvanised steel ties with a minimum section of 10 mm².

Not less than 4 ties shall be fixed per square metre.

2.5. MIXES FOR RENDERING (CEMENT OR CEMENT-LIME PLASTERING)

The mixes for rendering shall be:

Treatment	Mix proportions (parts by volume)		
	Cement	Lime	Sand
Exterior	1	1	5
Interior	1	1	6
Rough cast finish	1	2	9
Smooth finish	1	4	8

The method of measuring materials for the render shall be such that the specified proportions of the materials can be controlled and accurately maintained during the progress of the work.

The quantity of water shall be such as to obtain a satisfactory workability for the specific use of each render.

Render which is set or become dry or unworkable shall not be used nor retempered with water.

Any render that is not used within 30 minutes after the first water has been added shall be rejected and removed from the Site.

The equipment and tools used for transporting and for placing batched render shall ensure that contamination and loss of ingredients do not take place.

2.6. BRICK WORK

2.3.1. BRICKS

Bricks will be used for partitions only.

Bricks shall be of the best available quality.

Bricks shall be sound, hard, uniform in colour, regular in size and shape with straight parallel surfaces and sharp edges and free of cracks, stones and lumps, especially of lime.

Bricks intended for fair-faced walls with tooled joints shall be particularly suitable with regard to durability and weather-resistance and of uniform colour.

Bricks shall be well burnt. Their compression strength shall be at least 5.5 N/mm² on an average of any twelve (12) bricks, but at least 3.5 N/mm² for any individual brick.

The Contractor shall submit brick samples along with test certificates to the Engineer for approval.

2.3.1. DAMP-PROOF COURSE

Damp-proof course shall be provided for all block-work at approximately 200 mm above ground level using.

- bituminous roofing felt not less than 3 mm thick or
- polyethylene sheeting not less than 0.5 mm thick
- or any other approved material,

laid on an even bed of cement-sand mortar (1:1) and lapped 150 mm at all joints. The damp-proof membrane shall cover the full width of the blocks.

2.3.1. MORTAR

Mortar to be placed between the bricks shall be cement-lime-sand mortar in the ratio of 1:1:6.

Below the damp-proof course, the blocks shall be laid in cement-sand mortar in the ratio of 1:4.

2.7. INTERNAL PLASTER

Internal plaster shall be applied to walls and partitions in offices, toilets and entrance hall.

Internal plaster to walls and ceilings shall be applied to the bonding coat. The undercoat shall be 1 part gypsum browning plaster to 3 parts sand by volume, applied firmly in one continuous operation between angles and joints to a thickness of not less than 10 mm, cross scratched to provide a key for the next coat.

The finishing coat shall be gypsum finishing plaster applied to a thickness of 5 mm and trowelled or floated to produce a tight, matt, smooth surface with no hollows, abrupt changes of level or trowel mark. This coat shall be applied to the undercoat as soon as it has set and has developed reasonable suction. Internal plastering shall generally be carried out in accordance with BS5492.

Alternatively internal plaster to walls shall be applied to the bonding coat in two coats. The undercoat shall be a mix of 150 kg cement, 0.30 m³ lime and 1 m³ sand applied to a thickness of 15 mm. The finishing coat shall be to the same mix, but the sand shall be very fine, applied to a thickness of 5 mm.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

2.8. EXTERNAL SMOOTH RENDER

Smooth render shall be applied to plinths, columns, overflows and gargoyles, copings, and elsewhere as required.

The undercoat shall consist of one part sulphate resisting cement to two parts lime to six parts sand by volume. It shall be applied firmly in a thickness of 15 mm cross scratched to provide a key for the next coat.

The finishing coat shall be composed of one part white Portland cement, one part lime, one part limestone powder and four parts white gypsum by volume with oxide colouring agent added to suit applied in a thickness of 8 mm. The coat shall be trowelled to create a flat, smooth, hard surface.

Coats shall be applied in a continuous operation wherever possible. Joints where unavoidable shall be formed with a neat V-joint through the full thickness of the finishing coat.

2.9. EXTERNAL TEXTURED TYROLEAN RENDER

Textured render shall be applied to mid-wall panels and roof fascias and elsewhere as required.

The undercoat shall be one part sulphate resisting Portland cement to two parts lime to four parts sand by volume applied in a thickness of 15 mm.

The textured coat shall consist of one part white Portland cement to five parts lime to three parts of sand by volume with oxide colouring agent added to suit and shall be spattered onto the wall by a hand operated machine to give an even but rough texture to the surface. All adjoining surfaces that are not to receive the finish shall be adequately masked. The thickness of coating shall be sufficient to cover the undercoat. External rendering shall be carried out in accordance with BS 5262.

3. EXECUTION

3.1. PREPARATION

All surfaces designated to receive concrete blocks shall be clean and level to the lines and grades shown in the Drawings or as directed.

Laying of blocks shall not proceed until the Engineer has inspected and approved the prepared surfaces.

3.2. BLOCKWORK (CONCRETE BLOCKS REFERRED ALL AS BLOCKS)

Blockwork shall be built without recesses or projections unless otherwise shown on the Drawings.

Blocks shall be soaked in water before use. The tops of walls left off shall be wetted before work is recommended.

Blocks shall be well buttered with mortar before being laid and all joints shall be thoroughly flushed up, raked or pointed as the work proceeds. Except or otherwise specified vertical and horizontal joints are not to exceed 1 cm in thickness.

Blockwork shall be carried out in a uniform manner such that no portion shall be more than 1 m above another. Blockwork shall be kept true and square and the whole properly bonded together. Particular attention shall be paid to ensure strict verticality of blockwork.

Half block walls and inner and outer skins of double-skin walls and casings shall be built in stretcher bond.

All blockwork shall be cleaned down on completion to remove mortar dropping, runs or stains and again before rendering to remove any efflorescence.

Expansion joints shall be provided in external blockwork at approximately 12 m centres. The joint shall be formed with "Flexcell" or other approved expansion strip and sealed with "Seaastic" or other approved joint sealer. Care shall be taken to ensure that the wall is properly bonded or tied at each side of the expansion joint to prevent any loss of stability.

When required, galvanised steel ties, meshes or cramps shall be carefully embedded in the mortar.

3.3. BONDING OF BLOCKS TO CONCRETE WORKS

Where blockwork abuts concrete columns, walls or beams, there shall be adequate bonding between the two materials by means of wire ties or approved wire mesh which shall be recessed 40 mm from the face of the brickwork or blockwork at such intervals as approved by the Engineer.

3.4. CONNECTION WITH DOORS AND WINDOWS

The spaces around the door frames and built-in items shall be solidly fixed with mortar.

Spaces around the door and window hold fasts shall be filled with concrete Class A.

3.5. BRICKS OR BLOCKS TO BE RENDERED

Blocks which are to receive rendering or plastering shall have a surface which will ensure good adhesion of the applied finish.

3.6. RENDERING

Projecting burs of grout shall be removed and the surface shall be wire brushed and cleaned with scrubbers. If the surface is smooth it shall be prepared by roughening with a pointed tool to form pocks, not less than 3 mm deep, spaced not more than 5 cm apart.

Outside rendering shall be of uniform thickness applied in one coat of 15 mm minimum.

Inside plastering shall be 20 mm thick made of two layers: 15 mm under coat and 5 mm finished coat.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

3.7. LAYING OF BRICKS

The Engineer will take samples of bricks at random from deliveries to the site for comparison with the approved specimen. Supplies which are not in conformity with the requirements shall be removed from the site.

All brick work shall be set out and built to the thickness and heights required, be built strictly vertical and all quoins etc. shall properly be bonded together, laid perfectly plumb, true to line, level and in accurately spaced courses.

Before laying the bricks they shall be soaked in water for at least one (1) hour.

Mortar shall be mixed dry and water added until the correct consistency is obtained. All mortar shall be used within forty-five (45) minutes after the addition of water.

Walls shall be bricked up in a uniform manner so that no portion is raised more than 0.75m at any time.

Mortar joints shall be full and approximately 10 mm thick. They shall be raked out at least 10 mm deep as the work proceeds.

At concrete columns, surfaces shall be chipped and steel binders shall provide rigid connection between column and blockwork, wherever no expansion joints are provided.

3.8. FINISHING

Following completion of rendering all surfaces shall be thoroughly cleaned.

Any unsatisfactory work shall be removed and the rendering shall be re-applied.

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SECTION 05100

STRUCTURAL STEEL CONSTRUCTION AND STEELWORKS

1. GENERAL

1.1. WORK INCLUDED

The Work included under this Section consists of shop design, supply and installations of miscellaneous metalwork (steel, stainless steel, aluminium,...) when required, including but not limited to the following items (if any):

1. Structural steel construction
2. Railings.
3. Ladders.
4. Steel stairs and rungs.
5. Hatches.
6. Hand rails.
7. Footbridges.
8. Chain-link fences.
9. Cast iron frames, covers and gratings.
10. Steel frames for precast concrete covers, miscellaneous metal covers and gratings.
11. Placing of anchor or embedded items.
12. Various steel supplies.

The work shall include all fittings, cutting, drilling and blocking required to install the Work, and to make all the required connections with adjoining work. All anchors, sockets, pipe sleeves and expansion bolts required for fixing the metalwork to the construction shall be furnished by the Contractor, except anchors for erection of equipment supplied under other contracts which will be supplied by other Contractors.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. QUALITY ASSURANCE

- a. General

Manufacturing of metalwork shall be executed by qualified personnel.

b. Qualification of Welders

Welders shall be certified welders in accordance with AWS 01.1.

Uncertified welders shall pass at site qualification tests in accordance with procedures recommended by AWS 01.1.

c. All the aluminium installation should be manufactured by a single manufacturer with a uniform finish and based on a prototype approved by the Engineer.

1.4. STANDARDS AND CODES

1. American Society for Testing and Materials

- a) ASTM A 36 Specification for Structural Steel
- b) ASTM A 48 Specification for Gray Iron Castings
- c) ASTM A 53 Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
- d) ASTM A 307 Specification for Carbon Steel Bolt and Studs, 60 000 psi Tensile
- e) ASTM A 575 Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
- f) ASTM A 788 Specification for Steel Forging, General, Requirement.
- g) ASTM B 221 Specification for aluminium Alloy Extended bars, Rods, Wires Shapes and Tubes

2. American Welding Society

AWS D1.1 Structural Welding Code

3. British Standards

4. European Standards

1.5. SUBMITTALS

The Contractor shall submit the following documents:

- Copies of certified manufacturer's tests.
- Shop drawings and erection drawings shall be submitted to the Engineer's approval at least one month before beginning the manufacture of the various items.

1.6. SHOP DRAWINGS

Shop drawings of all metalwork shall show detail of assembly, method of assembly, detail of anchorage or connection with the main structures.

1.7. TOLERANCES

A. Manufacture Tolerances

1. Dimensions without direct influence on the assembly of the element: 0.2%.
2. Main dimensions: 0.1%.
3. Local (area 200 x 200 mm): 0.5/400 cm².
4. Flatness: 1 mm.
5. Main parallelism, main squaring: 1 mm/m.
6. Straightness, alignment: 2 mm.

B. Erection Tolerance

7. Dimension without influence on the operation of the element: 0.2%.
8. Main dimensions: 0.1%.
9. Local (area 200 x 200 mm): 0.5/400 cm².
10. Flatness: 1 mm.
11. Straightness, alignment: 2 mm.
12. Verticality: 2 mm.
13. Horizontality: 2 mm.

C. All tolerances shall allow proper operation of the equipment.

2. PRODUCTS

2.1. MATERIALS

Except where otherwise specified, material shall be in accordance with EN 1993, EN 10025, EN 10210 and 10219.

2.2. FABRICATION

Each part shall be clearly marked in such a manner that part can be easily identified on shop erection drawings.

All metalwork shall be carefully and accurately assembled by welding or by screws, bolts and rivets, concealed as far as possible.

The joints shall be filled, milled or machined as may be necessary to secure close and perfect connections. All frames shall be provided with suitable bracing connections. All frames shall be provided with suitable bracing to maintain alignment during transport.

Members shall not be overstressed during the construction and hammering will not be permitted.

Any metalwork damaged during transport or erection shall be removed by the Contractor and replaced by new materials to the satisfaction of the Engineer at no extra cost to the Employer.

Built-up work shall be assembled completely at the shop, accurately finished and the section match-marked for field erection.

Concerning ladders, the fabrication shall include back protection whenever the ladder height is more than 2 m.

3. EXECUTION

3.1. INSPECTION

The Engineer will inspect all metalwork before erection on Site, such inspection covering:

1. assembly quality,
2. geometric characteristics,
3. corrosion protection,
4. embedded supports,
5. quality of surface finish.

3.2. ERECTION

No metalwork shall be incorporated into the Permanent Works until it has been inspected and approved.

All embedded metalwork shall accurately set in place before the concrete is poured or, subject to the approval of the Engineer, recesses may be left in the concrete and the metalwork placed, anchored and blocked in place after the concrete of the structures has set.

Where, in the Engineer's opinion, it is impracticable during construction to place anchors or fasteners required for the installation of ladders, or other miscellaneous metalwork, holes shall be drilled in the structures and expansion bolts installed.

Grout, where required, shall consist of epoxy cement or of aggregate, sand, cement and water in the proportions proposed by the Contractor and approved by the Engineer. Forms for grouting shall be installed where necessary. Grout shall fill all space of recesses, with no voids. After grout has hardened, any visible wedges shall be removed, and exposed joints neatly finished to a smooth dense surface.

3.3. WELDING

Members to be joined by welding shall be cut accurately to size, with edges sheared, flame-cut, or machined to suit the required type of welding and to allow thorough penetration. The surfaces of plates to be welded shall be free from rust, grease, and other foreign matter along the edges prepared for welding. The cut surfaces shall be free of all injurious defects.

Weddings shall be made in accordance with the Code for Arc and Gas Welding in Building Construction, as formulated by AWS. All welding shall be continuous along the entire line of contact, except where tack welding is permitted. All exposed welds shall be ground smooth.

No welding of galvanised steel shall be permitted.

Inspection of welds in all steel may begin immediately after the welds are completed. In addition to inspection as required by AWS D1.1, all welds shall be visually examined. Procedure, technique and standards of acceptance shall be in accordance with AWS D1.1.

The Engineer reserves the right to direct radiographs of the welds. Location and findings of all radiographic inspections, together with descriptions of any repairs made, shall be recorded on proper testing sheets.

3.4. CORROSION PROTECTION

Corrosion protection, galvanization and/or painting shall be carried out in accordance with Section 01010 - Corrosion protection.

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SECTION 07000

WATERPROOFING, INSULATION AND ROOFING

1. GENERAL

1.1. WORK INCLUDED

The works covered by this Section relate to the following items:

- Roofing;
- Framework;
- Covering;
- Weather-proofing;
- Heat insulation;
- Sound insulation
- Odour-proofing.

of all the closed and covered enclosures in order to guarantee closure and cover, and to prevent nuisance caused by noise and smells.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

The works in the present Section will cover all necessary works for the completion of the building, including framing, insulation, claddings, cladding accessories like bottom flap, acroterion cover, corner pieces, opening surround, cover strips, plugging,...

All the holes in the cladding will be such as to avoid any deformation (oblong holes), in any direction due to the deformation of the framing.

All the supply for the present Section shall be manufactured by a single manufacturer to insure a uniform finish.

When required, special washers shall be introduced to avoid direct contact between framing and aluminium cladding.

It also includes supply and installation of:

- Stormwater gutters and downspouts;
- Zenith lighting;

- Smoke outlets and associated remote control devices;
- Connections for roof outlets for smoke pipes or ventilation ducts;
- Connection and interface works between the different structures;
- All the accessories needed for perfect finishing work;
- Protective barriers to prevent falling of personnel and objects during the works period in accordance with regulations in force on the date of signature of the contract.

1.4. CODES AND STANDARDS

Works are to be carried out in accordance with standard professional practice, and in compliance with all current rules and standards.

- For example, French Standards AFNOR may be used together with DTU Specifications (Series 43 - Waterproofing, 43.1, 43.2, 43.3 and 43.5 - Ribbed steel sheet roofing.)
- Specific trade regulations where relevant (claddings, double-sided roofing, etc.).
- Fire prevention regulations (APSAIRD rules).
- Industrial safety regulations.

The Contractor shall propose a product and the corresponding standards guaranteed by the supplier and/or the manufacturer.

1.5. SUBMITTALS

- Calculation notes for framework, roofing, insulation, etc.
- Working design drawings with associated justification and detailed technical specifications;
- Report of terrace water priming test;
- Technical solutions, processes and schedule for work on structures to be rehabilitated.
- Colour shall be approved by the Employer and for this purpose, samples shall be submitted to the Engineer together with documentation required.

2. PRODUCTS

2.1. GENERAL

The materials used must comply with standards and regulations in force at the time of signature of the contract and must take into account the aggressive ambient atmosphere.

2.2. TRANSLUCENT PANELS

If PRV colourless translucent ribbed panels are used for external cladding, they shall comply with Standard NF P 38301 and shall be installed as indicated on the Drawings.

The supply shall include any additional connecting and supporting accessories.

2.3. HEAT INSULATION

2.3.1. VAPOUR BARRIER

Self-adhesive strips or added screens shall be laid as per DTU.

2.3.1. INSULATING SHEETS OR PANELS

Non-loadbearing insulating panels shall be installed and will contribute to heat resistance. It shall be laid as recommended per DTU.

Work shall comprise all laying and connection constraints, in particular for ventilation between roof sheets and insulation.

If panels are used, they shall be cut and raised level with ridge ventilation openings, to ensure free ventilation of buildings.

2.4. CLADDINGS

- A. Cladding shall be constructed of prelacquered steel sheets with minima thickness of 0.50 mm.**
- B. All accessories shall be prelacquered aluminium, as for outside cladding, with the same colour, or another colour as approved by the Engineer.**

All types of additional profiles and joint needed (like compriband expandable joints or gun laid joints), particularly at connecting points with other structures (for instance masonry, window and door frames) shall ensure absolute air and watertightness and perfect finish.
- C. Bottom flap shall be provided to form a dripboard at connection with walls and openings, closing up the bottom of the roof panels.**
- D. Acroterion cover shall be provided and crowns the top, at the connection with gutters, flashings or counterwallings.**
- E. Corner pieces shall be provided and especially shaped for re-entrant and projecting angles.**

3. EXECUTION

3.1. GENERAL

All waterproofing, insulation and roofing works shall be carried out in conformity with relevant European Standards.

3.2. COVERING AND WATERPROOFING

The terraced roofs shall be waterproofed by means of watertight layers and treated as specified hereinafter.

A. HEAT INSULATION

Before rendering the roof waterproof, a thermal insulation shall be laid consisting of 5 cm polystyrene foam, laid on a vapour barrier of 2/10 mm thick PVC sheet. Slabs of polystyrene foam shall be carefully placed without any gap. Broken slabs will not be allowed.

B. WATERPROOFING

The waterproofing shall be laid on a 100 g/m² glass fibre material for separating from heat insulation.

The waterproofing shall be constituted of two 110/35 thermoplastic bituminous elastomer flexible watertight coatings placed on a 250 g/m² unwoven polyester base. The first coating shall be unrolled dry and the second shall be propane gas heat-welded to the first.

The Contractor may propose non-conventional covering or sealing processes providing the same guarantees as standard solutions or elastomeric double layer lining.

All the necessary precautions shall be taken to limit noise (urban-type soundproofed equipment), dust and accident risks.

C. RAISING

On the inside faces of the parapet walls and all around the projections of the flatroofs (stacks of smoke pipes, ventilation, air coolers, etc.), the first coating shall be bonded by a cold impregnation sealant and a hot sealant application layer. The second flexible watertight coating shall be self-protected by aluminium sheeting and shall cover the inside face and the top of the parapet.

Expansion joints on the roof shall be covered with a continuous aluminium sheet, as shown on drawings. Special care shall be taken at crossing of two expansion joints.

D. COVERING

All roofs shall receive over the waterproofing:

- a layer of 10/30 gravel 8 cm thick, or
- precast tiles 30 x 30, 3 cm thick made with mortar with 350 kg of cement per cubic metre of sand; tiles will be placed with thin joint filled with bitumen and over a layer of sand 3 cm thick.

E. RAIN-WATER DOWN PIPES

Drainage or rain-water will be either through outside down pipes, or down pipes embedded in a concrete column or prefabricated water spout.

Down pipes shall be made of PVC, and 125 mm in diameter. A strainer shall be provided to prevent solid substances going through. At right angles with the emptying of rain-water a lead plate 40 cm x 40 cm welded to a pipe 30 cm long connecting the down pipe shall be provided. This plate shall be situated between two coats of bitumen felt, or butyl film.

When the rain-water down pipes are outside the building a lead plate shall be provided in order to pipe the waters down to a zinc box situated outside and fixed on the front of the buildings. From this box the rain-water down pipe shall be laid and fixed on the wall by removable pipe collars of galvanised steel.

Rain-water down pipes shall be connected to the general rain-water drainage system by means of a pit closed with a cast iron cover.

The Contractor shall submit the detailed layout of the drainage system to the approval of the Engineer.

All constructional measures shall be taken to weather-proof the facades of the structures.

SECTION 08100

DOORS AND WINDOWS - GLAZING

1. GENERAL

1.1. WORK INCLUDED

This section covers the manufacturing and fixing external air-tight doors and windows with single or double glazing as required for the various buildings.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. CODES AND STANDARDS

ASTM A-788	Specification for Steel Forging, General, Requirements.
ASTM B-221	Specification for Aluminium Alloy Extruded Bars, Rods, Wires Shapes and Tubes.
ASTM C-158	Method for Testing Flexural Testing of Glass.

1.4. QUALITY ASSURANCE

All the aluminium installation should be manufactured by a single manufacturer with a uniform finish.

2. PRODUCT

2.1. ALUMINIUM

Sections should be extruded from 6063-T5 aluminium alloy conforming to ASTM B-221.

2.2. FASTENING DEVICES

All the fastening devices shall be of aluminium, stainless steel or other corrosion resistant material with sufficient strength, and if visible should blend with the frame finishes.

2.3. HARDWARE - GENERAL

All the hardware fixed shall be of best quality available in the market. The finish of hardware must closely match the finish of doors and windows.

2.4. SCREEN AND MOSQUITO NET

All windows and ventilation openings shall be provided with insect corrosion resistant external screen and/or mosquito net.

2.5. HANDLE

Handle shall be brass or aluminium alloy, 100 mm long fixed with screws of the same material.

2.6. LOCK

At least all external doors shall be capable to be locked.

Locked doors shall be delivered with 3 keys.

Lock shall be automatic dead locking mortise lock with 2 bevelled latches and handles.

2.7. STOPPER

When required, doors shall be fitted with foot-operated friction door stoppers.

2.8. HYDRAULIC DOOR CLOSER

When required, doors shall be fitted with single-action type, face fixing hydraulic door closer.

2.9. HINGE

Hinge shall be brass built hinge of size 100 x 50 mm or extra heavy steel-butt-hinge of size 130 x 80 mm depending of the size of the door.

When shown on the Drawings or directed, doors shall be fitted with double-action oxidised brass, sprint-butt-hinge of size 100 x 50 mm.

2.10. GLASS

All the glass shall comply with the appropriate section of ASTM C-158.

Sheet glass shall be colourless free from bubbles, distortion and flaws of other significant nature. The glass shall be properly cut to fit the rebates so as to have a uniform space to accommodate rubber insertion all round the panel between edge of the glass and the rebate.

Plain glass is the type to be used for windows, doors, etc. unless otherwise directed. Its minimum thickness shall be 5 mm. The breaking strength under flexural load shall be not less than 30 MPa. It shall withstand 24 hours exposure to hydrochloric acid vapour and subsequent return to open air without impairment of either its transparency clearness or lustre.

Where phonic insulation is required, glasses shall have an acoustic absorption factor of 32 dB over the range 100 to 3200 Hz.

Unless otherwise agreed, glass blades for louvres shall be 150 mm wide with 25 mm overlaps and shall have polished edges.

Where the total length of a louvre exceeds 1100 mm, mullions shall be incorporated in the frame so that no louvre blade is larger than 1100 mm.

The blades shall be set into interlocking metal clips fixed to the frames. The clips and the frames shall be of aluminium.

Head and cell sections of the louvre frames shall match and be fitted with dual softness PVC or neoprene insert weatherstrips.

2.11. GLAZING BEADS

Metal glazing beads shall be supplied with the metal frame and shall be tightened with sunken screws.

All aluminium doors and windows shall have locking glazing beads and extruded vinyl gaskets.

2.12. DOORS AND WINDOWS

All windows and outside doors shall be designed to support a pressure of 1.5 kPa.

Buckling of openings: three angles of an opening being maintained fixed, a force of 100 N applied upright on the fourth free angle shall not introduce a displacement of this free angle greater than 5 mm.

The openings support a vertical force of 1 kN at the top edge of the door or windows opposed to the hinges without any permanent deformation.

Standard sized doors shall operate under a force of less than 5 daN and opening windows under a force of less than 3 daN.

Lock system shall be quick and efficient with the handle at 4 cm free distance from any fixed element.

Metallic joinery shall be built from standard sections allowing a dust proof joinery with double elastomer joints.

Number of hinges shall be 2, 3 and 4 for openings height of 1.00, 1.80 and 2.50 m respectively. Hinges shall be fitted with bronze ring and the male part shall be adjustable.

2.13. ENTRANCE ROLLING DOORS

Aluminium sheeting on steel framed door electrically controlled, suspended and rolling on an upper rail supported by the steel structure.

Insulation equivalent to insulation of aluminium insulated sheet walling (refer to section).

Ventilation openings with screen 600 x 600 mm.

Opening for glazing 600 x 800 mm (glass equivalent to the glass used for internal windows - refer to Section 2.10.D above).

Finishing equivalent to the sheet walling.

Shop drawings to be proposed to the Engineer's approval together with shop drawings for the whole buildings structural steelworks and sheet walling.

2.14. GLASS BLOCKS

Glass block walls shall be constructed from hollow glass blocks 240 x 240 x 80 mm or equivalent dimensions set in mortar in a perimeter framing to connecting walls and ceilings of aluminium channel sections.

The wall shall be set against the floor on 2 layers of bituminous felt. Channel sections shall be fixed to walls and ceilings with the concave face against the glass blocks and lined with 10 mm thick foamed polystyrene and 1 layer of bituminous felt before mortar is placed.

The glass blocks shall be set with flush joints to true horizontal and vertical lines in a 250 mm module. All channel sections shall be completely filled with mortar, and the joints between channels and mortar filled with an approved elastic joint filler.

Glass block walls shall be reinforced with 8 mm hot dip galvanized plain reinforcement bars around the perimeter and in every horizontal and vertical joint.

3. EXECUTION

3.1. FRAME

Where practicable, frames shall be placed prior to construction of enclosing walls and ceilings.

Frames shall be securely braced into position until permanent anchors are set.

3.2. GLAZING

Glazing channels, stops and rabbits shall be cleaned before receiving the glazing materials.

Glass shall be set in a manner which produces the best possible degree of uniformity in appliance.

Glass shall be protected from breakage after installation by installing streamers or ribbons attached to the framing and held free from glass.

3.3. PAINTING OF METAL WORK

All metal works shall be shop painted.

3.4. CLEANING

Glass shall be cleaned with methylated spirit on completion.

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SECTION 08200 PAINTING

1. GENERAL

1.1. WORK INCLUDED

1. Surfaces indicated to be painted in the description of the works.

1.2. RELATED SECTIONS

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. STANDARDS

Society for Protective Coatings (SSPC) Specifications, or equivalent

1.4. QUALITY ASSURANCE

Adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this Section shall be used.

1.5. SUBMITTALS

The Contractor shall submit 4 months before the scheduled date of painting 3 colour schedules of painting together with a description of colour codes, composition and manufacturer's recommendations concerning preparation of the surface and method of application of the paint of each type of paint and each type of exposure condition, as directed by the Engineer.

1.6. SAMPLE AREAS

Sample areas of not less than 1.50 m x 1.50 m shall be prepared and painted, one for each colour and/or type of surface finish as required or as directed by the Engineer.

If approved by the Engineer the sample areas will serve as minimum reference standards for painting.

1.7. DESCRIPTION OF WORK

The rooms will include the following interior works:

- Acid-resistant paint on floors with 10 cm run-up on interior walls in all electrical equipment, deodorisation and reagent storage rooms.
- Two coats of glyptal paint on all interior walls in technical equipment rooms, except pump pits, UV and tank building rooms.
- Two coats of glyptal paint on ceilings in electrical equipment rooms.

1.8. DELIVERY, STORAGE AND HANDLING

Paint materials shall be delivered in sealed original labelled containers, bearing manufacturer's name, type of paint, brand name, colour designation and instructions for mixing and/or thinning down.

All paints and associated materials shall be stored in dry covered storage which is adequately ventilated and protected from temperature extremes. Any paint which is, in the opinion of the Engineer, not in good original conditions according to manufacturer's specifications, shall be replaced by the Contractor at his own expense.

Precautionary measures shall be taken to prevent fire hazards and spontaneous combustions.

1.9. ENVIRONMENTAL REQUIREMENTS

Blast cleaning and painting work shall be carried out only when the ambient air and degree of humidity are within the requirements of the instructions for use of the product.

Paints shall be applied only to surface that are thoroughly dry and under such conditions of humidity and temperature as will cause evaporation rather than condensation. The surface temperature shall always be at least 3°C higher than the dew point.

Generally all work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C.

Adequate continuous ventilation shall be maintained before, during and after application of paint up the time of the paint if thoroughly dry.

Paint when applied shall be at approximately the same temperature as the surface on which it is applied.

2. PRODUCT

2.1. GENERAL

The type and quality of paint to be incorporated in the Works will be nominated by the Engineer, and only those products approved by the Engineer shall be accepted.

All materials shall be proven, first grade products and shall meet or exceed the average standards of reputable local manufacturers.

3. EXECUTION

3.1. INSPECTION

The Contractor shall thoroughly examine surface scheduled to be painted prior to commencement of work.

Defects and deficiencies in surface which may adversely affect work shall be corrected.

3.2. PROTECTION

The Contractor shall adequately protect other surface from paint and damage and shall repair damage to other surface as a result of inadequate or unsuitable protection. This shall include furnishing sufficient shields and protective equipment to prevent spray or dropping from fouling surfaces not being painted and particularly surfaces within storage and preparation areas.

Cotton waste, cloths and materials which may constitute a fire hazard shall be placed in closed metal containers and removed daily from Site.

Fittings and fastenings shall be carefully removed prior to painting operations. These items are to be carefully stored, cleaned and replaced on completion of work in each area.

3.3. PREPARATION

3.3.1. GENERAL

1. Surfaces to be painted shall be clean before applying paint or surface treatments. All oil, grease, dirt, rust, loose materials and other foreign substances shall be removed.
2. No coating work shall begin before the prepared surfaces, or the manner of preparation, have been approved by the Engineer.
3. Cleaning and painting shall be so programmed that dust or spray from the cleaning process will not fall on wet, newly painted surfaces.
4. Where required, imperfections and holes in surfaces shall be filled or obliterated in an approved manner.
5. Hardware, electrical fixtures and similar accessories shall be removed during preparation and painting operations and shall be replaced upon completion of painting operations.

3.3.1. CONCRETE AND MASONRY SURFACE

1. New concrete surface receiving paint shall be cured for a minimum of 28 days before being painted.

2. The Contractor shall remove contamination and shall acid etch and rinse new concrete floors with clear water, ensuring acid alkali balance is achieved.
3. The Contractor shall remove dirt, loose mortar, scale, powder, and other foreign matter from concrete and concrete block surfaces which are to be painted or to receive a clear seal.
4. Oil and grease shall be removed with a solution of tri-sodium phosphate, which shall then be thoroughly washed and drained from the surface.
5. Hairline cracks, small holes and imperfections on plaster surfaces shall be filled with patching plaster and the surface shall be smoothed to match adjacent surfaces.

3.3.1. WOOD SURFACE

1. Wood surface shall be planned or sanded to remove all tool marks.
2. All holes, cracks and depressions shall be cleaned out and overfilled with non-shrinking wood filler which, when completely set, shall be sanded back to match the adjacent surfaces.

3.3.1. PLASTER

1. Plaster shall be at least 2 months old and shall be thoroughly dry, clean, and free from grit, loose plaster, and surface irregularities before paint is applied.
2. Cracks and holes shall be repaired with patching plaster.
3. All plaster surfaces shall be tested for the presence of alkali which, if present, shall be removed with a solution of zinc sulphate mixed in the proportion of 1 kg to 2 litres of water. After drying, the precipitate shall be removed by brushing.

3.3.1. APPLICATIONS

No paint or other products may be applied until the surface has been prepared to the satisfaction of the Engineer and until the surface is completely dry.

Each coat of paint is to be slightly darker than the preceding coat unless otherwise approved by the Engineer.

Each intermediate coat is to be lightly sanded back before the application of the subsequent coat.

The paint shall always be thoroughly mixed according to the manufacturer's instructions prior to application and only approved thinners may be used.

The time between coats shall not be less than that recommended by the manufacturer.

Any painting considered to be unsatisfactory by the Engineer shall be sanded back and repainted at the Contractor's expense.

3.4. CLEANING

During painting the work area shall be kept clean and free of dust or other harmful substances.

On completion of painting the whole area shall be thoroughly cleaned or any splashes, spills or runs.

3.5. DRY FILM THICKNESS

The protective paint systems shall be applied in continuous films to give, at the minimum, the total dry thickness indicated in the coating schedule, as measured by approved methods.

One steel material wet thickness gauges shall be used continuously by the applicator during application to ensure that the dry thickness requirements will be met.

3.6. COATING SCHEDULE

The following coating schedule shall be adopted:

a. Wooden frames, doors

- Surface preparation: as specified.
- Prime coat: plasticised nitrocellulose sealer (2:) (such as NC Wood Sealer).
- Finish coat: plasticised nitrocellulose topcoat (3:) (such as NC Glossy Wood Finish).

b. Concrete and plaster

- Surface preparation: as specified.
- 1.Vinyl Emulsion Paint
 - Prime coat: alkali resisting masonry sealer (1:12) (such as Dulux Primeon).
 - Finish coat: vinyl acetate emulsion paint (3:60) (such as Paintex Vinyl Emulsion).
- 2.Plastic Emulsion Paint
 - Finish coat: (3:60)
- 3.Hard Gloss Enamel Paint
 - Long oil alkyd resin paint (3:60) (such as Dulux Synthetic Enamel).
- 4.Oil Repellent Paint and Concrete exposed to chemical action or heavy duty
 - In cracks and holes: epoxy sand mortar
 - Prime and finish coat: epoxy paint (4:120) (such as Epoxy Concrete Finish).
- 5.White colour Paint.
- No painting shall be applied to aluminium, stainless steel, copper bronze, chromium, nickel, brass or galvanized surfaces, unless directed by the Engineer.

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SECTION 08300

SUSPENDED CEILINGS

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading and erection of the miscellaneous suspended ceilings.

Works include but are not limited to the followings:

- supply and installation of metal framework and attachments for mounting to the load-bearing structure,
- supply and installation of tiles, strips, ceiling panels or other components of the ceiling itself including hooking, mounting and connection systems (anchors, clips, slides, slide rails, etc.),
- finishing (laquered metal profiles for edge covering, etc.) and all related works,
- protection of metal structures in the conditions defined in the present document,

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all other Contract Documents.

1.3. DESCRIPTION

Suspended ceilings shall be installed in halls, offices, sanitariums and in all pedagogical and living facilities. They won't be allowed neither in process areas nor in all exploitation and technical rooms in contact with water or condensation.

The false ceilings proposed may be of concealed framework, aluminium ceiling panels, coated gypsum board or laminated wood.

The selected materials must be suitable for the type of premises in which they are to be installed (humidity, excess pressure, etc.).

1.4. QUALITY ASSURANCE

1.3.1. CODES AND STANDARDS

Application of ceiling units shall be done in strict accordance with the manufacturer's specifications unless otherwise approved.

1.3.1. DESIGN CRITERIA

The false ceiling primary framework (where applicable) must be able to support the weight of lighting fixtures.

The secondary framework must be able to support the other technical equipment whether flush-mounted or suspended (fire detection system, sound installation, etc.).

All necessary measures must be taken to prevent problems due to condensation.

In damp premises, the false ceiling framework must be connected to the building earthing system.

1.3.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - A. The seals and the embedded parts shall be presented separately and unpainted for checking.
 - B. The surface appearance of embedded parts shall be examined and their dimensions checked.
 - C. All dimensions shall be checked.
 - D. Welds: Refer to Section 01020.

1.5. SUBMITTALS

The Contractor shall carry out studies, calculations, diagrams, construction and detail drawings of structures. These drawings shall show clearly the sizes, methods of fixing, jointing and anchorages to be used in the process.

1.6. DIMENSION TOLERANCES

1. Ceiling panels and metal strips: 1/500 of the span between supports, with upper limit at 5 mm.
2. Fibreboard panels: 1/300 of the span in the case of visible framework.
3. Unevenness tolerances: 3/10 mm for chamfered components.
4. Gap between visible framework and panels: 1 mm maximum.
5. General flatness of suspended ceilings made of panels, of fibreboard and aluminium: deflection or camber less than 3 mm under 1.20 m rule for ceilings smaller than 4 m² and under 2.00 m rule for ceilings larger than 4 m².

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. MANUFACTURING

The Contractor shall choose framework and materials in relation to regulatory requirements, in particular those concerning fire and panic risks, and contractual requirements in terms of resistance, absence of uplift, suitability in relation to humidity conditions of premises and soundproofing,

Timber framework shall be treated with insecticide using products with the CTB.F label that do not stain the ceilings,

2.2. SPARE PARTS AND SPECIAL TOOLS

The contractor shall specify and supply the special tools required for equipment maintenance.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. GENERAL

Space to receive ceiling units shall be satisfactorily closed and protected against the weather two months before beginning and during work.

Temperature shall be maintained at 10°C or above while system is being installed.

Space to receive ceiling units shall be dry and with no more dampening materials to be installed.

All cuts and recesses for incorporating components supplied by the different trades (electricity, heating, ventilation, etc.) are under Contractor's responsibility. This work must be carried out on the basis of instructions supplied by the different companies during the preparation of slab layout drawings, to be submitted, prior to any production, for the approval of the Owner or his representative,

The Contractor shall create grooves, notches and holes in the walls and load-bearing framework for securing, anchoring or putting in place of suspended ceiling components. He shall also fill in any such grooves, notches and holes that remain visible after installation work,

The Contractor is responsible for installation and removal of any scaffolding needed for performance of the works, irrespective of the height of the structures,

Tarpaulins and protection of structures of other trades, that might be damaged during the performance of the works described in the present chapter, shall be set.

Perfect coordination shall be assured:

- for the fitting of ducts, piping and wiring and installation of apparatus (light fittings, outlets, fire detectors, sound installation etc.),
- for connection of the structures (stability, etc.),
- for painting and covering works.

3.3. CEILING SUSPENSION SYSTEM

The false ceilings will be either suspended to the underside of the floors, of poured reinforced concrete on standard formwork or COFRASTRA type metal formwork (or similar), or on prestressed permanent shuttering concrete slab, under the framework comprised of beams and prestressed purlins.

In these last three cases, drilling and power-activated fastening is prohibited.

False ceiling framework must be installed using clamps around the purlins.

The provision of any special parts for securing the components is included in the supply.

3.4. FIELD QUALITY CONTROL

1. Erection tolerances:
Refer to Section 01020 and paragraph 1.6.
2. Examination of paintwork.

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SECTION 11210

SCRAPER AND SUCTION BRIDGES

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the extraction system equipment, including but not limited to:

1. Scraper bridges,
2. Suction bridges,
3. Pipes,
4. Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Concrete Section as will be shown on the civil construction drawings.

5. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Concrete Section.

6. Covers above the slots shall be provided by the Contractor.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection;
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;

PART 3 – TECHNICAL SPECIFICATIONS

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A. Section 03300 – Concrete ;
- B. Section 01030 – Basic Electrical requirements;
- C. Section 11318 – Grit classifier;
- D. Section 15420 – Air lift;
- E. Section 16000 – Handling equipment;
- F. Section 17100 – Instrumentation.

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Identification number:	103-TB-101 and 103-TB-401
Type:	Travelling bridge Model RCA Alu by RMC or any other equivalent product
Number:	2
Location	Grit and grease removal tanks
Bridge characteristics: -Length net -Width net -Travelling speed -Number of wheels -Materials :	30.0 m 12.0 m 5 cm/s 4 Aluminium
Bottom scraper (grit) :	2 bottom scrapers per tank : 4 500 mm wide and 3 000 mm wide respectively Materials : Inox 304 L
Surface scraper (grease) :	2 surface scrapers per tank : 2 000 mm wide and 2750 mm wide respectively Materials : Inox 304 L
Motor:	0.37 kW – speed 4.7 tr/mn – 400V – 50 Hz – IP 55 – Class F
Accessories	2 Jib cranes installed on the side and on the middle of the travelling bridge for air turbine removal and/or installation after maintenance. Embarked electrical cabinet with folding electrical supply Air lift system for suction in two tanks

PART 3 – TECHNICAL SPECIFICATIONS

1.3.2. OPERATING CONDITIONS

- A.** The scraping bridge is gathering the solids on the bottom of the chamber towards a collection pit at one end. The solids are then recovered by a fixed pump or an air lift.
- B.** In case of a suction bridge the solids are eliminated by a suction pump or air lift , set up on the movable bridge, and discharged into a lateral disposal along the chamber.
- C.** The Contractor shall provide characteristics of the proposed equipment:
 - Rotating speed in rd/min or moving speed in m/min
 - Nominal power of the driving motor
 - Weight of the overall equipment and of each main part
 - Input and output ports diameters
 - Main operation loads, particularly when they are in relation with Civil works fastenings.

1.3.3. CONTROL AND MONITORING

The operation mode of scraper and suction bridges should have both:

- A.** Manual control and PLC automatic control.
- B.** Local control and distance control.

The control box will be composed at least of the following controls and instructions, for each equipment:

1. Manual / auto commutator
2. Lighted button "ON"
3. Lighted button "OFF"
4. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer.

Moreover the following detectors shall be installed and connected to the PLC:

Malfunctions and alarms.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

- A.** Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

PART 3 – TECHNICAL SPECIFICATIONS

- B.** Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
- C.** Workshop inspections and tests:
 - a.** The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b.** The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.
 - c.** Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Test commissioning procedure
5. Commissioning tests list.
6. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
7. Internal wiring diagrams and control principle drawing of control box
8. Weight and material of each component

1.6. GUARANTEE

1.6.1. PERFORMANCE

Vibrations amplitude shall not exceed values specified by the VDI 2055.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. SCRAPER BRIDGE

The scraper bridge should be equipped with:

- Either a U-shaped walkway, fitted with two guardrails, with access at each end (rectangular basin), and a ladder at the back of the bridge so that an operator can climb out should he fall into the basin,
- or a radial U-shaped walkway, fitted with two guardrails, with an electrical-contact retractable ladder for raising the bridge and a ladder at the back of the bridge so that an operator can climb out should he fall into the basin (round basin),
- A bearing system, with shaft(s) and geared motor(s),
- Either a bottom scraper for collecting solids,
- Or a surface scraper for collecting grease,
- Or a bottom and surface scraper,
- A solids/supernatant liquid extraction system
- An emergency stop, with safety stops,
- A festoon cable power supply system,
- A jam detector.

The long travel, raising and lowering movements of the grease scraper are interlocked with limit stops.

The on-board electrical cabinet is completely sealed and contains a heating resistor.

2.1.2. SUCTION BRIDGES

The suction bridge should be equipped with:

- either a radial U-shaped walkway, fitted with two guardrails, with an electrical-contact retractable ladder for raising the bridge and a submerged ladder at the back of the bridge so that an operator can climb out should he fall into the basin (round basin),
- Or a U-shaped walkway, fitted with two guardrails, with access at each end (rectangular basin), and a ladder at the back of the bridge so that an operator can climb out should he fall into the basin,
- A pivot consisting of a slewing ring and an electrical collector,
- A bearing system, with shaft(s) and geared motor(s),
- Jam detectors,
- A brake-formed sheet collecting gutter,

- Dip tubes with submerged bottom intakes,
- Hydrostatic drains, fitted with telescopic valves for collecting solids,
- A solids extraction system (vacuum pump, air lift, etc.)
- A surface scraper for floating; in the case of a radial system, the scraper consists of an adjustable fixed part and an articulated part.
- A system for cleaning the slotted sill.

The bridges are designed so that they can be disconnected quickly at the slewing ring without the need to raise the central pin.

2.1.3. MOTOR CHARACTERISTICS

2.1.3.1. MOTOR

The motor shall be:

- IP55 protected
- 380 Volts,
- 50-Hertz
- Class F insulation.

The motor system should be installed on a public assembly type of steel foundation, and it shall be equipped with driving belt adjustable device, as well as the protection cover for the belt and the wheel.

2.1.3.2. DRIVING HEAD

Gear box will be made of 250-graded cast iron according to BS1452.

Shafts and gear-wheels shall be made of wrought steel.

2.1.3.3. WHEEL

Wheel shall be made of wrought aluminium.

2.1.3.4. VOLUTE

Volute will be made of 250-graded cast iron according to BS1452.

Blades will be made of stainless steel 316L.

2.2. DIMENSION TOLERANCES

The deviation of the plane position shall be less than ± 20 mm. The elevation deviation shall not exceed ± 10 mm.

2.3. PIPES

Inlet and outlet pipes shall be made of cast iron, stainless steel 304L or HPDE (Refer to Section 14100)

2.4. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare parts are:

- For each alternative scraper bridge
 - 2 driving wheel
 - bushings
- For each longitudinal skimmer
 - 1 set of wheel
 - 1 set of bushing
- For each floor scraper
 - 1 set of spring
- For each suction scraper bridge
 - 1 motor reducer
 - 1 slip ring
 - 1 pump

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

- a.** Equipment position
- b.** Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020 and paragraph 2.2.

3.2.2. DRY TESTS

A. Testing of all operation characteristics during 24 hours and without water:

- a.** For each compressor taken individually,
- b.** For each compressors combination eventually necessary to get the overall installation flow.

During these tests, vibrations, temperature increasing and noise shall particularly be checked.

B. Examination of paintwork.

3.2.3. COMMISSIONING TESTS

1. Examination of paintwork.
2. For each solid/floating materials removing system, checking of operation conditions for nominal flow and during 24 hours.
3. The supplier shall provide a extraction effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of sediment flushing and solid/floating material conveying. Each extraction system shall fit individually with requirements.
4. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.
5. Leakage shall not be observed out of the pipes.

SECTION 11301

COARSE SCREENING EQUIPMENT

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the fine screening equipment, including but not limited to:

1. Coarse screens,
2. Cleaning systems,
3. Level sensors,
4. Belt conveyor,
5. Skip.
6. Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section and shown on the approved Contractor shop drawings.

7. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Civil Works Section.

8. All platforms, ladders, or rungs that may be necessary for screens operations and handling will be provided by the Contractor.

The above listed equipment shall be considered as a package that shall be coordinated and integrated by the screen manufacturer.

PART 3 – TECHNICAL SPECIFICATIONS

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection;
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A. Concrete works covered by the Civil Works Section;
- B. Section 19 100 - Electrical Equipment;
- C. Section 17 100 – Instrumentation;
- D. Section 14 412 – Belt Conveyor;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Equipment numbers:	Screens: 101-BS-101; 101-BS-201 ;
Type:	Mechanically raked bar screen
Model	Straight, vertical
Number:	3 duty
Location	Outdoors
Nominal flow per device	11 500 m ³ /h
Mesh spacing	40 mm
Bar width	10 mm (opening 80%)
Channel dimensions	Channel depth: 3 450 mm (to top of wall); Channel width 1 500 mm. The dimensions of the channel can be adjusted by the Contractor
Screenings discharge level above channel floor	No particular requirements. Contractor shall coordinate with screenings belt conveyor layout

PART 3 – TECHNICAL SPECIFICATIONS

Materials	Stainless Steel 304 L except concrete embedded parts in Stainless Steel 316 L Frame in two parts (for transportation purposes)
Motor	0.55 kW – 8 tr/min – TRI – 400V – 50 Hz – IP55 - F
Accessories (per device)	Sensor of stop position for end of cycle; Head loss detection; Dismountable protection cover; Waste discharge hopper with hinges and hood; with inspection door and adapted to the screw hopper Waste guide table to incline level of waste discharge Deflectors for lateral waterproofing of the screen Motor/drum/strap hood with pneumatic jack
Accessories for the package	Local control box rated for outdoor installation for power supply, limit switch, overload protection device and automatic cleaning control program. Compacting Screw conveyor (See below)

Equipment number:	101-BS-301;
Type:	Manual bar screen
Model	Straight, vertical
Number:	1 Standby
Location	Outdoors
Nominal flow per device	11 500 m ³ /h
Mesh spacing	40 mm
Bar width	10 mm
Channel dimensions	Channel depth: 3 450 mm (to top of wall) Channel width 1 500 mm
Materials	Stainless Steel 304 L except concrete embedded parts in Stainless Steel 316 L
Accessories	Raking comb with handle for manual cleaning of the screen. Comb teeth adapted to this specific screen mesh spacing and bar size.

Belt Conveyor screw:

Equipment numbers:	101-BC-001

PART 3 – TECHNICAL SPECIFICATIONS

Type:	Belt Conveyor
Number:	1
Location	Outdoors
Nominal flow per device	12 m3/day screenings
Dimensions	9,8 m long, belt width 500 mm
Materials	Stainless steel 304 L
Motor	2.2 kW – 1400 rpm – TRI – 400V – 50 Hz – IP55 - F
Accessories	Support feet to support the belt conveyor on the channels top of wall and on the ground (2 m below top of wall of channels) Blockage sensor; Dismountable protection cover; SS 304L Waste distribution device in two dumpsters (manual rotation) Push button “forward” integrated in the screens local control box.
Requirements	Conform to Section 14 412 – Belt Conveyors

Level Detection:

Instrument numbers:	101-UF-001 ;
Type:	Ultrasonic level sensor
Number:	1
Location	Outdoors, raw wastewater
Requirements	See Section 17100

Note: level detection of sensor 102-UF-001 provided under Section 11 305 – Fine Screening will be used to compute the hydraulic headloss through the coarse screen.

1.3.2. OPERATING CONDITIONS

Coarse screens shall be discontinuously and automatically cleaned, thanks to both head loss detection and timer (with possible adjustments). Cleaning system shall be composed of a cleaning comb. The rake assembly shall include teeth, which penetrate the depth of the bar screen to ensure positive solids removal. The rake shall discharge its waste at least one time during the cleaning cycle through the topmost position.

Wastes are discharged in a conveying belt which evacuates them towards two skips. The end of the belt is equipped with a waste distribution device, manually rotated to direct wastes into one of the two skips.

1.3.3. CONTROL AND MONITORING

The racking mechanism and the conveying belt shall have a Manual mode and an Automatic Mode.

- Under Manual mode, each screen may be turned ON or OFF locally.
- Under Automatic Mode, the screens may be turned ON or OFF remotely.
- When at least one screen is ON, then the belt conveyor shall turn ON via an interlock.

When turned ON, the screen raking mechanism and the belt conveyor shall be operated according to the Manufacturer's program integrated in the local control box.

The local control box shall be equipped with:

1. Manual / Auto switch
2. Lighted button "ON"
3. Lighted button "OFF"
4. Defaults presentation.
5. Program for Cyclic working on clock or / and head losses detection,
6. Indicator of Malfunctions and Alarms, including but not limited to "high headloss alarm".

The following information shall be reported to the facility PLT for each piece of equipment:

- ON/OFF status
- Motor overload

The following information shall be reported to the facility PLT from the local control box:

- Auto /Manual Status
- Alarm status

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - a) The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

c) Welds: Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

All main parts of the screens (bars, frame, fixings, fastenings, etc.) and their supports shall be made of stainless steel 304L.

All concrete embedded parts shall be made of stainless steel 316L.

The screens shall be provided with a frame allowing easy removal of the screen from the channels for maintenance purposes.

2.2. DIMENSION TOLERANCES

1. Tolerances of the screens equipment inner assembling before installation (hopper, cleaning comb, belt conveyor) shall be conform to the manufacturer instructions.
2. After installation, the deviation of the plane position of the equipment shall be less than ± 10 mm. The elevation deviation shall not exceed ± 10 mm.
3. The deviation of screens installation angle (angle between the screen axis and the horizontal line) is not larger than $\pm 0.5^\circ$.
4. The deviation of all screws installation angles (angle between the screw axis and the horizontal line) is not larger than $\pm 0.5^\circ$.

2.3. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts for the screens are the following:

- a) 1 set of all necessary lifting and operation cables
- b) 1 set of raking teeth

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

1. The contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.
2. The equipment shall be assembled on site and checked before installation.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

1. The following inspections shall be carried out before and after concreting:
 - a) Distance between the lateral embedded parts,
 - b) Flatness of the embedded parts, verticality, horizontality,
2. Erection tolerances:

Refer to Section 01020 and paragraph 2.2 above.

3.2.2. DRY TESTS

1. Examination of paintwork.
2. The raking comb and the fine screens bars shall have no blocking or point of resistance, over the entire length of the screen.
3. Overall system must run for two hours without neither loading nor water: transmission should be calm, block phenomena should not be observed. The temperature of the screw axis shall not exceed 70°.

3.2.3. COMMISSIONING TESTS

1. Machine must run for 24 hours at nominal flow and without observing any difficulties. The raking comb shall operate well without block or miss. The overload device shall react quickly and precisely.
2. The supplier should check that screen performances are in accordance with the required Guaranties, particularly concerning maximum head losses requirements.
3. Rags, waste plastics or other suitable material shall be tested in water flows to verify screens efficiency.
4. Contractor shall carry out a site load examination according to CJ/T3048-1995 standard. He shall check at least:
 - a) screens efficiency in the case of max design water level condition,
 - b) effect of removing garbage,
5. Leakage shall not be observed out of the compacting screw.
6. Examination of paintwork.

SECTION 11305

FINE SCREENING EQUIPMENT

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the fine screening equipment, including but not limited to:

1. Fine screens,
2. Cleaning systems,
3. Level sensors,
4. Compacting screw conveyor,
5. Skip.
6. Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section and shown on the approved Contractor shop drawings.

7. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Civil Works Section.

8. All platforms, ladders, or rungs that may be necessary for screens operations and handling will be provided by the Contractor.

The above listed equipment shall be considered as a package that shall be coordinated and integrated by the screen manufacturer.

PART 3 – TECHNICAL SPECIFICATIONS

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection;
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A. Concrete works covered by the Civil Works Section;
- B. Section 17100 – Instrumentation;
- C. Section 14 410 – Screw Conveyors;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Equipment numbers:	Screens: 102-BS-100; 102-BS-200 ; 102-BS-300
Type:	Self-cleaning fine screen
Number:	3 duty
Location	Outdoors
Nominal flow per device	6 800 m3/h
Mesh spacing	6 mm
Channel dimensions	Channel depth: 3 700 mm (to top of wall) Channel width 1 500 mm The dimensions of the channel can be adjusted by the Contractor.
Screenings discharge level above channel floor	No particular requirements Contractor shall coordinate with screenings screw conveyor layout
Materials	Stainless Steel 304 L except concrete embedded parts in Stainless Steel 316 L Frame in two parts (for transportation purposes)
Motor	0.55 kW – 8 tr/min – TRI – 400V – 50 Hz – IP55 - F

PART 3 – TECHNICAL SPECIFICATIONS

Accessories (per device)	Sensor of stop position for end of cycle; Head loss detection; Dismountable protection cover; Waste discharge hopper with hinges and hood; with inspection door and adapted to the screw hopper Waste guide table to incline level of waste discharge Deflectors for lateral waterproofing of the screen Motor/drum/strap hood with pneumatic jack
Accessories for the package	Local control box rated for outdoor installation for power supply, limit switch, overload protection device and automatic cleaning control program. Compacting Screw conveyor (See below)

Equipment number:	102-BS-400;
Type:	Manual bar screen
Model	Straight, vertical
Number:	1 Standby
Location	Outdoors
Nominal flow per device	6 800 m ³ /h
Mesh spacing	20 mm
Bar width	10 mm
Channel dimensions	Channel depth: 3 700 mm (to top of wall) Channel width 1 500 mm
Materials	Stainless Steel 304 L except concrete embedded parts in Stainless Steel 316 L
Accessories	Raking comb with handle for manual cleaning of the screen. Comb teeth adapted to this specific screen mesh spacing and bar size.

Compacting screw:

Equipment numbers:	102-SW-001
Type:	Screw compactor ; shaftless screw
Number:	1
Location	Outdoors

PART 3 – TECHNICAL SPECIFICATIONS

Nominal flow per device	36 m3/day non compacted screenings
Length	9 m long
Materials	Stainless steel 304 L
Motor	1.5 kW – 1400 rpm – TRI – 400V – 50 Hz – IP55 - F
Accessories	Support feet to support the screw conveyor on the channels top of wall and on the ground (2 m below top of wall of channels) Blockage sensor; Dismountable protection cover; Manual valve and sinusoid valve for compression chamber washing; Evacuation pipes for filtrates (ND 150 mm) to return to screening channel. SS 304L Waste distribution device in two dumpsters (manual rotation) Push button “forward” integrated in the screens local control box.
Requirements	Conform to Section 14 410- Screw Conveyors

Level Detection:

Instrument numbers:	102-UF-001; 102-UF-002
Type:	Ultrasonic level sensor
Number:	2
Location	Outdoors, raw wastewater
Requirements	See Section 17100

1.3.2. OPERATING CONDITIONS

Fine screens shall be discontinuously and automatically cleaned, thanks to both head loss detection and timer (with possible adjustments). Cleaning system shall be composed of a cleaning comb. The rake assembly shall include teeth, which penetrate the depth of the bar screen to ensure positive solids removal. The rake shall discharge its waste at least one time during the cleaning cycle through the topmost position.

Wastes are discharged in a conveying compacting screw which evacuates them towards two skips. The end of the compacting screw is equipped with a waste distribution device, manually rotated to direct wastes into one of the two skips.

1.3.3. CONTROL AND MONITORING

The racking mechanism and the compacting screw shall have a Manual mode and an Automatic Mode.

- Under Manual mode, each screen may be turned ON or OFF locally.
- Under Automatic Mode, the screens may be turned ON or OFF remotely.
- When at least one screen is ON, then the screw conveyor shall turn ON via an interlock.

When turned ON, the screen raking mechanism and the screw compactors shall be operated according to the Manufacturer's program integrated in the local control box.

The local control box shall be equipped with:

1. Manual / Auto switch
2. Lighted button "ON"
3. Lighted button "OFF"
4. Defaults presentation.
5. Program for Cyclic working on clock or / and head losses detection,
6. Indicator of Malfunctions and Alarms, including but not limited to "high headloss alarm".

The following information shall be reported to the facility PLT for each piece of equipment:

- ON/OFF status
- Motor overload

The following information shall be reported to the facility PLT from the local control box:

- Auto /Manual Status
- Alarm status

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - a) The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

c) Welds: Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

All main parts of the screens (bars, frame, fixings, fastenings, etc.) and their supports shall be made of stainless steel 304L.

All concrete embedded parts shall be made of stainless steel 316L.

The screens shall be provided with a frame allowing easy removal of the screen from the channels for maintenance purposes.

2.2. DIMENSION TOLERANCES

1. Tolerances of the screens equipment inner assembling before installation (hopper, cleaning comb, compacting screw) shall be conform to the manufacturer instructions.
2. After installation, the deviation of the plane position of the equipment shall be less than ± 10 mm. The elevation deviation shall not exceed ± 10 mm.
3. The deviation of screens installation angle (angle between the screen axis and the horizontal line) is not larger than $\pm 0.5^\circ$.
4. The deviation of all screws installation angles (angle between the screw axis and the horizontal line) is not larger than $\pm 0.5^\circ$.

2.3. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts are the following:

- a) 1 set of all necessary lifting and operation cables
- b) 1 set of raking teeth

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

1. The contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.
2. The equipment shall be assembled on site and checked before installation.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

1. The following inspections shall be carried out before and after concreting:
 - a) Distance between the lateral embedded parts,
 - b) Flatness of the embedded parts, verticality, horizontality,
2. Erection tolerances:

Refer to Section 01020 and paragraph 2.2 above.

3.2.2. DRY TESTS

1. Examination of paintwork.
2. The raking comb and the fine screens bars shall have no blocking or point of resistance, over the entire length of the screen.
3. Overall system must run for two hours without neither loading nor water: transmission should be calm, block phenomena should not be observed. The temperature of the screw axis shall not exceed 70°.

3.2.3. COMMISSIONING TESTS

1. Machine must run for 24 hours at nominal flow and without observing any difficulties. The raking comb shall operate well without block or miss. The overload device shall react quickly and precisely.
2. The supplier should check that screen performances are in accordance with the required Guaranties, particularly concerning maximum head losses requirements.
3. Rags, waste plastics or other suitable material shall be tested in water flows to verify screens efficiency.
4. Contractor shall carry out a site load examination according to CJ/T3048-1995 standard. He shall check at least:
 - a) screens efficiency in the case of max design water level condition,
 - b) effect of removing garbage,
5. Leakage shall not be observed out of the compacting screw.
6. Examination of paintwork.

SECTION 11318

GRIT CLASSIFIERS

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the grit classifiers.

1. Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.

2. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Civil Works Section.

3. Covers above the slots shall be provided by the Contractor.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A.** Section 01000 - General requirements;
- B.** Section 01010 - Corrosion protection;
- C.** Section 01020 - Basic mechanical requirements;
- D.** Section 01030 - Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A.** Concrete works covered by the Civil Works Section;
- B.** Electrical works covered by the Electrical Equipment Section;
- C.** Section 15420 – Air lift;
- D.** Section 17100 – Instrumentation;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Identification	103-GC-511, 103-GC-512, 103-GC-513
Type:	Grit classifier
Number:	2 + 1 in stand-by
Location:	Area 103 - Grit and grease removal tank
Nominal flow sandy water:	100 m3/h
Motor:	0.75 kW – 4.6 tr/min- TRI – 380V– 50 Hz – IP55 - F
Materials:	Shaftless spiral made of cold rolled flat bars in special steel, hardness 400 HB Tank, cover, u-flanges in stainless steel AISI 304L
Devices included:	
Inlet coupling ND200 / Outlet coupling ND250	
Cover plate	
Shaftless spiral for grit conveying	
Motor reducer (security)	

1.3.2. OPERATING CONDITIONS

After being extracted from the grit chamber well, a mixture composed of sand, air and water is conveyed through pipes to a grit classifier that has to separate grit and water.

The grit classifier used is composed of an inlet hopper, a segregating channel and a grit Archimedean screw. The unit is driven by a gear motor.

The Contractor's bid shall include:

- performance guarantees
- the simplified installation drawings of the proposed equipment
- the characteristics of the equipment
- the technical data sheets or manuals for the coatings used
- the coating procedure

1.3.3. CONTROL AND MONITORING

The operation mode of grit classifiers should have both:

1. Manual control and PLC automatic control.
2. Local control and distance control.

Grit classifiers local control facilities shall be located in the grit chambers control box with mixers and compressors commands.

The box will be composed at least of the following controls and instructions, for each equipment:

1. Manual / auto commutator
2. Lighted button “ON”
3. Lighted button “OFF”
4. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the grit classifiers control.

Moreover the following detectors shall be installed and connected to the PLC:

- Malfunctions and alarms.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - a) The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth. All dimensions shall be checked.
 - c) Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. INLET HOPPER

The inlet hopper shall be made of thick stainless steel.

The slope of the hopper's sides shall be at least maintained at 60° from the horizontal level to prevent grit from building up.

An inner overflow weir shall be used to maintain a constant water volume and an appropriately sized drainpipe shall be installed to return the overflowing water to the grit chamber inlet channel.

2.1.2. TROUGH CHANNEL

The segregating channel shall be made of thick stainless steel.

2.1.3. ARCHIMEDEAN SCREW

The screw shall be made of thick stainless steel.

2.1.4. GEAR MOTOR

The motor shall be:

- IP55 protection grade,
- Non-overloading,
- Constant speed motor with 380 Volts,
- 50-Hertz
- Class F insulation.

2.2. DIMENSION TOLERANCES

1. The deviation of the plane position shall be less than ± 20 mm. The elevation deviation shall not exceed ± 10 mm.
2. The deviation of screw installation angle (angle between the screw axis and the horizontal line) is not larger than $\pm 0.5^\circ$.

2.3. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts are:

-equipment maintenance

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

1. The following inspections shall be carried out before and after concreting:
 - a) Equipment position
 - b) Flatness, verticality, horizontality of the embedded parts,

2. Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

1. Grit classifiers must run individually for two hours without neither loading nor water: transmission should be calm, block phenomena should not be observed, and temperature of the screw axis shall not exceed 70°.
2. Examination of paintwork.

3.2.3. COMMISSIONING TESTS

1. Machine must run for 24 hours at nominal flow and with observing any difficulties.
2. The supplier shall provide a grit segregation effectiveness testing report, taking samples from incoming and outgoing water ditches.
3. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.
4. Leakage shall not be observed out of the grit classifier.
5. Examination of paintwork.

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SECTION 11 322

THICKENING SCRAPER AND PICKET FENCE

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the extraction system equipment, including but not limited to:

1. Scraper and picket fence with rotating mechanism,
2. Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Concrete Section as will be shown on the civil construction drawings.

3. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Concrete Section.

4. Covers above the slots shall be provided by the Contractor.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection;
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A. Concrete works covered by the Civil Works Section;
- B. Section 11210 – Lamella plates;
- C. Section 17100 – Instrumentation.

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Identification number:	105-PF-101 ; -102; -103; -104
Type:	Rotating Travelling bridge
Number:	4
Location	Primary sedimentation tanks
Picket fence for thickening:	Maximum elevation of the pickets from the bottom of the tank: 884.00 masl Bottom slab elevation : 881.00 masl Intervals between pickets: 700 mm Materials : Galvanized Steel
Bottom scraper:	Height of the plate: 200 mm Suspended to the arm by 50/60 diameter tubes, adjustable in height Materials : Galvanized steel
Motor:	3 kW – speed 1.5 tr/mn – 400V – 50 Hz – IP 55 – Class F Installed outdoors.

1.3.2. OPERATING CONDITIONS

- A. The picket fence is directing the solids towards the bottom of the tank.
- B. The bottom scraper plates are pushing the to the central collection pit. The solids are then recovered by suction and transported to the sludge holding and buffer tank.
- C. The Contractor shall provide characteristics of the proposed equipment:
 - Rotating speed in rd/min or moving speed in m/min
 - Nominal power of the driving motor

- Weight of the overall equipment and of each main part
- Main operation loads, particularly when they are in relation with Civil works fastenings.

1.3.3. CONTROL AND MONITORING

The operation mode of scraper and suction bridges should have both:

- A.** Manual control and PLC automatic control.
- B.** Local control and distance control.

The control box will be composed at least of the following controls and instructions, for each equipment:

1. Manual / auto commutator
2. Lighted button "ON"
3. Lighted button "OFF"
4. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer.

Moreover the following detectors shall be installed and connected to the PLC:

Malfunctions and alarms.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

- A.** Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
- B.** Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
- C.** Workshop inspections and tests:
 - a.** The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b.** The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.
 - c.** Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Test commissioning procedure
5. Commissioning tests list.
6. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
7. Internal wiring diagrams and control principle drawing of control box
8. Weight and material of each component

1.6. GUARANTEE

1.6.1. PERFORMANCE

Vibrations amplitude shall not exceed values specified by the VDI 2055.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

The Thickening Scraper and Picket Fence should be equipped with:

- A bearing system, with shaft(s) and geared motor(s),
- A central rotating shaft made of an ND500 tube on which two frames are welded on opposite sides. Two arms fabricated from folded steel plates shall be bolted to the frame. On these arms angle plates shall be welded at regular intervals to form the picket fence.
- A steel pivot guide equipped with an autolubricating ring filled with marine grade lubricant and installed at the bottom of the tank to ensure the proper rotation of the shaft
- Bottom scraper plates fabricated from folded steel plates equipped with rubber bibs for collecting solids towards the central pit, and suspended to the arm by adjustable height tubes.
- An emergency stop, with safety stops,
- A festoon cable power supply system,
- A jam detector.

2.1.1. MOTOR CHARACTERISTICS

2.1.1.1. MOTOR

The motor shall be:

- IP55 protected
- 380 Volts,
- 50-Hertz
- Class F insulation.

The motor system should be installed on a public assembly type of steel foundation, and it shall be equipped with driving belt adjustable device, as well as the protection cover for the belt and the wheel.

2.1.1.2. DRIVING HEAD

Gear box will be made of 250-graded cast iron according to BS1452.

Shafts and gear-wheels shall be made of wrought steel.

2.2. DIMENSION TOLERANCES

The deviation of the plane position shall be less than ± 20 mm. The elevation deviation shall not exceed ± 10 mm.

2.3. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare parts are:

- For each of the Thickening Scraper and Picket Fence
 - 1 scraper plate
 - bushings
- For each longitudinal skimmer
 - 1 set of wheel
 - 1 set of bushing
- For each floor scraper
 - 1 set of spring
- For each suction scraper bridge
 - 1 motor reducer
 - 1 slip ring
 - 1 pump

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

- a.** Equipment position
- b.** Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020 and paragraph 2.2.

3.2.2. COMMISSIONING TESTS

1. Examination of paintwork.
2. Verification of the rotation speed and vibration requirements.

SECTION 11332

SUBMERSIBLE HORIZONTAL SHAFT MIXERS

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of submersible horizontal shaft mixers equipment.

The equipment shall be complete with all base plates, foundation bolts, heat exchanger and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all others parts and section of the contract.

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

<u>Identification</u>	
Type	Tri-blade
Number	2 (1 per sludge storage tank)
Location	Sludge storage tanks
<u>Operating conditions</u>	
Duty	Continuous or discontinuous
Drive	Constant speed
Fluid service	Primary sludge up to 35 g/l of suspended solids concentration
Fluid temperature	5-40°C

Fluid pH	6-9
Fluid specific gravity	1,05
<u>Description</u>	
Type	Immersed speed mixer
Number of blades	3
Impeller diameter	500 mm
Impeller rotation speed	270 rpm
Material	General requirements are indicated in part 2 : Products – Components and sub-assemblies. Particular requirements are as follows : Impeller : gray cast iron EN JL 1040
Motor:	4 kW– 400V – 50 Hz – IP 68 – Class F
Accessories (per installed mixer)	
Thermal sensor	
Guide bars, attachment for guide bars, elevating chain incl. suspension attachment : Stainless steel X2CrNi18-09 1.4307 (304L)	
10 m oil resistant electrical cable and bracket	
Cable fixing facilities and cable protection	
1 lifting device (rudder in galvanized steel and hoisting winch in stainless steel 304L)	

1.3.1. MAIN CHARACTERISTICS

- a. All mixers shall be driven by electric motors in accordance with the requirements of the electrical specifications.
- b. The direction of rotation of all the mixers shall be clockwise when viewed from the motor end of the mixer set assembly.
- c. All mixers of same type shall be identical in design and construction in all respects including performance, parts, mountings, connecting flange dimensions and materials.
- d. The mixer rotating assembly design shall be such that the first critical speed of the mixer with its motor and the transmission assembly, when running as one system, is at least 150 percent of the maximum operating speed of the mixer.

- e. Each component casting of the mixer body shall have a wall thickness of 10mm minimum over and above that required to meet the strength requirements, to compensate for the corrosive and abrasive action of the sewage.
- f. The mixers shall be capable to work for long periods continuously without cleaning or attention and special precautions shall be taken to avoid wear on working surfaces due to grit.

1.3.2. OPERATING CONDITIONS

Submersible horizontal shaft agitators are used for maintain suspended solids in suspension and homogenize the sludge concentrations from different lamellar tanks prior to dewatering operations.

The agitators may be adjusted horizontally, and have self-cleaning paddles. The agitators are fixed to guide rails and can be handled using lifting device n fixed to the technical walkways.

Moreover the Contractor shall provide characteristics of the proposed equipment:

- Circulation speed of the fluids,
- Rotation speed,
- Absorbed power,
- Weight of the assembly and each equipment

1.4. QUALITY ASSURANCE

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - The seals and the embedded parts shall be presented separately and unpainted for checking.
 - The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

The contractor shall submit the results of workshop test.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.

6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. GENERAL

The end stops shall be protected against any water infiltration occurring as a result of failure of the mechanical seals.

It must be easy to dismantle the various components.

The bearing shall be of the grease-lubricated sealed ball bearing type.

The seals shall be mechanical. The shaft shall be sealed using two tight mechanical seals fitted in tandem regardless of the direction of rotation.

The Contractor shall submit a detailed note describing the lubrication and greasing system that he proposes.

2.1.1. MOTOR AND GEAR HEAD

The service life of the convolution bearing for supporting the impellers shall be 20 years as a minimum. The bearings of reducer shall be well lubricated with working duration no less than 100,000 hours. The gears designed should comply with ISO or equivalent standard, with servo ratio no less than 2.0.

2.2. FABRICATION

If applicable, particular requirements mentioned above in part 1 must be enforced.

2.2.1. BODY AND CASING

Gray cast iron EN JL 1040 or better

2.2.2. SHAFT

The pump shaft shall be of alloyed steel precision-ground, and provided with renewable bronze or stainless steel sleeve where it passes through the stuffing box and is in contact with water. The shaft shall be rigidly supported by at least two (2) sets of heavy-duty antifriction ball bearings. Lubrication of bearings shall be done with grease.

2.2.3. IMPELLER

Stainless steel X2CrNi18-09 1.4307 (304L)

2.2.4. NUTS, BOLTS AND OTHER SUPPORTS

All exposed nuts, bolts, double guide bars, attachment for guide bars, elevating chain incl. suspension attachment shall be in stainless steel X2CrNi18-09 1.4307 (304L).

2.3. DIMENSION TOLERANCES

- A.** Tolerances of the mixers inner assembling before installation (blade paddles, hollow shaft, driving device) shall be conform to the manufacturer instructions.
- B.** After installation, the deviation of the plane position of the driving axis shall be less than ± 5 mm. The verticality of this shaft shall be less than 1/1000.
- C.** The elevation deviation of paddles shall not exceed ± 5 mm.

2.4. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts for each submersible horizontal mixer are:

- a.** 1 axis,
- b.** 1 paddles,
- c.** 1 gear head
- d.** 1 gear box

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

- A.** The following inspections shall be carried out before and after concreting:
 - a.** Holes position
 - b.** Flatness, verticality, horizontality of the embedded parts,
- B.** Erection tolerances:

Refer to Section 01020.

3.2.2. DRY TESTS

- 1. Examination of paintwork.

3.2.3. COMMISSIONING TESTS

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

1. Checking of operation parameters (rotation speed, flow speed, absorbed power), for each agitator tested individually.
2. For each agitator, checking of operation conditions for nominal flow and during 24 hours. The water level shall remain nearly constant during these 24 hours testing operations (difference shall be less than 10cm).
3. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.
4. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

SECTION 11370

POLYMER PREPARATION

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of automatic polymer preparation unit, including but not limited to:

1. Polymer storage,
2. Automatic polymer preparation unit,
3. Polymer injection pumps,
4. Inline dilution,

The equipment shall be complete with all base plates, foundation bolts, and all other items of equipment necessary to make the installation complete and perfect in every detail.

The above listed equipment shall be considered as a package that shall be coordinated and integrated by the manufacturer.

The polymer equipment shall be designed for automatic operation.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all others parts and section of the contract.

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

1.3.1.1. POLYMER STORAGE

<u>Identification</u>	201-BF-001
Type	Manual polymer big bag emptying station
Location	Sludge building – polymer room

Description	
Maximal capacity	1 000 kg
Components	Frame Lifting beam Telescopic support beam Vibrating support dish - 0,18 kW – 50 Hz – 380 V Access door Buffer hopper Gate valve
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies.

1.3.1.2. POLYMER PREPARATION

Identification	No global number, see element numbers hereafter
Type	Automatically preparation unit for dry polymer
Location	Sludge building – polymer room
Operating conditions	
Duty	Continuous – 16h/day – 7 days a week
Fluid service	Dry polymer
Description	
Preparation unit	Automatic preparation unit with three compartments (mix compartment, maturation compartment, storage compartment)
Preparation unit capacity	Between 2 and 6 m ³ /h (for one to three sludge dewatering equipments)
Total volume	9 m ³
Polymer concentration in solution	2 to 4 g/l
Automatic polymer feeding	Hopper stainless-steel with a cover, an inspection panel and one level sensor – Capacity 500 l

PART 3 – TECHNICAL SPECIFICATIONS

	Screw conveyor(201-SW-001) : 200 kg/h P = 0,55 kW
Automatic polymer dosing and injection	Hopper stainless-steel with a cover and two level sensors – Capacity 50 l Dosing screw (201-DS-001)- capacity: 5 to 40 kg/h Wetting system for flushing-in and wetting of the powder, included : wetting cone – water line injection – 12 m³/h - 3 bars with surpression pump (201-SUR-001), solenoid valve (201-SV-001), pressure reducer, flow set valve, flow rate indicator with “no flow” pass detector.
Mix compartment	Capacity = 4 m³ Cover with an inspection panel One vertical slow mixer (201-MX-001) – maximal speed = 100 rpm - P = 0,55 kW - Drainage device with valve Siphon-like partition
Maturation compartment	Capacity = 2,5 m³ Cover with an inspection panel One vertical slow mixer (201-MX-002)– maximal speed = 100 rpm - P = 0,55 kW - Drainage device with valve Siphon-like partition
Storage compartment	Capacity = 2,5 m³ Cover with an inspection panel Drainage device with valve Over flow device 4 level sensors (201-FL-001/002/003/004) Polymer dosing pump connection
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies.

1.3.1.3. POLYMER PROGRESSIVE CAVITY PUMPS

<u>Identification</u>	201-PC-101/201/301
Number	3
Location	Sludge building – Polymer room
Model	Progressive cavity pumps – horizontal installation
<u>Operating conditions</u>	
Duty	Continuous – 16 h/day – 7 days a week
Drive	Manual variable speed geared motor
Ambient environment	Indoor
Ambient temperature	5-40°C
Fluid service	Polymer solution (2 to 4 g/l)
Fluid temperature	15 – 30 °C
Fluid pH	6-9
Fluid specific gravity	1,05
<u>Description</u>	
Unit capacity	1 to 3 m ³ /h
Maximal pressure	2 bars
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies.
Motor	1,1 kW – 400 V – 50 Hz – IP 55 – F
Accessories (per installed pump)	
One suction and discharge pipe	
Upstream and downstream isolation valves (gate valves)	
Non-return valves (ball valve)	
Pressure gauges	
Magnetic flowmeters 201-MF-101/201/301	

Dry Running Protection Device

1.3.1.4. INLINE WATER SERVICE DILUTION

Inline water service dilution	3 water injection lines - 3 bars with solenoid valve (201-SV-101/201/301), pressure reducer, manual flow set valve, flow rate indicator with “no flow pass” detector.

1.3.2. OPERATING CONDITIONS

1.3.2.1. GENERAL

The preparation unit is designed for an automatic functioning as soon as the dewatering units are operating.

The operator is only required to load big-bags on the emptying station and to open the gate valve to load polymer powder in the automatic polymer feeding device. Polymer bags shall be lowered into the framework by an electrical stacker.

The preparation unit is divided into three separate chambers, so that a sufficient maturing time for the polymer solution can be ensured. The division of the reservoir largely prevents the matured and freshly prepared solution from mixing and ensures continuous discharge.

The contractor proposes all capacities to guaranty the reliability of dewatering operations.

All motors must be easily reached for maintenance operation.

Inspected panels must be enough sized to make cleaning operations easier.

Overflow and drainage devices must be connected to drain gutter.

A local control panel including all power supply (mixers, screws, solenoid valve, pumps) and automatism is also provided. Defaults must be sent to the SCADA.

1.3.2.2. AUTOMATIC POLYMER FEEDING

Dry polymer shall be fed by mechanical, positive displacement volumetric feeder. Motor shall be variable speed.

The discharge port of the volumetric feeder shall be completely enclosed in a chamber. The polymer/water initial wetting area shall be clearly visible. The acrylic barrel shall prevent inadvertent drifting of airborne polymer dust and protect feeder discharge from environment. The discharge port shall be fitted with a pneumatically operated valve to isolate dry polymer from the environment between cycles.

Dry polymer shall rely on gravity to transfer from feed device to wetting device. This shall eliminate the need for any type pneumatic conveying system.

1.3.2.3. DILUTION WATER

Dilution water flow for polymer batching shall be from well service water (6 bars) or in case of poor quality from drinking water supply, equipped with reduced pressure backflow preventer. Drinking water available service pressure is around 1,5 bars. The Contractor foresees the surpression pump to achieve needed service pressure for polymer preparation (at least 3 bars). Dilution water shall be maintained at a constant rate by means of a flow control valve. A differential pressure indicator/switch shall be supplied to display water differential pressure. Low differential pressure switch shall shut down system and energize alarm at Local Control Panel after adjustable time delay. Water flow (on/off) shall be controlled by a solenoid valve with spring to close for fail-safe operation. Dilution water feed shall include rotameter to provide visual indication of flow.

1.3.2.4. MIXERS

The Contractor shall provide characteristics of the proposed equipment:

- Circulation speed of the fluids,
- Absorbed power,
- Weight of the assembly and each equipment

1.3.2.5. PUMPS

1.3.2.5.1. *Pump Duties*

Each of the pumps shall be capable of operating continuously without damaging effects. If the Contractor considers that additional measures or controls are necessary to protect the Plant from any long term damaging effects, then all such equipment and controls shall be provided and shall be deemed to have been included in the contract price. The details shall be submitted with the Tender.

1.3.2.5.2. *Pump Suction Ability (NPSHR)*

The pump shall be capable of operating satisfactorily in the specified operating range. The pump NPSHR shall be less than the NPSHA under any operating condition at Site to avoid cavitation. If the pump requires any increase of the system head so as to achieve satisfactory operation at any point in the specified operating range, then this shall be clearly stated in the Tender. The method and details of creating the additional system head shall be stated and drawings showing any changes required in the civil layout shall be submitted. Where such requirements affect the hydraulics of the complete system, hydraulic calculations shall be carried out and included in the Tender. If the change implies higher energy cost during operation of plant, then this will be taken into account during tender assessment.

1.3.2.5.3. *Pump Rated Speed (NR)*

The maximum rated speed of the pumps shall be designed by the Contractor.

1.3.2.5.4. *Pump Shaft Power and Pump Efficiency*

The pump shaft power characteristics shall be stable within the duty range and shall be non-overloading at the pump operating speed.

1.3.2.5.5. Reverse Rotation Capability

Under shut down conditions, reversal of the pump rotation will take place and the pump, motor and shafting shall be designed accordingly.

1.3.2.6. POST DILUTION ASSEMBLIES

It shall provide additional dilution required by application. System shall include skid-mounted post-dilution units consisting of a static mixer in a clear PVC housing, rotameter-type flow indicator with rate-adjusting valve. The post-dilution water flow rate shall be adjustable. Provide rotameters to measure dilution water flow.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

- A.** Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
- B.** Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
- C.** Workshop inspections and tests:
 - a.** The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b.** The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

- 1. Installation, maintenance and operation manuals with requirements of accuracy
- 2. Manufacture and quality assurance measures
- 3. Protective coating list of all parts
- 4. Commissioning tests list.
- 5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
- 6. Internal wiring diagrams and control principle drawing of control box

7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. MIXERS

The mixer shall utilize stainless steel impellers. The mix tank impeller shall be driven by a washdown duty motor coupled with a right angle gear reducer. The gear reducer and motor shall be mounted on a stainless steel or fiberglass channel crossing the mixing/holding tank. The impeller shall be coupled to the gear reducer.

The impeller diameter shall be as large as possible to fit inside the tank diameter, guaranteeing the most uniform distribution of mixing energy.

The mixer shaft shall be stainless steel with clear PVC sleeve to direct polymer slurry from the wetting device into hollow-bladed impeller.

2.2. PUMPS

2.2.1. GENERAL

All pumping units shall be supplied as complete pumping systems, including the pump, its driving motor, the drive shaft and couplings, local control panels and all necessary appurtenances (including protection devices, switches, etc.).

Pumps and motors shall be flexible-coupled. That portion of the shaft extending through the mechanical seal (s) shall be equipped with a replaceable sleeve (sealed or positive locked to the shaft) such that the entire shaft need not be replaced when it is scored or worn in this area. Pump shafts shall be designed for a maximum deflection at the shaft seal of 0.05 mm (0.002 in). All couplings, connections, external sealing, etc. shall be weather protected, suitable for outdoor installation.

Pump shafts shall run in ball bearings. The bearings shall be grease-lubricated and shall be contained in dust-proof and moisture-proof housing. The bearings and frame design shall be such that the bearings can be re-lubricated by use of external greasing devices. The pump design shall ensure that the outboard bearing can carry a combined thrust and radial load. Bearings shall be adequately designed to carry all radial and thrust loads through the normal operating range of the pump. Bearings for pumps in continuous operation (or in continuous rotation of operation) shall have an L-10 life of at least 40,000 hours at the operating point.

Mechanical seals, not packing, shall be used for all pumping units. Seals shall be of the type not requiring water sealing or flushing water.

Oil level shall be maintained by a constant level oiler with visible oil supply.

All openings in the pump shall be large enough to permit passage of solids with maximum diameter of 60 mm.

Connections to concrete foundations for all pumps shall be sufficient to withstand a displacing force equal to that developed by an internal pressure equal to three times shut-off head at maximum operating speed.

PART 3 – TECHNICAL SPECIFICATIONS

Pumping units shall be designed to operate without damaging vibration over the entire specified range of flow and head conditions and (where appropriate) over the range of speeds specified.

Major pump components shall be of gray cast iron with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pump- age, other than stainless steel or brass shall be protected by a factory-applied spray coating of alkyd primer with oxiranesther paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be of controlled compression of rubber O-rings in two planes and O-rings contact of four sides without the requirement of a specific torque limit.

Neither rectangular sectioned gaskets neither requiring specific torque nor scaling compound shall be considered as equal.

Pumping units shall have no dangerous critical or resonance frequencies. The Contractor shall be responsible for the analysis of critical speeds and the complete mass elastic system, and shall submit calculations in this regard to the Engineer or his representative for approval prior to erection.

Pumping units shall be suitable for connection to No.-Flow shut-off switches, such switches to be supplied with all check valves supplied.

Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 40°C.

2.2.2. CABLE ENTRY SEAL

The Cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomere grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable the assembly shall provide ease of changing the cable. The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.2.3. MOTORS

The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air-filled watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155°C. The stator shall be dipped three times in Class F varnish and shall be heat-shrink fitted into the stator housing. The motor shall be designed for continuous duty handling pumped media of 40°C and capable of up to 15 evenly spaced starts per hour. Thermal switches set to open at 125°C and closed at 70°C shall be embedded in the stator load coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomer o-ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable. The motor and pump shall be designed and assembled by the same

PART 3 – TECHNICAL SPECIFICATIONS

manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15 the motor shall have a voltage tolerance of plus or minus 10% the motor shall be designed for operation up to 40oC ambient temp. and with a temp. rise not to exceed 85oC. This chart shall also include data on starting and no-load characteristics. The motor and the cable are capable of continuous submergence underwater without loss of watertight integrity acc. To protection class IP68 (20m), the rated power shall be adequate so that the pump is not overloaded throughout the entire indicated pump performance curve.

Power cable includes two conductors 1.5 mm for the monitoring of thermal switches and optional protecting sensors.

2.2.4. BEARING

The pump shall be provided with grease lubricated thrust and radial bearings designed for all loads imposed by the specified service. Bearing life for all pump and motor bearings shall be 100,000 hours minimum

2.2.5. MECHANICAL SEAL

Each pump shall be provided with a tandem mechanical shaft seal system consisting of two independent seal assemblies. The seals shall operate in an oil-reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump housing and the oil-chamber, shall contain one stationary and one positively driven rotating tungsten carbide ring. The upper, secondary seal unit, located between the oil-chamber and the motor housing, shall contain one stationary tungsten-carbide seal ring and one positively driven rotating tungsten-carbide seal ring. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotating for sealing. For special applications other seal face material shall be available. Other seal types shall not be considered acceptable or equal to the dual independent seal specified. Each pump shall be provided with an oil chamber for the shaft sealing system, the drain and inspection plug, for the oil, shall be accessible from the outside.

2.2.6. ROTOR AND STATOR

The pump shall be two-stage design employing a convoluted rotor operating in a similarly convoluted stator. The convolutions shall be configured to form a cavity between the rotor and stator which shall progress from the pump's inlet to discharge port with the operation of the rotor. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a good seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber.

2.3. FABRICATION

Polymer storage	Frame and telescopic support beam : galvanized steel
	Lifting beam : painted steel
	Buffer hopper and vibrating support dish : X2CrNi18-09 1.4307 (304L) or painted steel or galvanized steel
	All exposed nuts and bolts : Stainless steel

	X2CrNi18-09 1.4307 (304L)
Polymer preparation	Tanks : polyester Pipe and valves : PVC pressure Mixers : stainless steel (304L) Hopper : stainless steel (304L)
Progressive cavity pumps	Body : gray cast iron EN JL 1040 Rotor : Stainless steel X20Cr13 1.4021 Stator : Buna-N synthetic rubber with a minimum shore durometer hardness of 60 bonded to a steel tube. Shaft : Stainless steel X20Cr13 1.4021

2.4. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts are

- for each mixer :
 - Set of pressure gauge assembly
 - 1 mechanical seals
 - 1 motor coupling
- for each size of pump furnished:
 - One stator,
 - One rotor,
 - One connecting rod,
 - One set connecting rod joint assembly,
 - One bearing assembly,
 - One set of V-belts,
 - Two sets of drive pins, washers, and screws,
 - Two sets of gaskets and o-rings,
 - One mechanical seal.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

- A.** The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.
- B.** The shaft mixers (blade paddles, shaft, driving device) shall be assembled on site and checked before installation.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

- A.** The following inspections shall be carried out :
 - a.** Holes position
 - b.** Flatness, verticality, horizontality of the embedded parts,
- B.** Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

- 1. Examination of paintwork.

3.2.2.2. GENERAL

- a.** The Tests on Completion shall consist of the following:

- 1. Installation inspection;
- 2. Pre-commissioning tests
- 3. Commissioning tests;
- 4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

- b.** The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.2.3. INSTALLATION INSPECTION

- a.** When the Contractor is satisfied that the unit sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.

PART 3 – TECHNICAL SPECIFICATIONS

- b. The unit will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.2.4. PRE-COMMISSIONING TESTS

- a. Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
- b. All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.
- c. Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.2.2.5. COMMISSIONING TESTS

- a. For each agitator, checking of operation conditions for nominal flow and during 24 hours. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.
- b. For each pump set and shall include but not necessarily be limited to the following:
 - performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;
 - vibration monitoring to demonstrate compliance with specified vibration severity limits;
 - reverse rotation of the pump set due to backflow;
 - simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.
 - Performance proving tests shall be carried out on one pump set at a time by pumping clean water. Flow rates shall be measured using flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.
 - Pressure measurements shall be taken at a number of locations as directed by the Engineer, including the outlet flange of the discharge bend of pump. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated, including losses in the discharge pipe work.
- c. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

SECTION 11373
COMBINED GRAVITY BELT SLUDGE THICKENING AND BELT
FILTER PRESS DEWATERING

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of dewatering unit, including but not limited to:

1. Gravity belt thickener (EMO type OMEGA 20 MD or equal)
2. Belt filter press (EMO OMEGA 1200 or equal),
3. Wash water pump,
4. Air compressor,
5. Screw conveyors,

The dewatering unit (items 1 to 5) shall be provided as a completely integrated system designed for continuous and automatic operation.

The equipment shall be complete with all base plates, foundation bolts, and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORK

Supplies and works included under this section shall comply and be co-ordinated with all others parts and section of the contract.

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

<u>Operating conditions and performance requirements</u>	
Duty	Continuous – 16 h/day – 7 days a week

Ambient environment	Indoor
Ambient temperature	5-40°C
Fluid service	Primary sludge between 25 to 35 g/l of suspended solids concentration and polymer (powder)
Fluid temperature	5-40°C
Fluid pH	6-9
Fluid specific gravity	1,05
Sludge concentration after dewatering operation	Average : 24 % Minimum 22 %
Solids capture efficiency	> 94%

1.3.1.1. GRAVITY BELT THICKENER

<u>Identification</u>	202-BT-101/201/301
Number	3
Type	Gravity belt thickener
Location	Sludge building – dewatering room
<u>Description</u>	
Floculator	Tank capacity: 500 l 1 vertical mixer P = 1,1 kW – 50 Hz – TRI – 400 V – 50 Hz – IP 55 – F Variable frequency drive
Belt width	2,0 m
Maximum SS flow	1 000 kg SS/h
Flow rate	28 m ³ /h
Filtration length	2,70 m
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies.

PART 3 – TECHNICAL SPECIFICATIONS

Components for each unit	Removal cover (X20Cr13 1.4021 or X2CrNi18-09 1.4307 (304L)) with sludge inlet flange and air extraction flange. Wash water line with solenoid valve, manual valve, manometer, pressure sensor and flowmeter. Hopper feeding the belt filter press with high level sensor. Sludge level sensors on belts

1.3.1.2. BELT FILTER PRESS

<u>Identification</u>	202-FP-101/201/301
Number	3
Type	Belt filter press
Location	Sludge building – dewatering room
<u>Description</u>	
Belt width	2,0 m
Maximum SS flow	1 000 kg SS/h
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies.
Accessories for each unit	Removal cover (X20Cr13 1.4021 or X2CrNi18-09 1.4307 (304L)) with sludge inlet flange and air extraction flange. Wash water line with solenoid valve, manual valve, manometer, pressure sensor and flowmeter. Hopper feeding the screw conveyor with high level sensor. Mechanical device for belt tension Pneumatic device for belts self-aligning, jacks, compressed air injection with solenoid valve, security sensors.

	Sludge level sensors

1.3.1.3. WASH WATER PUMP

<u>Identification</u>	202-PC-101/201/301
Number	3
Type	Vertical multicellular pump
Location	Sludge building – dewatering room
<u>Description</u>	
Impeller type	Radial
Unit flow	18 m ³ /h
Inlet pressure	0.2 to 0.5 bars
Discharge pressure	5 to 7 bars
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies.
Motor	5,5 kW – 1500 rpm – TRI – 400 V – 50 Hz – IP 55 – F
Accessories (per installed pump)	Upstream and downstream isolation valves (gate valves) Inlet filter with automatically cleaning Flow rate indicator on suction pipe with “no flow” pass detector. Pressure gauges Dry running protection device

1.3.1.4. AIR COMPRESSOR FOR SELF-ALIGNMENT

<u>Identification</u>	202-CP-101/201/301
Number	3
Type	Piston compressors
Location	Sludge building – dewatering room

<u>Description</u>	
Aspiration	In the room
Unit flow	7 m ³ /h
Pressure	5 to 7 bars
Tank	100 l – safety valve – pressure sensor
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies.
Motor	1,5 kW – 2850 rpm – TRI – 400 V – 50 Hz – IP 55 – F
Accessories (per installed compressor)	Condensate trap Inlet filter Inlet air dryer pressure relief valve and manometer

1.3.1.5. CONVEYING SCREW

<u>Identification</u>	202-SW-101/201/301
Number	3
Type	Shaftless screw conveyors
Location	Sludge building – dewatering and liming rooms
<u>Description</u>	
Capacity	5 wet t/hour
Trough diameter	328 mm
Trough length	Screws 1 and 2 : 8 m – Screw 3 : 13 m
Lead angle	15-20°
Maximum screw operating speed	30 rpm

PART 3 – TECHNICAL SPECIFICATIONS

Materials	General requirements are indicated in part 2: Products – Components and sub-assemblies.
Motor	Screws 1 and 2 : 3 kW – 1450 rpm – TRI – 400 V – 50 Hz – IP 55 – F Screw 3 : 4 kW – 1450 rpm – TRI – 400 V – 50 Hz – IP 55 – F
Accessories (per installed screw conveyor)	Removal cover on trough Torque switch Inlet hopper with drain outlet and gate valve Outlet hopper in sludge mixer

1.3.2. OPERATING CONDITIONS

The dewatering room must be organized to leave enough place for a fourth dewatering unit installed.

The dewatering unit shall be provided as a completely integrated system designed for continuous and automatic operation.

Sludge conditioning shall be improved by mixing in a flocculation tank before gravity belt thickener.

Sludge must be uniformly spread over belts by means of rulers.

The geared motors of gravity belt thickener and belt filter press are manual variable speed.

A scraper peels off sludge in the screw conveyor hopper.

Rubber rolls must be disposed to have a progressive pressing that improve dewatering operation and percent capture.

Contractor must describe the pneumatic device that keeps automatically belts in good alignment.

The unit must have at least these security devices:

- Sludge level sensors at the inlet of each element (gravity belt thickener, belt filter press, hopper of the screws conveyor),
- Sludge level sensors on belts,
- Wash water pressure sensor for each element (gravity belt thickener, belt filter press),
- Rolls and belts position sensors on the left and on the right,

Belts are washing continuously with well filtered water to keep their filtration capacities. One pump is provided for each of the three units.

As indicated on the structure plans, centrates are collected in a concrete tank linked to the foul water sump.

The contractor includes one or several local control panels in the dewatering room with Operator Interface Terminal (OIT) connected to the SCADA. The OIT shall allow data entry, process monitoring, status monitoring and alarm monitoring of the dewatering unit.

1.3.3. DEWATERING PERFORMANCE REQUIREMENTS

The equipment provided for sludge dewatering shall achieve the following operational performance. The Contractor is responsible for installing the dewatering equipment package to achieve these performances.

The following performances shall be tested during the Commissioning Period:

- a. Cake solids: minimum 22%, average 24% solids with a sludge feed between 2.5 g/L and 3.5 g/L
- b. Percent capture: 94%
- c. Polymer usage: 6 kg dry polymer/ kg TSS in the sludge treated.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

- A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
- B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
- C. Workshop inspections and tests:
 - a. The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b. The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

- 1. Installation, maintenance and operation manuals with requirements of accuracy
- 2. Manufacture and quality assurance measures

3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

Floculator tank	Tank : HDPE Vertical mixer : Stainless steel X2CrNi18-09 1.4307 (304L)
Gravity belt thickener and belt filter press	Frame, hopper, cover : Stainless steel X2CrNi18-09 1.4307 (304L) inox 304L Belts : polyester Rollers : Rubber All exposed nuts and bolts : Stainless steel X20Cr13 1.4021 or X2CrNi18-09 1.4307 (304L)
Wash water pump	Body, shaft and impeller : Stainless steel X2CrNi18-09 1.4307 (304L) All exposed nuts and bolts : Stainless steel X20Cr13 1.4021 or X2CrNi18-09 1.4307 (304L)
Air compressor	Body, shaft and piston : Stainless steel X2CrNi18-09 1.4307 (304L) or Tank : galvanized steel All exposed nuts and bolts : Stainless steel X20Cr13 1.4021 or X2CrNi18-09 1.4307 (304L)
Screw conveyors	Screw conveyor troughs : stainless steel 304 Screw Conveyor Flights: carbon steel Removal troughs cover : EPHD or stainless steel 304

	Inlet and outlet hoppers : stainless steel 304 Bearing end plates: stainless steel 304 Support Saddles: stainless steel 304 Gear box : cast iron EN JL 1040 and epoxy

2.2. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts are

- for gravity belt thickener
 - 2 filtration belts
 - 6 pinch rollers
 - 90 nozzles
 - 3 scrapper
 - 3 rubber belts (sludge inlet)
 - 3 side belts (sludge orientation)

- for belt filter press
 - 3 lower belts
 - 3 upper belts
 - 3 lower scrappers
 - 3 upper scrappers
 - 120 nozzles
 - 6 set of jack seals
 - 30 EHDP belts support 1
 - 3 rubber belts (sludge inlet)

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

- A.** The following inspections shall be carried out :
 - a.** Holes position
 - b.** Flatness, verticality, horizontality of the embedded parts,
- B.** Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

- a.** When the Contractor is satisfied that the unit sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.
- b.** The unit will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3. COMMISSIONING TESTS

3.2.3.1. GENERAL

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.3.2. PRE-COMMISSIONING TESTS

- a.** Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
- b.** All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.
- c.** The backdrive shall be modulated and other control inputs simulated for a minimum of 8 hours to provide an initial test of control responses. A controlled shutdown and emergency shutdown cycle shall be included.
- d.** All programmed sequence control, protection, alarms, and other specified control features in dewatering units shall be demonstrated. Control logic inputs and outputs shall be simulated for all equipment and devices composed or linked to dewatering units.

3.2.3.3. COMMISSIONING TESTS

Operational test will consist of beginning and tuning operation of the three dewatering units and subsequent successful operation for seven consecutive days; or longer if malfunctions occur.

The flow per dewatering unit may range between 50 and 100 percent of the liquid throughput specified in this Section.

Engineer and dewatering unit Supplier will be present for the operational test procedure.

If restart is required due to malfunctions during the seven consecutive days of operation, the Contractor shall be responsible for providing additional on-site startup service by the technical representative at no additional cost to the Owner.

The Contractor shall follow the operational test procedures as follows:

- Tune and adjust dewatering units to begin the operational test,
- Contractor shall bear the cost for supply of polymer for the operational test period.
- Subsequent to proper tuning, perform an initial thorough inspection of all system components, including electrical and instrumentation and controls. Verify that all required electrical testing has been completed.
- Repair or replace any faulty components found during initial inspection within 48 hours at no cost to the Owner.
- Subsequent to initial inspection, operate the dewatering unit for a minimum period of seven consecutive days, which shall coincide with closed-loop operational testing as specified. Operation shall be defined as a minimum of 10 continuous hours per day, excluding system startup and shutdown time.
- The initial startup procedure is deemed complete if no malfunctions occur during the seven consecutive days of operation.
- If malfunctions occur which preclude dewatering and shutdown of the dewatering unit during the seven consecutive days of operation, perform and complete corrective action within 48 hours. Restart the dewatering equipment for a minimum of seven consecutive days of additional operation.
- The startup procedure is deemed complete if no malfunctions occur during the seven consecutive days of subsequent operation.
- If malfunctions occur during the seven consecutive days of subsequent operation, terminate the operational test period and perform and complete corrective action within 48 hours prior to requesting an additional operational test.
- If an additional operational test is necessary, follow the procedures outlined above.
- The satisfactory completion of the operational test is at the sole discretion of the Project Representative.

3.2.3.4. GUARANTEED PERFORMANCE ACCEPTANCE TESTING (GPAT):

GPAT will consist of an initial dewatering unit optimization period followed by a period of performance verification in which an intensive sampling program will be conducted.

The Contractor shall develop a detailed procedure and schedule for GPAT (GPAT Testing Plan) and submit to the Engineer for approval, in accordance with Section 010000. The GPAT Testing Plan shall be approved by the Engineer prior to the start of GPAT.

Coordination of the detailed GPAT schedule with the testing of related processes and ancillary systems is the sole responsibility of the Contractor.

The Contractor shall conform with the GPAT testing requirements as follows:

- Provide all test equipment, including instruments, analyzers, chutes, sample drums, and bins required to conduct sampling and analysis during the GPAT period.
- At the Owner's discretion, the Contractor shall split all samples for duplicate analysis by the Owner.
- The Contractor shall bear all costs for sampling and analysis, including splitting samples for independent analysis by the Owner.
- The Owner will bear the cost of independent analysis on split samples.
- All analyses shall be performed by an independent laboratory.

The procedure for the GPAT is as follows:

- Operate dewatering equipments for a period of at least seven consecutive days at a minimum of 15 hours per day, excluding system start-up and shutdown. If the dewatering unit does not exhibit stable operation during this period, or if more data is required to fulfill the obligations of GPAT, the Engineer will direct the dewatering equipment manufacturer to extend the testing period at no cost to the Owner.
- Document system performance during this period and conduct sampling and analyses as specified in this section. Provide all raw data to the Project Representative, so that the Owner can independently monitor system performance.
- During the course of the GPAT test period, samples and/or measurements will be taken by the Contractor once per hour (starting one hour after the dewatering unit has reached stable operation each day), or more frequently over the course of each operating day. A minimum of 10 samples/measurements shall be taken each day. The Contractor may extend the GPAT test period, at no additional cost to the Owner.
- Evaluation of dewatering performance against the specified performance criteria will be based on an average of all samples taken, minus the highest and lowest value data points in each performance category: cake solids, percent capture, and polymer usage.
- During the course of the GPAT, the units must be operated at or above the minimum solids or liquid loading specified in this Section. Solids or liquid loading to the dewatering must be reported simultaneously with the collection of each sample.
- The Engineer reserves the right to assess the results. If in the Project Representative's sole discretion, the statistical deviation is considered in excess of acceptable levels, additional testing and analysis may be stipulated at no additional cost to the Owner. If sludge characteristics are not within the ranges specified in this Section, the Manufacturer shall make compensating calculations for the effects, if any, of the changed conditions. Supporting data from 3rd party technical journals or reference books shall be provided by the Manufacturer. These calculations will be considered by the Engineer in determining conformance with the specific conditions, but will not be the sole basis of the evaluation.
- The Contractor shall compile the results and descriptions into a bound report titled "Results of Guaranteed Performance Acceptance Testing".
- Within five working days of receiving the report, the Engineer will inform the Contractor as to whether the dewatering unit complies with the provisions of the Contract for dewatering performance.
- If the results of the GPAT indicate that the dewatering fails to meet the specified performance criteria, the Contractor will be allowed to retry the GPAT. In agreeing to retry the GPAT, the Contractor further agrees to the following:
 - All retesting shall be performed at no additional cost to the Owner.

PART 3 – TECHNICAL SPECIFICATIONS

- Any costs or delays to the Contractor due to the retry of the GPAT shall be the responsibility of the Contractor.
 - The Manufacturer shall revise the dewatering Optimization Report and resubmit to the Contractor and Project Representative prior to the restart of the GPAT.
- The Contractor will be allowed a total of three attempts at the GPAT. If after three attempts the dewatering unit does not meet the specified performance requirements, the Owner, at its sole discretion, may reject the equipment and require either replacement by the Contractor with dewatering equipment of the Owner's choosing or equivalent monetary compensation from the Contractor.

3.2.3.5. SAMPLING AND ANALYSIS:

The Contractor shall conduct sampling and analyses during GPAT in accordance with the following:

Sample	Analysis
Dewatering unit Feed	Total suspended solids (TSS) Volatile suspended solids (VSS) Total solids (TS)
Centrate	Total suspended solids (TSS) Total solids (TS)
Dewatered cake	Total solids (TS)
Limed sludge	Total solids (TS)

In addition, record centrifuge WAS feed instantaneous and cumulative flow rates, polymer usage, power usage, torque, and any other parameters necessary to demonstrate compliance with the performance requirements specified.

Incorporate final GPAT data in concise tabular form in the GPAT Report submitted at the conclusion of the test period.

SECTION 11379

LIMING EQUIPMENT PACKAGE

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF WORK

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of liming equipment, including but not limited to:

1. Quick lime storage silo,
2. Arch-breakers (SODIMATE Type DDS 400 or equal),
3. Lime dosing screw (SODIMATE type DDMR 70 SCF - AB or equal),
4. Screw conveyors
5. Injector screws (SODIMATE Type DMR 80 SCF - AB or equal),
6. Lime/sludge mixer (SODIMATE Type MBV 240 or equal),

The liming equipment shall be provided as a completely integrated system designed for continuous and automatic operation.

The equipment shall be complete with all base plates, foundation bolts and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and be co-ordinated with all others parts and section of the contract.

1.3. DESCRIPTION

<u>Operating conditions</u>	
Duty	Continuous – 16 h/day – 7 days a week
Fluid service	Primary sludge between 22 to 26 % of suspended solids concentration and polymer (powder)
Fluid temperature	5-40°C
Fluid pH	6-9
Fluid specific gravity	1,05
Quick lime bulk density	800 kg/m ³
Quick lime bulk purity	> 90%
Sludge concentration after liming operation	>30 %
Sludge pH after liming operation	>12
Rate of lime	30 % - 40 %

1.3.1.1. QUICK LIME STORAGE SILO

<u>Identification</u>	203-LB-101/201/301
Number:	3
Location	Outdoor - Sludge building area
Model	Vertical cylindrical silo with long skirt
<u>Operating conditions</u>	
Duty	Continuous
Ambient environment	Outdoor
Ambient temperature	-25° to 42°C
<u>Description (for each silo)</u>	

Total volume	54 m ³
Useful volume	50 m ³
Diameter	2,90 m
Empty weight	4 000 kg
Total Height	13,20 m
Accessories	Conical roof with cone angle of 15 degrees Conical bottom with cone angle of 60 degrees Outlet DN 200 Ladder with crinoline, intermediate landing and security gates on the roof. Lifeline on the roof Dust filter on the top with cover (203-DF-101/201/301) – 0,08 kW – IP65 – 400V Safety valve Inspection panel Ø 600 Loading pipe with fitting and cap High and low level sensors and revolving light and Lifting lugs On the skirt : one door 1,80 m x 0,8 m – exhaust air grill and ground connections

1.3.1.2. QUICK LIME ARCHBREAKER

<u>Identification</u>	203-AB-101/201/301
Number:	3
Location	Sludge building area
Model	Arch-breaker spindle
<u>Operating conditions</u>	

Duty	Continuous
Ambient environment	Outdoor
Ambient temperature	-25° to 42°C
<u>Description (for each unit)</u>	
Capacity	100 to 500 kg/h
Body diameter	400 mm
Diameter	2,90 m
Components	Spindle with flexible blades fixed by hubs - Length = 1 m Rigid inferior arm Trapdoor Isolating valve DN 200 Adjustable link conduit
Gear motor	Speed 30 tr/mn Motor : 0,55 kW (400 V, 50 Hz, 1450 tr/mn, IP55)

1.3.1.3. LIME DOSING SCREW

<u>Identification</u>	203-DS-101/201/301
Number	3
Location	Sludge building area
Model	Spiral screw conveyor
<u>Operating conditions</u>	
Duty	Continuous – 16h/day – 7 days a week
Ambient environment	Outdoor
Ambient temperature	-25° to 42°C

<u>Description</u>	
Capacity	100 to 500 kg/h
Dosing spiral diameter	70 mm
Dosing spiral length	Screws 1 and 2 : 1 m – Screw 3 : 4 m
Materials	General requirements are indicated in part 2: Products – Components and sub-assemblies.
Gear motor	Speed : 90 rpm Motors screws 1, 2 and 3 :1,1 kW – 1450 rpm – TRI – 400 V – 50 Hz – IP 55 – F – Frequency converter
Accessories (per installed screw conveyor)	Dosing tube Inlet hopper connected to archbreaker, Outlet hopper connected to lime screw conveyor One tamping sensor,

1.3.1.4. **LIME SCREW CONVEYOR**

<u>Identification</u>	203-SW-101/201/301
Number	3
Location	Sludge building - liming room
Model	Spiral screw conveyor
<u>Operating conditions</u>	
Duty	Continuous – 16h/day – 7 days a week
Ambient environment	Indoor
Ambient temperature	5° to 40°C
<u>Description</u>	
Capacity	100 to 500 kg/h

PART 3 – TECHNICAL SPECIFICATIONS

Conveying spiral diameter	80 mm
Conveying spiral length	Screw 1 to mixer 1 : 5 m Screw 2 to mixer 2 : 8,50 m Screw 3 to mixer 3 : 5 m
Materials	General requirements are indicated in part 2: Products – Components and sub-assemblies.
Gear motor	Speed : 110 rpm Motors Screw 1 : 1,1 kW Screw 2 : 2,2 kW Screws 3 and 4 : 1,1 et 5,5 kW 1450 rpm – TRI – 400 V – 50 Hz – IP 55 – F Frequency converter
Accessories (per installed screw)	Dosing tube Inlet hoppers connected to lime dosing screw, Outlet hoppers connected to lime injecting screw, Adjustable link conduit One tamping sensor,

1.3.1.5. LIME INJECTING SCREW

<u>Identification</u>	203-SW-102/202/302
Number	3
Location	Sludge building – Liming room
Model	Spiral screw conveyor
<u>Operating conditions</u>	
Duty	Continuous – 16h/day – 7 days a week
Ambient environment	Indoor
Ambient temperature	5° to 40°C

<u>Description</u>	
Capacity	100 to 500 kg/h
Dosing spiral diameter	80 mm
Dosing spiral length	Screws 1, 2 and 3 : 1 m
Materials	General requirements are indicated in part 2: Products – Components and sub-assemblies.
Gear motor	Speed : 115 rpm Motors (screws 1, 2 and 3) :0,75 kW – 1450 rpm – TRI – 400 V – 50 Hz – IP 55 – F
Accessories (per installed screw conveyor)	Tube Inlet hopper connected to lime screw conveyor, Outlet hopper connected to sludge/lime mixer One tamping sensor

1.3.1.6. **SLUDGE/LIME MIXERS**

<u>Identification</u>	
Number	3
Location	Sludge building – Liming room
Model	Paddles mixer
<u>Operating conditions</u>	
Duty	Continuous – 16h/day – 7 days a week
Ambient environment	Indoor
Ambient temperature	5° to 40°C
<u>Description</u>	
Capacity	Sludge : 4,5 m ³ /h – Lime : 0,6 m ³ /h

Components	One inlet hopper with : - on the top : one rectangular opening for sludge intake, one circular opening for lime intake and one screw tapping for level sensor - on one side : one bay panel One trough with removal cover Two counter-rotating shafts, fitted with intersecting and adjustable paddles, Ø : 240 mm One outlet hopper Seal by adjustable stuffing box
Gear Motor	Speed : 26 rpm Motor : 2,2 kW – 400V – 50 Hz – IP55, F Frequency converter
Materials	General requirements are indicated in part 2: Products – Components and sub-assemblies.
Accessories	High level sensor (admittance detector)

1.3.2. OPERATING CONDITIONS

The liming room must be organized to leave enough place for a fourth liming unit installed.

The liming unit shall be provided as a completely integrated system designed for continuous and automatic operation.

Lime screws and mixers shall be closed and connected to reduce dust emission.

Units shall not need preventive cleaning.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

- A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
- B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS – COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

Quick lime storage silo	Silo : Stratified polyester Lifeline : aluminium or stratified polyester Outlet flanges : stainless steel X2CrNi18-09 1.4307 (304L) Access equipments, exhaust air grill, dust filter cover : Aluminium Ground connections and lifting lugs: galvanized steel. Loading pipe and accessories : stainless steel X2CrNi18-09 1.4307 (304L)
Lime archbreaker	Arch breaking spindle: stainless steel 304 Body: painted carbon steel Flexible blades: stainless steel 304 Gear box : cast iron EN JL 1040 and epoxy
Lime screw conveyors Lime dosing screw Lime injector screw	Screw conveyor tube : stainless steel 304 Screw Conveyor Flights: carbon steel Inlet and outlet hoppers : stainless steel 304

PART 3 – TECHNICAL SPECIFICATIONS

	Bearing end plates: stainless steel 304 Support Saddles: stainless steel 304 Gear box : cast iron EN JL 1040 and epoxy
Sludge lime mixers	Inlet and outlet hopper stainless steel 304 One trough with removal cover stainless steel 304 Two counter-rotating shafts : carbon steel Gear box : cast iron EN JL 1040 and epoxy
Bolts, nuts and washers:	stainless steel X2CrNi18-09 1.4307 (304L)

2.2. SPARE PARTS

- Quick lime storage silo
 - One dust filter
- Lime archbreaker
 - 3 Flexible blades
 - One set of end bearings and packing
 - One gear motor
 - One set of seals
- Lime screws (for each type of screw)
 - One gear motor
 - One set of seals
- Sludge/Lime mixers
 - 3 counter-rotating shafts
 - 1 set of end bearings and packing
 - 3 set of seals
 - One gear motor

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

- A.** The following inspections shall be carried out :
 - a.** Holes position
 - b.** Flatness, verticality, horizontality of the embedded parts,

- B.** Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

- a.** When the Contractor is satisfied that the unit sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.
- b.** The unit will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3. COMMISSIONING TESTS

3.2.3.1. GENERAL

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.3.2. PRE-COMMISSIONING TESTS

- a.** Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
- b.** All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.

- c. The backdrive shall be modulated and other control inputs simulated for a minimum of 8 hours to provide an initial test of control responses. A controlled shutdown and emergency shutdown cycle shall be included.
- d. All programmed sequence control, protection, alarms, and other specified control features in dewatering units shall be demonstrated. Control logic inputs and outputs shall be simulated for all equipment and devices composed or linked to dewatering units.

3.2.3.3. COMMISSIONING TESTS

Operational test will consist of beginning and tuning operation of the three liming units and subsequent successful operation for seven consecutive days; or longer if malfunctions occur.

The flow per liming unit may range between 50 and 100 percent of the liquid throughput specified in this Section.

Project Representative and liming unit Supplier will be present for the operational test procedure.

If restart is required due to malfunctions during the seven consecutive days of operation, the Contractor shall be responsible for providing additional on-site startup service by the technical representative at no additional cost to the Owner.

The Contractor shall follow the operational test procedures as follows:

- Tune and adjust liming units to begin the operational test,
- Contractor shall bear the cost for supply of lime for the operational test period.
- Subsequent to proper tuning, perform an initial thorough inspection of all system components, including electrical and instrumentation and controls. Verify that all required electrical testing has been completed.
- Repair or replace any faulty components found during initial inspection within 48 hours at no cost to the Owner.
- Subsequent to initial inspection, operate the dewatering unit for a minimum period of seven consecutive days, which shall coincide with closed-loop operational testing as specified. Operation shall be defined as a minimum of 10 continuous hours per day, excluding system startup and shutdown time.
- The initial startup procedure is deemed complete if no malfunctions occur during the seven consecutive days of operation.
- If malfunctions occur which preclude dewatering and shutdown of the dewatering unit during the seven consecutive days of operation, perform and complete corrective action within 48 hours. Restart the liming equipment for a minimum of seven consecutive days of additional operation.
- The startup procedure is deemed complete if no malfunctions occur during the seven consecutive days of subsequent operation.
- If malfunctions occur during the seven consecutive days of subsequent operation, terminate the operational test period and perform and complete corrective action within 48 hours prior to requesting an additional operational test.
- If an additional operational test is necessary, follow the procedures outlined above.
- The satisfactory completion of the operational test is at the sole discretion of the Project Representative.
- Owner will bear the cost and be responsible for disposal of the dewatered cake during operational testing.

SECTION 13 210

LAMELLAS PLATES

1. GENERAL

1.1. WORK INCLUDED

This section of the specifications covers the Lamellas of the primary sedimentation tanks.

The supply shall include the following main items:

1. Lamellas,
2. Lamellas assembly system,
3. Anchoring and Support system.
4. The special tools and the spare parts.

1.2. RELATED WORKS

- A.** Supplies and works included under this section shall comply with the requirements of the following:
1. Section 01010 - Corrosion protection
 2. Section 01020 - Basic mechanical requirements
- B.** Work under this section shall be co-ordinated with:
1. Civil Engineering works and Building works;

1.3. DESCRIPTION

1.3.1. LAMELLAS

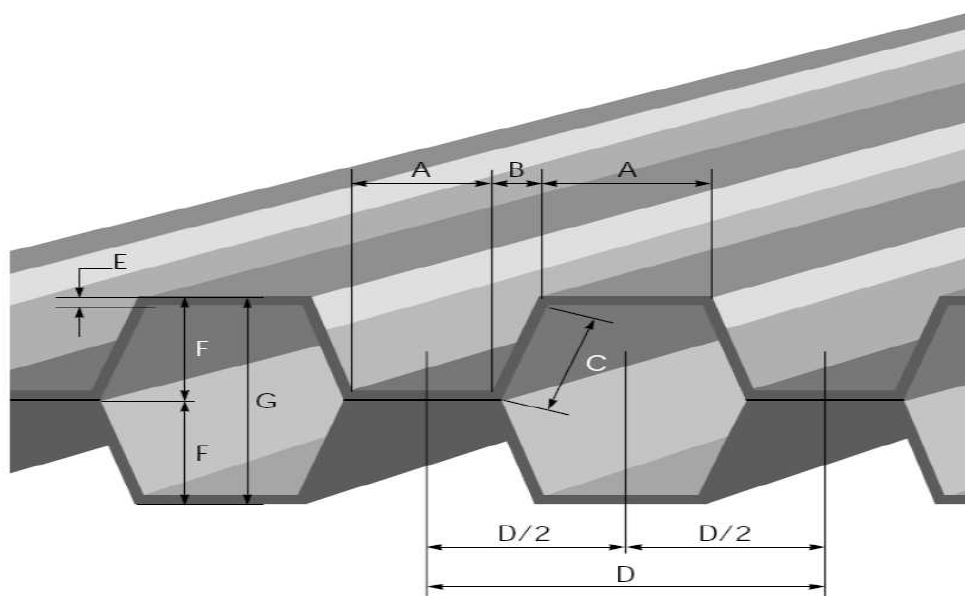
The lamellas shall be installed in four lamellar tanks. Each lamellar tank shall be divided in 2 parts on each side of the collection channel. A total of 8 zones shall be equipped with lamellas presenting the following characteristics:

Type:	Lamellas 90 x 40 V
Location:	Primary sedimentation
Number of zones:	8

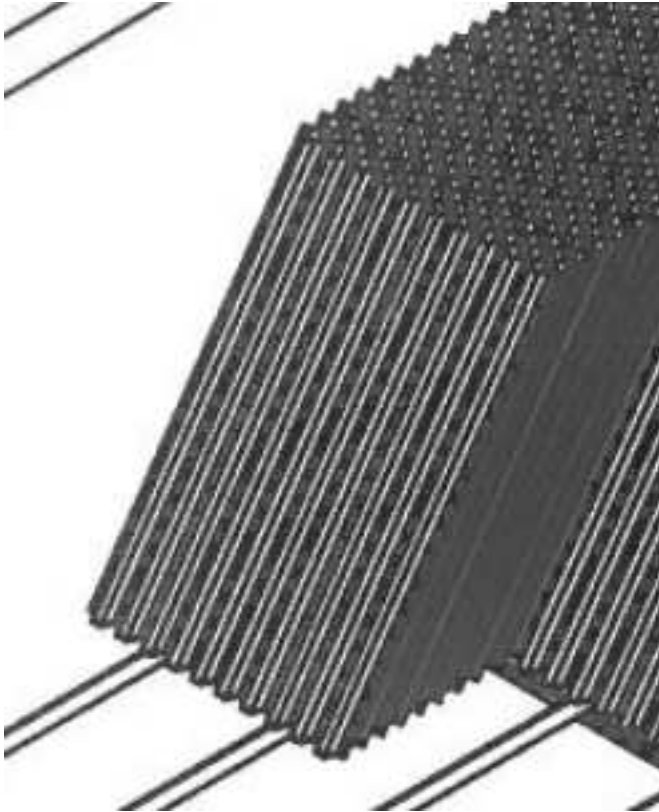
Dimension of each zone	15.85 m x 7.85 m
Height:	1 900 mm
Width	1 000 mm standard width On one side, plates shall be cut according to the overall basin dimension. Plates may be cut on site.
Angle	60 degrees
Plate Material:	Super high impact Polystyrene type : Thermoplastics ISO 2897-PS-I,G,093-03-07-18 or ISO 2897-PS-I,G,093-03-10-18 Or Polyethylene or PVC.
The plates shall be assembled with 304 SS staples on site or welded.	

Specific dimensions of lamella plates stated below shall be met:

Length of overlap (A)	mm	30
Length of tube side (B)	mm	15
Length of tube side (C)	mm	42,72
Length of one wave (D)	mm	90
Plate thickness (E) varies within the thermoformed plate between:	mm	0.7 minimum 1.2 maximum
Depth of one wave (F)	mm	40



Each lamella shall be cut such that when installed at a 60 degree angle the bottom and top part of the lamella plate shall be completely horizontal. The height of the assembled lamellas (1m90 long each) shall be 1m46, as they shall be welded together at a 60 degree angle.



1.3.2. SUPPORT SYSTEM

The support system shall support the entire weight of the plates plus 50%, in order to account for organic material collected on the plates when the tank is emptied for maintenance.

The support system shall be made of SS 304, or concrete and SS 304. The anchoring system shall meet the corrosion protection requirements of Section 01010.

1.4. QUALITY ASSURANCE

1.4.1. DESIGN CRITERIA

- A.** Refer to Section 01020.
- B.** The lamellas shall be designed to withstand without damage an MCE (maximum credible earthquake).

1.4.2. SOURCE QUALITY CONTROL

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - a) At the end of manufacture, the lamellar plates shall be presented, for checking
 - a) Welds:
Refer to Section 01020.

1.5. SUBMITTALS

Refer to Section 01 000 -General requirements

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. MANUFACTURE

The tolerance on the dimension of each plate delivered on site shall be +/- 0.1%.

The one site assembly of the bee's nest pattern shall be performed by the contractor immediately before installation on the support system in the tank. Blocks of 6 to 8 plates stapled together shall be prepared outside of the tank, then installed on the support system, at which point the blocks shall be stapled together.

The dimensions of the bee's nest pattern assembly specified in Section 1, shall be met with a tolerance of +/- 0.1%.

2.2. TRANSPORT AND STORAGE

Plates shall be transported and stored at temperatures between -10 °C and + 60 °C.

2.3. SPECIAL TOOLS AND SPARE PARTS

The Contractor shall supply the following tools and spare parts:

1. 100 plates, unwelded
2. Air powered stapler

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

- A. The Contractor shall check the dimensions of the delivered plates prior to welding.
- B. The Engineer shall check the plates prior to their assembly: Any plate showing signs of bulking due to heat above 60°C during transport and storage shall be rejected by the Engineer.

3.2. FIELD QUALITY CONTROL

- A.** The Contractor shall check the setting and alignment of support system prior to fixing the welded plates
- B.** The Contractor shall check the dimensions and the regularity of the pattern of the welded plates prior to their fixing on the support system.

oOo

SECTION 14100 PIPES AND FITTINGS

1. GENERAL

1.1. WORK INCLUDED

This specification applies to the supply, assembly and testing of pipes and fittings.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A.** Section 01000 - General requirements;
- B.** Section 01010 - Corrosion protection

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A.** Civil Engineering works and Building works;
- B.** Section 09910 – Painting;
- C.** Section 13241 – Air blowers;
- D.** Section 14150 – Valves, gates & appurtenances;
- E.** Section 14270 – Dosing pumps;
- F.** Section 14300 – Miscellaneous pumps;

1.3. QUALITY ASSURANCE

1.3.1. STANDARDS

Preference shall be given to ISO Standards (International Standards Organization).

Other standards such as EN (European Committee for Standardization/CEN), BS (British Standards Institution/BSI), AFNOR (Association Française de Normalisation), DIN (Deutsche Standards für Normung), ASTM (American Testing and Material Standards), ANSI (American National Standards Institute), ACI (American Concrete Institute), AWWA (American Water Works Association), API (American Petroleum Institute) can only be used either if they are compatible and better than the relevant ISO Standards or when no ISO Standard covers the product, based on the Engineer's satisfaction.

All standards and references shall in any case be deemed to include the latest edition available 28 days before the deadline for submission of Bids.

All units of weight and measurements shall be based on the Metric System of Weights and Measurements.

1.3.1.1. PVC PIPES AND FITTINGS

- ISO/R 161/1: Thermoplastics pipes for the conveyance of fluids - Nominal outside diameters and nominal pressures - Part 1: Metric series.
- ISO 264: Unplasticized polyvinyl chloride (PVC) fittings with plain sockets for pipes under pressure - Laying lengths - Metric series.
- ISO/R 265: Pipes and fittings of plastics materials. Socket fittings with spigot ends for domestic and industrial waste pipes. Basic dimensions: metric series.
- ISO/R 1133: Plastics. Determination of the melt flow rate of thermoplastics.
- ISO 2035: Unplasticized polyvinyl chloride (PVC) moulded fittings for elastic sealing ring type joints for use under pressure. Pressure-resistance test.
- ISO 2044: Unplasticized polyvinyl chloride (PVC) injection-moulded solvent-welded socket fittings for use with pressure pipe - Hydraulic internal pressure test.
- ISO 2507: Unplasticized polyvinyl chloride (PVC) pipes and fittings. Vicat softening temperature. Test method and specification.
- ISO 2536: Unplasticized polyvinyl chloride (PVC) pressure pipes and fittings, metric series - Dimensions of flanges.
- ISO 3114: Unplasticized polyvinyl chloride (PVC) pipes for potable water supply. Extractability of lead and tin. Test method
- ISO 3126: Plastics pipes - Measurement of dimensions.
- ISO 3127: Thermoplastics pipes - Determination of resistance to external blows.
- ISO 3473: Unplasticized polyvinyl chloride (PVC) pipes. Effect of sulphuric acid. Requirement and test method
- ISO 3606: Unplasticized polyvinyl chloride (PVC) pipes. Tolerances on outside diameters and wall thicknesses,
- ISO 4065: Thermoplastic pipes. Universal wall thickness table,
- ISO 4422: Unplasticized polyvinyl chloride (PVC) pipes and fittings for water supply. Specification,

- ISO/TR 7074: Performance requirements for plastics pipes and fittings for use in underground drainage and sewage,
- ISO/TR 7473: Unplasticized polyvinyl chloride pipes and fittings. Chemical resistance with respect to fluids,
- NFT 54003: PVC tubes to convey fluids.
- NFT 54016.II: Characteristics of PVC tubes.
- NFT 54028: Plastics. Unplasticized PVC pipe elements. Assembling with adhesive. Dimensional characteristics
- NFT 54039: tests to be used for sealing-ring assemblies,
- NFT 54041: Elastomer sealing rings,
- BS 2494: 1990 - Elastomeric seals for joints in pipework and pipelines
- BS 3505: 1986 – Specifications for unplasticized polyvinyl chloride pressure pipes for cold potable water.
- BS EN 1452 - 2000 - Joints and fittings for use with unplasticised PVC pressure pipes (including hydraulic pressure tests).
- BS 4514: 1983 uPVC soil and ventilating pipes, fittings and accessories
- BS 4660: 1989 Unplasticised PVC underground drain pipe, fittings for drainage and sewer pipes. Nominal size 110 and 160.
- BS 5255: 1987 Thermoplastics waste pipes and fittings
- BS 8301: 1985 Code of Practice for building drainage
- NF EN 681-2: Rubber seals - Specification for materials for joint seals on pipes used in the field of water and drainage - Part 2: thermoplastic elastomers.

1.3.1.2. DUCTILE IRON PIPES AND FITTINGS

- BS EN 545 (or NF EN 545 – 2010): Ductile iron pipes, fittings, accessories and their joints for water pipelines — Requirements and test methods.

- EN14901: Ductile iron pipes fittings and accessories – epoxy coating (heavy duty) – requirements and test methods.
- NF EN 598: Pipes, connections and fittings.
- NF A 48-870: Standard joints.
- NF EN 681: Joint rings.

1.3.1.3. STAINLESS STEEL PIPES

- ISO 5252: Steel tubes.
- ISO 1127: Stainless steel tubes - Dimensions, tolerances and conventional masses per unit length.

1.3.2. DESIGN CRITERIA

All piping shall be designed for a minimum working pressure of 10 bar expect for the effluent pressure line which shall be designed for a minimum working pressure of 16 bar.

1.3.3. SHOP INSPECTION AND TEST

1. Inspection

The quality of all materials, the process of manufacture shall be subject to inspection and approval by the Engineer or by an independent testing laboratory selected by the Employer. Such inspection shall be made at the place of manufacture and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipes may have been accepted as satisfactory.

2. Hydrostatic test

Before coating and lining each pipe with a service pressure higher than 6 bars shall be tested. The test pressure for steel pipes shall be given by the following formula:

$$P = \frac{20 St}{D}$$

Wherein:

P = Hydrostatic test pressure in bar

S = 75% of yield point of steel used in MPa

t = Wall thickness in mm

D = Outside diameter in mm

Test pressure for PVC and concrete pipes and fittings shall be according to the applicable standards.

1.4. SUBMITTALS

1.4.1. GENERAL

In his proposal, the Contractor shall provide for all pipes and fittings all necessary guarantees concerning the nature of the materials used, the quality of execution and implementation, their stability during operation in normal conditions of use, and the interior and exterior protective linings and coatings on the pipes, as well as all supporting calculation memoranda and characteristics.

1.4.2. CERTIFICATES

The Contractor shall furnish a mill certified report, in triplicate, of the tests for each material to be utilized in the work. The certifications shall contain the result of chemical and physical tests required by these specifications for the materials.

1.4.3. SHOP DRAWINGS

The Contractor shall submit detailed working and shop drawings and schedules of all pipe, fittings and appurtenances. Shop drawings shall include but not be limited to the following:

- Lists and schedules of material, linings and coatings.
- Schedules of pipe lengths and thicknesses.
- Details of proposed joints, hardnesses and installation details.
- Names of suppliers and identification of materials and equipment to be supplied.
- Shop drawings shall show the locations of unions, bolted flanged connections or other appurtenances to permit ready dismantling of piping systems.

The work of this section shall be completely co-ordinated with the work of other sections. The Contractor shall verify at the site, both the dimensions and work of other sections which adjoin his materials. Field measurements shall be taken at the site and incorporated in the shop drawings, with specific notes.

1.5. DESCRIPTION

Utility Network pipe materials shall be in accordance with the information given in the table hereafter.

TYPE OF FLUID	PIPES IN BUILDING	BURRIED PIPES
Waste water	-	Ductile Iron or Concrete
Decanted water	-	Ductile Iron or concrete
Decanted service water, Ø40	PVC	PVC
Foul Drain water	PVC	Ductile Iron,HDPE or PVC
Grease	PVC	Ductile Iron or PVC
Sand	Ductile Iron or SS	Ductile Iron
Chemicals	HDPE	HDPE
Liquid sludge	Stainless Steel	Ductile Iron
Foul air	Aluminium or PVC	-
Compressed air	PVC	-
Well service water	HDPE or PVC	HDPE or PVC
Drinking water	HDPE or PVC	HDPE or PVC

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. STAINLESS STEEL PIPES

A. General specifications

The general characteristics of stainless steel tubes must comply with the international standards in force.

B. Assembly

Pipes shall consist of stainless steel tubes and connections welded together.

Welds more than 1.5 mm thick should preferably be done with filler metal.

Welds inside pipes shall be protected by injecting argon or nitrogen into the pipe.

All welds must be cleaned mechanically or chemically.

Air shall be used for cooling.

The Contractor shall use parts prefabricated in the factory for bends and tapers.

All supports, fixing accessories and screws shall also be made of stainless steel.

2.1.2. CHECKING OF WELDS

Welds shall be prepared, carried out, checked and repaired in accordance with the specifications of NF and ISO standards.

Welds shall be prepared with hollow chamfers, V-shaped for single-side welds and X-shaped for double-side welds.

A straight root face at the base of the chamfer is only permitted if it is of regular height and small enough not to hamper penetration.

V-shaped welds will normally have chamfers opening outwards. They shall be repeated backwards after chipping.

The Contractor's checks shall include the following operations:

A. The appearance of all welds must be checked

The Contractor shall check that all welds are regular and properly connected to the part. Their width end-to-end must be no more than $1.8e + 5$ mm, with e being the thickness of the sheet in the case of a V-shaped chamfer or half its thickness in the case of an X-shaped chamfer.

Average build-up is between the following limits:

$$\left(0,5 + \frac{e}{20}\right) \text{ mm et } \left(2 + \frac{e}{10}\right) \text{ mm}$$

Maximum difference in level is:

$$\left(\frac{e}{20} + 1\right) \text{ mm}$$

The length "a" of an apparent continuous defect (groove or lack of penetration) shall be less than 30 mm, the distance separating two defects less than 3a and the sum of all "a" values over the length of the joint L less than L/10.

B. Penetrant test

All welds shall be checked by means of a penetrant test as per standard ISO 3452.

The Contractor shall carry out the penetrant tests himself.

The Engineer reserves the right to carry out additional tests if he considers it necessary. The corresponding costs shall be borne by the Engineer if the results should prove to be satisfactory and by the Contractor if not.

C. Acceptance or rejection of welds

Weld defect acceptance criteria shall be determined according to the nature, service conditions and importance of the equipment inspected, and in light of the danger and consequences involved in the event of a burst.

More generally, the criteria shall be derived from the standards in force and specific to each class of equipment.

D. Repairing welds

Defective welds shall be repaired by eliminating the defective area down to sound metal and repeating the weld. Repaired areas shall be re-inspected.

If the new inspection reveals unacceptable work, an additional inspection shall be carried out on either side of the area in question.

If this new inspection does not reveal any defect leading to rejection of the weld, only the area concerned by the first inspection shall be repaired. If not, a complete inspection shall be performed.

A welded area cannot be repaired more than twice in order to avoid changes in the structure of the metal resulting from repeated heating, unless specified to the contrary.

2.1.3. HDPE PIPES

A. General

The general characteristics of HDPE pipes must comply with the international standards in force.

B. Assembly

HDPE pipes shall be sawn perpendicular to the centre line and cleanly to avoid sharp edges, burrs and roughness.

The area shall be completely scraped and the surface cleaned with solvent.

Welds shall be made:

- **either by polyfusion:** an electrically heated mirror shall be used to reach a plasticising temperature at the ends of $200^{\circ}\text{C} \pm 10^{\circ}\text{C}$. The weld shall be made by pressing the ends together under a pressure of 1.5 to 2 kg/cm² to obtain a single length,
- **or by welding**, particularly in the case of shaped parts:
 - with a hot steel torch (controlled temperature and air flow) and HDPE filler rod,
 - with a heated wedge device, using HDPE filler wedges,
 - by extension to all HDPE parts.

Polyethylene connectors will also be joined by polyfusion, either by butt fusion or, in the case of fittings with a socket, by means of a heating sleeve or incorporated electrical heating resistance activated by an automatic welding device.

Connections to pipes made of traditional materials (steel, ductile iron, etc.) shall be made by means of a moulded HDPE collar polyfused to the end of the tube and by a coated backing flange.

For HDPE pipe connections to manholes, neoprene holes will be added to the end of the tube or manhole access fittings shall be provided, with a welded HDPE collar and gusset assembly embedded in the concrete.

Pipes shall be tested in accordance with articles 76, 78 and 79 of section 71 of the French General Technical Specifications. The test pressure shall be equal to the service pressure plus 50% (article 76.5).

2.1.4. DUCTILE CAST IRON PIPES AND CONNECTIONS

A. General

The general characteristics of ductile iron pipes, connections and fittings must comply with the international standards in force.

A calculation note concerning concrete anchor blocks shall be submitted to the Engineer for approval.

B. Connection of pipes

Pipes shall be joined by socket joint and possibly elastomer seals. Non-buried pipes shall be joined by flanges.

C. Lining

Socket jointed pipes shall be lined with centrifuged high alumina cement mortar and sockets with red epoxy paint.

D. Coating

Coatings shall be as follows:

- A layer of electrolytic zinc and epoxy paint on all pipes
- Red-brown epoxy powder for flange connections and connecting parts.

2.1.5. PVC PIPES

A. General

The general characteristics of PVC tubes intended to convey fluids are described in standard NF T 54-003.

This complies with international standards ISO/161/1, ISO/3606 and ISO/3126.

PVC tubes for pressurised or buried pipes: the characteristics of the tubes shall comply with the specifications of standard NF T 54-016.II

B. Assembly

All pipes shall have sealed joints.

The dimensional characteristics of sealing-ring assemblies of pressurised pipe elements shall comply with the specifications of standard ISO 2045.

Pipe elements include:

- PVC tubes
- Ductile iron fittings

Standard NF T 54-039 describes the tests to be used for sealing-ring assemblies.

Elastomer sealing rings shall comply with standard NF T 54-041.

2.1.6. DISMANTLING JOINTS

These joints should enable all valves and other fittings on the pipes to be dismantled and reassembled.

They shall be made of ductile iron or steel, and sized in accordance with the diameter of the pipes and maximum service pressure.

They shall consist of two sleeves sliding into one another and fitted with an assembly flange at each end. Watertightness at the point of sliding shall be guaranteed by a rubber seal compressed by an intermediate companion flange.

The dismantling joint shall be assembled on the pipe and fittings by means of threaded rods.

It shall be of "free" type if the pipe is not submitted to longitudinal stress, and otherwise of "self-abutting" type.

2.1.7. FLANGES

Flanges shall be determined in accordance with standardisation rules depending on the diameter of the pipes and the service pressure.

They shall be of flat type, made of steel or stainless steel, to be welded on to pipes with a perpendicular face and drill holes.

The seal bearing surface may be raised, with concentric grooves 8 mm apart and 0.4 mm deep, without rough edges, in order to improve the adherence of the seal and prevent it from slipping.

The sealing surfaces of the flanges shall be coated. Careful attention must be paid to the angular position of the flanges.

2.1.8. SEALS

Seals shall be fitted between flanges; they shall be of flat type and adapted to the characteristics of the flanges.

Seals shall be made of webbed rubber or synthetic rubber.

2.1.9. DIELECTRIC INSULATING SEALS

All fittings of a different nature shall be mounted between flanges with dielectric insulating seals.

These insulating seals shall be made of an insulating material such as bakelite. They shall be fixed with appropriate bolts, nuts and washers.

2.1.10. BOLTING

All assembly screws, bolts, pins, threaded rods, nuts and washers shall be made of Z2CN 18-10 L stainless steel and comply with standardisation regulations with regard to the diameters and cutting of threads, which must not offer resistance. Threads of screws and bolts used on parts subject to vibrations and shocks shall be locked.

2.1.11. CORROSION PROTECTION

See technical specifications relating to corrosion in section 01010.

2.2. SPECIAL TOOLS AND SPARE PARTS

Refer to General Requirements

3. EXECUTION

3.1. HANDLING OF PIPES

Pipes of all types must be handled with care. Pipes shall be placed on the ground or laid in trenches gently, avoiding rolling them on stones or on rocky ground without first creating a runway using planks.

Any pipe accidentally dropped from any height whatever must be considered as suspect and may only be laid after further inspection. With regard to steel pipes, the coating shall be protected against friction wear by packing straw or other soft material between them. They must rest on planks and not on round timber.

All the above stipulations also apply to connections and fittings.

3.2. CUTTING PIPES

Depending on laying requirements, the Contractor shall be entitled to cut pipes. However, all necessary precautions must be taken to ensure that this is only done in cases of absolute necessity and as infrequently as possible.

Pipes may be cut by any process suited to the material in question, so as not to disturb its physical state and obtain a clean cut.

The Contractor shall do his utmost to ensure that the new spigot ends resulting from such operations are smooth and that they produce assemblies that are as reliable as ordinary pipe ends.

3.3. LAYING PIPES

Pipe interiors shall be inspected at the time of laying and carefully cleared of all foreign bodies that may have entered them. The ends shall be carefully cleaned.

Whenever work is interrupted, pipes being laid shall be blocked with a plug to prevent foreign bodies or animals from entering.

Tubes and connections shall be inspected before being assembled to ensure, in particular, that the outer protective coating and possible inner protective lining is intact or restored to its original condition.

Coatings and linings must be carefully repaired whenever they have been removed or damaged.

3.4. TESTING PIPES

A. Preparing the tests

Testing operations on joints and pipes shall be carried out by the Contractor at his own expense in accordance with the Engineer's instructions.

Tests are carried out in conditions that allow the pipe and especially all the joints to be properly examined. In particular, the Contractor shall provide and place all blank plates, thrust blocks supply pipes and any other accessory installations required for carrying out the tests, as stipulated, and all necessary equipment.

B. Test methods

Tests shall be carried out in accordance with section 70 of the French General Technical Specifications.

C. Compliance and additional tests

The Contractor shall make good any faulty sealing observed during the tests, by immediately and at his own expense making any repairs whatsoever that the tests have shown to be necessary. However, he shall not bear the cost of replacing, supplying and placing parts not supplied by him if any weakness is shown to be due to the poor quality of the materials or faulty manufacture. The same is true of the cost of the preliminary investigations if such defects should be confirmed.

Once repairs have been made a new test shall be performed in the same conditions as those described above. However, the costs incurred by such tests shall be borne by the Engineer if repairs have been carried out as a result of a burst or deterioration arising from an intrinsic defect in a part not supplied by the Contractor.

D. Report

A report is drawn up jointly by the Engineer and the Contractor for each test.

E. Height setting

Before any backfilling operations, the height setting of the pipes shall be checked systematically by a surveyor; this work will be paid for by the Contractor and submitted to the Owner for approval.

F. Inspection

All pipes of ≥ 1200 mm diameter shall be inspected visually prior to filling.

All pipes of < 1200 mm diameter shall be inspected by video camera prior to filling.

All these inspections shall be recorded and sent to the Engineer. The cost of such inspections shall be borne by the Contractor.

oOo

SECTION 14150

VALVES, GATES & APPURTENANCES

1. GENERAL

1.1. WORK INCLUDED

The present specification shall apply to the valves, gates and appurtenances as designed by the Contractor.

1.2. RELATED WORKS

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A.** Section 01000 - General requirements;
- B.** Section 01010 - Corrosion protection
- C.** Section 01030 – Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A.** Civil Engineering works and Building works;
- B.** Section 09910 – Painting;
- C.** Section 14100 – Pipes and fittings;
- D.** Electrical equipment specifications;

1.3. QUALITY ASSURANCE

1.3.1. STANDARD

International standards when available shall apply for valve construction and materials:

- AWWA standards
- ASTM standards
- API standards
- ISO standards
- DIN standards

Others standards (NF, BS, JIS, etc.) may be accepted.

1.3.2. DESIGN CRITERIA

1. All valves of the same type shall be from one manufacturer.
2. The Contractor shall make evidence of the hydraulic performance of the valves proposed and particularly the following:
 - Air valves.
 - Flow control valves.
 - Altitude valves (level control valves).
 - Overspeed valves.
 - Check valves.

1.3.3. SHOP TESTS

1. Performance Tests

Each valve, gate and appurtenance shall be operated three times from the fully closed to the fully opened position and the reverse, under a no-flow condition to demonstrate that the complete assembly is workable.

2. Hydrostatic Test

Valves specified shall be hydrostatically tested as follows:

- Upstream/downstream Leak-tightness test at 1.1 times the maximum admissible working pressure at 20°C.
- Body strength test at 1.5 times the maximum admissible working pressure at 20°C.

1.4. SUBMITTALS

The Contractor shall submit detailed shop drawings and working drawings with relevant calculation notes.

a. Calculation notes

The Contractor shall provide documentary evidence of the performances of the valves for the service as required.

b. Shop drawings

Shop drawings shall include but not limited to the following:

1. Lists and schedules of valves.
2. Dimensions, and materials.
3. Instructions for installation.

2. PRODUCTS

2.1. GENERAL

a. Construction

All valves of the same type shall be from one manufacturer.

All valves shall have following markings and they shall be designed cast in raised letters upon some appropriate part of the body:

- name of mark of manufacturer,
- year of manufacturing,
- working pressure,
- arrow direction for valves designed for one-way flow only.

Valve ends shall be flanged ends except where otherwise specified. Where flanged ends are used, mating dimensions and drilling shall be in accordance with the pipe and fitting flange as specified in section 14100 – Pipes and fittings.

Thickness of flanges shall be determined as based on the working pressure specified and shall conform to internationally accepted standards.

All materials which will be specified hereunder shall conform to AFNOR, ASTM, BS, DIN or other internationally accepted standards.

Valves shall be equipped with hand lever, manual actuator, pneumatic actuator or electric actuator as shown on the drawings or as required for the operation.

Actuators shall have arrows cast thereon to indicate the direction of rotation for opening the valve.

Valves 50 mm in size and smaller shall be all bronze, unless otherwise specified, except for hand wheels which shall be of cast or malleable iron, and provided with screw ends.

The minimum working pressure of valve shall be as specified herein unless otherwise shown in the valve schedule.

b. Painting

All valves, gates and appurtenances, unless otherwise specified shall be shop primed on the exterior in accordance with the applicable specification of section 09910 - Painting.

All valves, gates and appurtenances, shall have an inside lining certified by the recognized authorities for linings in waste water service.

2.2. GATE VALVES

All gates valves will have screw and yoke rising stem.

2.2.1. GATE VALVES

Gate valves shall be designed and manufactured in accordance with AWWA C500 or other internationally accepted standards. Working pressure shall be 10 bar.

PART 3 – TECHNICAL SPECIFICATIONS

The valve body and bonnet shall be of DIN 1693 grade GGG-40 ductile cast iron.

The stuffing box shall be the same materials of the body as specified above and shall be tight in the open position. The depth of the stuffing box shall be not less than the diameter of the valve stem. Packing for the stuffing box shall be made of suitable materials approved by the Engineer. Asbestos shall not be used. O-ring stem seals may be used, subject to the approval of the Engineer and these seals shall have a minimum of two (2) "O" ring seals, of which at least one (1) shall be above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

Valve stem shall be stainless steel, DIN 17 440 grade I-4462.

2.2.2. RESILIENT-SEATED GATE VALVES

Resilient-Seated (RS) gate valves shall be designed and manufactured in accordance with AWWA C509 or other internationally accepted standards. Working pressure shall be 10 bar.

RS type gate valves shall be DIN 1693 grade GGG-40 ductile cast iron-body resilient-seated gate valves with non-rising stems (NRS) and outside screw-and-yoke rising stems. Valves shall be designed to provide an unobstructed waterway having a diameter of not less than the full nominal diameter of the valve when in the open position.

For stem seals, either gland packing or O-rings included other pressure-actuated stem seal shall be provided. The stuffing box or O-rings packing plate shall be the same materials of the valve body. Gland packing for the stuffing box shall be made of suitable materials approved by the Engineer. Asbestos shall not be used. O-ring seals shall be designed to have a minimum of two O-ring seals, of which at least one shall be above the stem collar and replaceable under full working pressure while the valve is in the fully open position.

Valve stems shall be stainless steel DIN 17 440 grade I-4462.

All valves shall be equipped with handwheels.

Resilient seats shall be applied to the gate and shall seat against a corrosion-resistant surface. The surface shall be non-metallic applied in a manner to withstand the action of line fluid and operation of the sealing gate under long-term service. Resilient seats shall be bonded or mechanically attached to the gate. All exposed mechanical attaching devices and hardware used to retain the resilient seat shall be of corrosion-resilient material.

Bolts and nuts to be used for bonnet, packing plate, gland and others shall be stainless steel unless otherwise noted.

All interior and exterior ferrous parts of the valve except for finished or seating surfaces shall be finished with fusion bonded epoxy protective coating conforming to AWWA C213. Total dry film thickness on the interior and exterior surface shall be more than 400 microns and not less than 300 microns respectively.

2.2.3. BRONZE GATE VALVES

Bronze gate valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure shall be 10 bar. Valves shall be equipped with either screw ends or flanged ends. Valves in size 50 mm and smaller shall be bronze body, screw bonnet, gate valves having a solid wedge, inside screw and rising stem.

Valves in size 65 mm and 80 mm shall be bronze body, flanged bonnet, gate valves having a solid wedge, inside screw and non-rising stem.

The body shall be bronze casting having tensile strength not less than 196 N/mm². Disc shall be bronze casting specified above or copper having tensile strength not less than 314 N/mm². Stem shall be copper specified above.

2.2.4. STAINLESS STEEL GATE VALVES

Stainless steel gate valves shall be solid wedge disc type gate valves with outside screw-and-yoke rising stems and designed for handling acids or other chemicals. Valves shall have hand wheels and flanged ends. Working pressure shall be 10 bar.

Unless otherwise specified, major parts of the valve such as body, bonnet, stem, disc, gland with gland bolts and nuts, bonnet bolts and nuts and other parts which may contact with handling liquid shall be made of AISI 316 stainless steel and stainless steel casting.

2.3. BUTTERFLY VALVES

2.3.1. FLANGED BUTTERFLY VALVES

Valves shall be cast iron or ductile iron disc elastomer-seated, tight closure butterfly valves and shall be designed and manufactured in accordance with AWWA C504. Valves shall be designed for a maximum nonshock shut off pressure of 10 bar. Flanges shall conform to ISO PN 10 and flange to flange dimensions shall conform to ISO 5752 series 14. Valves body shall be ductile iron and shall conform to DIN 1693 grade GGG-40.

Valve shafts shall be made of AISI 316 stainless steel or Monel. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs. If of "stub shaft" construction, each stub shaft shall be inserted into the valve disc hubs for a distance of at least 1.5 times the shaft diameter.

Elastomer seats shall mate with the following seat surfaces which shall conform to AWWA C504: Stainless steel, Monel or bronze. Sprayed or plated mating seat surfaces shall not be used. Deposit seat surfaces may be acceptable if approved by the Engineer.

Elastomer seat for valves, 600 mm and smaller shall be clamped, mechanically secured, bonded, or vulcanized to the valve body.

Rubber seats for valves, 700 mm to 1,800 mm shall be mechanically clamped or secured to the valve body or disc.

All clamps and retaining rings for elastomer seats shall be of corrosion-resistant material with a maximum zinc content of 16 per cent and a maximum aluminium content of 3 per cent. All nuts and screws used with clamps and retaining rings shall be of stainless steel, and shall be secured with resin.

Valve disc shall be of a cast or fabricated design with no external ribs transverse to the flow. Valve discs shall be of ductile iron, or stainless steel. They shall conform to these as specified below:

- Ductile iron: DIN 1693 grade GGG-40.

- Stainless steel: AISI 316 or other type approved by the Engineer.

Shaft seals shall be provided wherever shafts project through the valve body. Shaft seals shall be preferably designed for standard O-ring seals. O-ring seals shall be contained in a removable corrosion-resistant recess.

2.3.2. WAFER BUTTERFLY VALVES

Wafer butterfly valves for water shall meet the applicable requirements specified in 2.3.a) above for flanged Butterfly valves except as otherwise specified herein.

Valves shall be designed to fit between two pipe flanges and for the maximum nonshock shut-off pressure of 10 bar.

Valves shall be either seat-in-body and have elastomer seat which shall be designed to lap over both faces of the valves, or designed in compliance with watertightness specifications of paragraph 2.3.a).

2.4. CHECK VALVES

2.4.1. SWING CHECK VALVES

Swing check valves shall be DIN 1693 grade GGG-40 ductile cast iron body and disc, and bronze seating type. The valves shall be designed and manufactured in accordance with AWWA C508. Working pressure shall be 10 bar. Flanges shall conform to ISO PN 10 and flange to flange distance shall conform to ISO 5752 series 14.

Valves shall be suitable to operate in a horizontal or vertical position with flow upward and when fully open, valves shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valve shall be furnished with hinge arms, levers and springs or weights and when necessary, furnished with a by-pass pipe and by-pass valves.

2.4.2. SPLIT DISC WAFER CHECK VALVES

Split disc wafer check valves shall be dual plate, two spring-loaded, semicircular plates type. The valves shall be designed and manufactured in accordance with API 594, or other internationally accepted standards.

Valves shall be designed to fit between two pipes flanges and for a working pressure of 10 bar.

Valve body and plates shall be of cast iron, ductile iron or AISI 316 stainless steel. Bronze casting plates may be permitted. Hinge pin, stop pin and springs shall be of AISI 316 stainless steel. Valves shall have resilient seating in the valve body unless otherwise specified. Seat materials shall be EPDM or high content nitrile (BUNA "N") elastomer.

2.4.3. BRONZE SWING AND LIFT CHECK VALVES (50 MM AND SMALLER)

Bronze swing and lift check valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure shall be 10 bar. Valves shall be equipped with screwed ends.

Swing check valves shall be suitable to operate in a horizontal or vertical position with flow upward. Lift check valves shall be suitable to operate in a horizontal position with flow upward when fully open. Both of swing and lift check valve shall have a net-flow area not less than the area of a circle with a diameter equal to the nominal pipe size.

Valves shall be bronze body, screwed bonnet and disc. Valves shall be designed to have bronze seatings or resilient seating. Resilient seats shall be made of Teflon.

The body shall be bronze casting, and bonnet and disc shall be of bronze casting or copper. The said bronze casting and copper shall conform to the requirements specified in 2.2 c) above.

2.4.4. AXIAL SPRING LOADED CHECK VALVES

The axial spring loaded check valves shall be low stroke, low inertia check valve consisting of a body in the form of concentric rings supported by spacers and a mobile sealing assembly incorporating a similar arrangement of concentric rings to those in the body. Working pressure shall be 10 bar. Valves shall be equipped with flanged ends. The body shall be cast iron conform to ASTM A48-64-35B. The sealing assembly shall be made of polyurethane. The spring shall be stainless steel conform to AISI 316L or equivalent.

2.5. PLUG VALVES

Plug valves shall be DIN 1693 grade GGG-40 ductile cast iron body, non-lubricated, resilient faced eccentric plug type valves. Valves shall be designed for a working pressure of 10 bars.

Port areas of valves shall be at least 80% of the full pipe area.

The valves body and bonnet shall be cast iron or ductile iron or a corrosion resistant, cast-iron alloy containing 1% to 1.5% nickel. The materials specified above shall have a minimum tensile strength of 216 N/mm². If the body is cast iron, the seat shall have a welded-in overlay of not less than 90% pure nickel on all surfaces contacting the plug face. The seat face shall be machined. If the body is corrosion resistant cast-iron alloy, the raised seat shall be machine finished and protected with an approved epoxy coating.

The plug shall be cast iron as specified for the body and shall have a resilient coating to provide bubble-tight shutoff. The resilient coating shall be chloroprene (Neoprene).

2.6. GLOBE VALVES

2.6.1. ANGLE HOSE VALVES

Angle hose valves shall be bronze body Y-Globe valves with renewable composition disc. Valves shall have rising stem and screwed ends with stainless steel replaceable quick coupling and cap. Working pressure shall be 10 bar. Valves shall be designed and manufactured in accordance with standards approved by the Engineer.

Discs shall be hard but sufficiently resilient to maintain tight seal within the pressure and temperature range and have high flexural and impact strength. Discs shall be made of Teflon or other materials approved by the Engineer.

Disc holder shall be made of bronze casting or copper.

PART 3 – TECHNICAL SPECIFICATIONS

2.6.2. HOSE BIBS

Hose bibs shall be bronze body globe valves with renewable composition disc. Valves shall have rising stems, screw-in bonnet, screwed inlet and hose coupling outlet. Working pressure shall be 10 bar. Valves shall be designed and manufactured in accordance with standard approved by the Engineer and shall be swivel nose faucet, faucet with hose coupling or lawn faucet.

Stem with disc and disc nut shall be bronze, bronze casting or copper. Disc shall be medium soft composition as recommended by the manufacturer for the intended use.

2.7. DIAPHRAGM VALVES

Diaphragm valves shall be of the weir or straightway type as noted, with cast iron body, resilient reinforced rubber diaphragm and cast iron bonnet. They shall be fitted for spoked hand wheel operation.

The valves shall be used in water, air, and weak chemical service lines.

The reinforced rubber diaphragm shall be connected to a spindle actuated compressor so that it will be lifted to provide an adequate water-way for minimum pressure loss. Further, the diaphragm shall be forced tight against the body even when the compressor is lowered. The diaphragm shall seal the bonnet compartment and working parts from the fluid stream. The diaphragm shall be capable of easy replacement without removing the valve body from the pipe line.

The valves shall be protected against corrosion with a minimum 3.0 mm thick neoprene lining suitable for the service intended and consistent with associated piping unless otherwise noted.

2.8. BALL VALVES

2.8.1. BALL VALVES FOR WATER LINES

Stainless steel ball valves shall be non-lubricated and shall have stainless steel ball and body with Teflon seats. Valves shall be designed for a working pressure of 10 bar and shall have screwed ends. Valves shall be wrench operated.

Major parts of the valve such as body, stem and ball shall be made of AISI 304 or 316 stainless steel and stainless steel casting.

2.8.2. STAINLESS STEEL BALL VALVES FOR CHEMICAL SERVICE

Stainless steel ball valves shall be non-lubricated and shall have stainless steel ball and body with Teflon seats. Valves shall be designed for handling chemicals and for working pressure of 10 bar. Valves shall have flanged ends.

Valve ports shall be at least the area of a circle of diameter equivalent to the nominal size of the valve. Valves, 100 mm and smaller in diameter shall be wrench operated. Valves, 125 mm and larger shall be hand wheel operated through a worm gear. Port position shall be plainly visible to the operator by means of an indicator.

Unless otherwise specified, major parts of the valve such as bodies, stem, ball, gland with gland bolts and nuts and other parts which may contact with handling liquid shall be made of AISI 316 stainless steel and stainless steel casting.

2.9. OVERSPEED VALVE

The overspeed valve shall be self-operating automatic shut-off valve consisting of:

- hydraulically controlled butterfly valve, opened by hand operated hydraulic actuator and closed by counterweight with adjustable dash-pot,
- mechanical overspeed detection system with adjustment facilities,
- shut-off mechanism ensuring irreversible closing of the valve upon overspeed condition is detected.

The valve shall be double flanged type and shall comply with the specifications related to butterfly valve as far as design and materials are concerned.

The valve shall be equipped with a set of limit switches in IP67 enclosure.

2.10. PRESSURE REDUCING VALVES

Pressure reducing valves for plant water service shall be DIN 1693 grade GGG-40 ductile cast iron body, self-contained, direct-acting, spring-loaded type. Valves shall operate at a primary pressure range of 0 to 10 bar and at an adjustable secondary pressure range of 1.5 to 6 bar. Valves shall have flanged ends and the working pressure shall be 10 bar.

All parts subject to wear shall be accessible for repair or replacement without removing the valve from the line. Secondary pressure of valve shall be designed to be adjustable without any use of special tools while it is in service.

Two (2) manometers one for the primary side and the other for the secondary side of the pressure reducing valve shall be provided.

2.11. AIR VALVES

2.11.1. SINGLE ORIFICE TYPE AIR VALVES

Single orifice type air valves shall be DIN 1693 grade GGG-40 ductile cast iron body and single float actuated air valves with flanged ends. Valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure shall be 10 bar.

Valves shall automatically operate so that they will exhaust accumulated air under pressure while the pipe is flowing full of water.

Each valve shall be furnished with integral bronze casting stop valve and cast iron flange.

Floats and balls shall be stainless steel, DIN 17 440 grade I-4301.

2.11.2. DOUBLE ORIFICE AIR VALVES

Double orifice air valves shall be DIN 1693 grade GGG-40 ductile cast iron body and double float actuated air valves with flanged ends. Double orifice type air valves shall be designed and manufactured in accordance with standard approved by the Engineer. Working pressure of all air valves shall be 10 bar.

Double orifice shall be designed to automatically operate so that they will:

- Positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation.
- Exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation.
- Exhaust accumulated air under pressure while the pipe is flowing full of water.

Each double orifice type air valve shall be furnished with stop valve, same size as air valve.

Floats and balls shall be stainless steel, DIN 17 440 grade I-4301.

2.12. PRESSURE RELIEF VALVES

2.12.1. FUNCTION

The pressure relief valves will limit pressure surges in the mains. The pressure relief valves shall discharge water as soon as the water pressure becomes greater than the watertightness pressure which shall be field adjustable.

2.12.2. CONSTRUCTION

The pressure relief valves shall consist of:

- a fixed bevelled horizontal nozzle,
- a flat mobile disc,
- a steel spring working in compression and pushing the disc downwards against the nozzle,
- a metallic hood diverting the discharge flow downwards.

The disc shall have no mechanical guides and shall center hydraulically itself on the water jet. The mechanical characteristics of the valve shall be calculated in the purpose to contribute to this self centering. There shall be no possibility of friction or jamming because of incrustations or deposits. The movement of the self-centering disc shall be perpendicular to the contact plane between disc and nozzle. Moving parts shall be of low inertia.

Watertightness shall be obtained by very carefull machining of the rigid corrosion-resistant metal contact surfaces.

Provision shall be made for adequate aeration of the discharge flow.

Watertightness must be obtained as soon as disc and nozzle are in contact without requiring additional compression.

Access to wear parts shall be quick and easy, and their replacement shall not require disassembling or disadjustment.

The valve shall be equipped with a connecting flange according to ISO PN 10.

2.12.3. MATERIALS AND PROTECTION

All active components such as nozzle, disc, springs, etc. shall be made of stainless steel.

The hood shall be painted with a red oxyde primer and additional finishing coats.

2.12.4. PERFORMANCE

The pressure relief valves shall be watertight until the sealing pressure specified in the Schedule is reached. When the valve is fully open the pressure below the disc shall not exceed the maximum pressure specified in the Schedule for a given discharge (also specified in the Schedule) through the valve.

2.12.5. FACTORY TESTS

The valves shall be tested at the design working pressure with the disc in the closed position to demonstrate the tightness of the disc and seats. Leakage shall not exceed 200 ml per-minute.

2.13. VALVES ACTUATORS

2.13.1. GENERAL

Actuators shall be capable of seating, unseating and rigidly holding the valve disc in any intermediate position under the maximum design unbalanced head and water velocity.

Means for holding the valves in intermediate positions shall be furnished.

The operating mechanism of butterfly valve actuators shall incorporate worm gears bronze and worms of hardened steel operating in a lubricating bath totally enclosed in a sealed water tight gear case.

All valves shall be equipped with adjustable mechanical stop limiting devices to prevent over travel of the valve disc in the open or closed position.

Actuator housing, supports and connections to the valve shall be designed with a minimum safety factor of five (5) based on the ultimate strength, of three (3), based on the yield strength, of the material used.

Each actuator shall be provided with a position indicator to show the position of the valve disc at all times. The indicators shall be read in per cent (0-100%) with minimum graduation of 5%.

Manual actuators shall require an input force of not greater than 18 daN pull on either hand wheel or crank. Hand wheels shall be of cast iron, clearly marked with an arrow and the work "open" and "close" cast in relief on the rim. Hand wheels shall be of the spoke type only. Webbed or disc type shall be used.

2.13.2. MANUAL ACTUATORS

1. Manual Actuators for Gate Valves (500 mm and smaller)

Manual actuators for gate valves, 500 mm and smaller including resilient-seated gates, non rising stem type shall be wrench nuts and hand wheels type without reducing gear. Rising stem type resilient-seated gate valves shall be equipped with hand wheels without reducing gear. Wrench nuts and hand wheels shall be made of cast iron or ductile cast iron.

2. Manual Actuators for Gate Valves (600 to 1,000 mm)

Manual actuators for gate valves, 600 to 1,000 mm shall be bevel gear type, totally enclosed actuators. Actuators shall be equipped with hand wheel and linear position indicator which shall be read in per cent (0-100%) with minimum graduation of 5%. The hand wheel shall be cast iron or ductile cast iron, and spoke type of suitable size. Operators shall be designed so that a pull of not more than 18 daN on a hand wheel which will produce an output torque equivalent to the maximum valve shaft torque required to operate the valve under actual line pressure and velocities.

3. Manual Actuators for Butterfly Valves

Manual actuators for butterfly valves shall be essentially an integral part of a butterfly valve. The rated torque capability of each actuator shall be sufficient to seat, unseat and rigidly hold in any intermediate position the valve disc. All valves shall be equipped with an adjustable mechanical stop-limiting devices to prevent over-travel of the valve disc in the open and closed positions. Actuator housings, supports, and connections to the valve shall be designed with a minimum safety factor of five (5), based on the ultimate strength, or three (3), based on the yield strength, of materials used.

Each manual actuator shall have all gearing totally enclosed. Actuators shall be designed to produce the specified torque with a maximum pull of 36 daN on hand wheel. Stop-limiting devices shall be provided in the actuators for the open and closed positions.

All gears actuators shall be self-locking and designed to transmit two (2) times the required actuator torque without damage to the faces of the gear teeth. Each manual actuator shall be equipped with a position indicator which shall be read in per cent (0-100%) with minimum graduation of 5%. The graduation shall be engraved on actuator cover plate.

Unless otherwise specified, the minimum number of handweel turns to rotate the disc from the fully open to the fully closed position, or vice versa, shall be as follows:

DN (mm)	Number of turns
300	25
400 to 600	30
800 to 1500	50

Butterfly valves with diameter lower than 100 mm may be operated by levers.

4. Gearing

Gears shall be of ductile iron, steel, or bronze, accurately machined with cut teeth, and smooth running with suitable shafts in bronze sleeve bearings or roller bearings of ample size.

All gears and bearings shall be enclosed in a cast iron housing. Fittings shall be provided so that all gears and bearings can be periodically lubricated.

2.13.3. ELECTRIC ACTUATORS

1. General

Two (2) types of electric actuators such as type A, integral control type and type B, standard type shall be specified hereinafter.

Each type of electric actuator shall be furnished in weatherproof construction. The motor shall operate on 380 volt, 3-phase, 60 hertz, service for open-close service.

Each type electric actuator shall be mounted by the valve manufacturer, tested and adjusted prior to shipment:

- Type A integral control type.

Electric actuator, Type A shall be integral control type and shall include, but not be limited to, the electric motor, reversing magnetic starter, limit switches, torque switches, space heaters, valve position potentiometer if specified, pushbutton station, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

The valve control units shall have pushbutton stations furnished in enclosures suitable for flush panel mounting or field mounting as required. The stations shall include pushbuttons, status lights, and a selector switch all as required.

- Type B standard type.

Electric actuator, Type B shall be standard type and shall include, but not be limited to, the electric motor, limit switches, torque switches, space heaters, valve position potentiometer if specified, shop wiring, gear case and a declutch hand wheel to allow manual operation of the valve.

2. Electric Actuators for Butterfly Valve

Gear case shall be of cast iron. Flanges for actuator attachment shall be integrally cast, fully machined, and template drilled.

Motors for electric valve actuator shall be capable of producing not less than 1.5 times the required operating torque.

Any gearing in direct association with the electric motor drive shall be totally enclosed and shall operate in a lubricant.

Actuator shall include an adjustable torque or thrust-limited switch capable of stopping the power to the motor when the valve has reached the stops in the open or closed position or when an obstruction has been encountered in either direction of travel.

Torque switches shall be factory set to satisfy the calculated value corresponding to the maximum operating conditions.

Limit switches shall be geared to the driving mechanism and in step at all times whether the unit is operated electrically or manually. The switches shall be of the adjustable type capable of being set to trip at the fully open and fully closed valve positions or at any point between. All electrical interconnections between limit switches, torque switches, indicator lights, and so forth, shall be factory wired and ready for operation. All gearing used in connection with limit switches shall be factory-lubricated.

Actuator shall be provided with a position indicator to show the position of the valve at all times. The indicator shall be read in per cent (0-100%) with minimum graduations of 5%.

Actuator shall be equipped with a hand wheel for manual operation. The hand wheel shall be connected so that operation of the motor will not cause the hand wheel to rotate and the operation of the hand wheel shall not cause the motor rotor to rotate. The hand wheel shall be engaged by an exterior lever or an automatic clutch. The action of the lever shall also declutch the motor if there is no device to accomplish this automatically when the power supply to the motor ceases. Should the power return to the motor while the hand wheel is in use, the design of the unit shall prevent the power from being transmitted to the hand wheel.

An arrow and the word "open" and "close" shall be placed on the hand wheel to indicate direction of resultant valve movement. Lettering shall be in the English language.

2.14. SPECIAL TOOLS AND SPARE PARTS

Refer to General Requirements

3. EXECUTION

No item.

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SECTION 14160 PENSTOCK

1. GENERAL

WORK INCLUDED

SCOPE OF THE WORK

This section of the specifications covers the supply and installation of penstocks and actuators as shown on the tender drawings for the Ameria stage II Pumping station.

The supply shall include the following main items:

- 1) Complete set of embedded parts,
- 2) Gate leaf,
- 3) Gate frame,
- 4) Manual or electrical gate operator,
- 5) Stem guide, and top wall mounting brackets where required,
- 6) Corrosion protection work,
- 7) Anchoring and support parts to be held or embedded in the primary concrete.

RELATED WORKS

SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH THE REQUIREMENTS OF THE FOLLOWING

- 1) Section 01020 – Basic Mechanical Requirements.
- 2) Section 01010 – Corrosion protection.

COORDINATION

Work under this section shall be coordinated with work covered by the following sections:

- 1) Section 15400 – Main pumps & motors.
- 2) Part 8 – General requirement.

- 3) Part 9 – Civil Engineering works and Building works.
- 4) Part 11 – Electrical Equipment.

SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

MAIN CHARACTERISTICS

SCREENING AREA

Identification number	101-SG-101/201
Type:	Sluice Gate
Number:	2
Location:	Coarse Screens
Height:	3300 mm plate ; 3950 mm frame
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal)
Operation:	Motorized

Identification number	101-SG-301
Type:	Sluice Gate
Number:	1
Location:	Coarse Screens
Height:	3300 mm plate ; 3950 mm frame
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal)
Operation:	Manual crankset

Identification number	102-SG-101/201/301
Type:	Sluice Gate
Number:	3
Location:	Fine Screens
Height:	3400 mm plate ; 4200 mm frame
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal)
Operation:	Motorized

Identification number	102-SG-401

PART 3 – TECHNICAL SPECIFICATIONS

Type:	Sluice Gate
Number:	1
Location:	Fine Screen stand by
Height:	3400 mm plate ; 4200 mm frame
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal)
Operation:	Manual Crankset

Identification number	102-GC-001/002
Type:	Sluice Gate
Number:	2
Location:	Exit pipe to Grit and Grease Removal (ND 1400)
Height:	1 500 mm
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal)
Operation:	Motorized

GRIT AND GRIT REMOVAL AREA

Identification number	103-SG-003
Type:	Sluice Gate
Number:	1
Location:	Grit and grease removal tanks
Height:	400 mm
Width	400 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal)
Operation:	Manual

Sedimentation Tanks Bypass

Identification number	105-SG-001,-002
Type:	Sluice Gate
Number:	2
Location:	Sedimentation tanks
Height:	1000 mm
Width	1000 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal)
Operation:	Motorized and level of opening controlled by the flow in the downstream flowmeter.

OPERATING CONDITIONS

The gate shall be designed for operation with seating and/or unseating head water conditions as indicated in the above table.

Where required, penstocks will be operated by means of electrically driven actuators with integral reversing starters. The motor drive will be automatically disengaged when under manual operation.

The gates shall be designed to ensure tight closure whilst maintaining freedom of the leaf movement during operation and minimizing sliding wear of the sealing faces.

Particular care will have to be taken for operation with the gate located at the emergency culvert outlet. It must be opened as soon as general power switch off occurs in TPS1 or TPS2. As this gate must be opened when a general switch down occurs, it can't be activated electrically. Therefore it must be in relation with the detection of a particular level in TPS2 intermediate shaft, namely 13.40. This process will be powered by solar batteries and stand-by diesel generator unit with automatic starter.

DESIGN CRITERIA

CODES AND STANDARDS

- 1) DIN 19704 Principles for computation of steel hydraulic plant.
- 2) DIN 19705 Recommendation for the design, construction and erection of hydraulic steel structure equipment.
- 3) DIN 4114 Steel construction – Stability analysis – Buckling – Lateral buckling – Local buckling.
- 4) DIN 1045 Reinforced concrete structures: design and construction.
- 5) NF A 46.503 Medium and heavy plates. Tolerances on dimensions and excess weight.

DESIGN CRITERIA

Refer to the table here above main characteristics.

The nut in the gate will be of rising spindle penstocks, and the handwheel of non-rising penstocks. The penstocks shall be designed to withstand without damage an MCE (maximum credible earthquake).

A neoprene seal shall be provided on 4 sides , except where installed in open channels, then neoprene seal shall be provided on 3 sides.

The operating gear of all penstocks will be capable of opening or closing the gate against an unbalanced head equal to the maximum working pressure.

Handwheels will be rotated clockwise to close the penstocks, and clearly marked with the words 'Open' and 'Close', with arrows in the appropriate direction.

Penstocks will be fitted with position indicators which will indicate whether the penstock is fully open or closed.

Handwheel and reduction gearbox will be designed for easy hand operation.

The gear boxes will be oil or grease filled.

Where required, penstocks shall be fitted with flush inverts to give a smooth flow passage at the bottom of the penstocks.

When the distance between the sill and the base floor is important, the extension rod will be fitted with a guide bearing every 2 m.

Each actuator will be fully weather proof and fitted with anticondensation heater, upper and lower limit switches and torques switches.

All local controls will be protected by a lockable cover.

SOURCE QUALITY CONTROL

- 1) Inspection and testing of raw materials used in the manufacture of the equipment. The Contractor shall supply certificates of mechanical tests and chemical analysis.
- 2) Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
- 3) Workshop inspection and tests:
 - a) At the end of manufacture, penstocks shall be presented, unpainted, for checking. The seals shall be presented separately.
 - b) Gate and embedded parts:

THE SURFACE ASPECT OF EMBEDDED PARTS SHALL BE EXAMINED AND THEIR DIMENSIONS CHECKED. SLIDING AND FRICTION SEALING SURFACES SHALL PERFECTLY FLAT AND SMOOTH.

ALL DIMENSIONS OF GATE MEMBERS SHALL BE CHECKED.

The Engineer reserves the right to participate in these tests.
 - c) Welds: Refer to Section 15010 – Basic auxiliary mechanical equipment requirements.

GUARANTEE

VIBRATION

The operation of the gate shall be guaranteed free of vibration.

SEALING

The equipment shall satisfy the guarantees specified hereunder, without any special means having to be used for sealing.

The leakages shall not exceed 0.02 l/s per linear meter of seal.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

MANUFACTURE

EMBEDDED PARTS

The embedded part will be of welded construction.

PENSTOCKS

The penstocks shall be of welded construction. The frame shall be in steel grade E 24-2, the gate leaf in stainless steel.

Non-ferrous metal sealing faces shall be formed from accurately machined or bronze strips bedded and fixed to machined recesses by non-corrodible countersunk screws. The faces of the strips will be then brought together in the operating position and hand scraped to a watertight finish.

Rubber sealing faces will be formed from synthetic rubber suitably shaped to interlock grooves in the frame of door and will be securely bonded thereto.

The nut in the door of non-rising spindle penstocks and in the handwheel of rising spindle penstocks will be gunmetal.

SPECIAL TOOLS AND SPARE PARTS

The Contractor shall specify and supply the special tools required for gate maintenance.

The Contractor shall supply the following spare parts: One complete set of seals with 20 % of the stainless steel bolts for the gate leaf.

3. EXECUTION

INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

The Contractor shall check the dimensions and setting of the sluice.

FIELD QUALITY CONTROL

INSPECTIONS BEFORE AND AFTER CONCRETING

Inspections

- a) Position of the sill,

- b) Distance between the lateral embedded parts,
- c) Perpendicularity of the lateral embedded parts with the sill,
- d) Flatness of the embedded parts, vertically, horizontally.

DRY TESTS

- 1) Testing of the various operations required for sluice closure and opening; seal friction surfaces shall be wetted.
- 2) Checking the position of seals with respect to embedded parts,
- 3) Checking the position of lateral guide systems with respect to embedded parts,
- 4) Checking the position and operation of the wedging system,
- 5) Examination of paintwork.

FINAL TESTS

With the water levels available at the time of the tests:

- 1) Inspection of seals,
- 2) Testing of the various operations required for closure and opening of the sluice,
- 3) Examination of paintwork.

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SECTION 14 161 STOP LOGS

1. GENERAL

1.1. WORK INCLUDED

This section of the specifications covers the sliding stop logs of the Plant.

The supply shall include the following main items:

1. Embedded parts including lateral guides,
2. Stop log leaf,
3. Equipment for storing and holding in position the stop log.
4. The anchoring system of the built-in parts embedded in the secondary concrete,
5. The corrosion protection work,
6. The anchoring and support parts to be held or embedded in the primary concrete.
7. The special tools and the spare parts.

1.2. RELATED WORKS

- A.** Supplies and works included under this section shall comply with the requirements of the following:
1. Section 01010 - Corrosion protection
 2. Section 01020 - Basic mechanical requirements
- B.** Work under this section shall be co-ordinated with:
1. Civil Engineering works and Building works;

1.3. DESCRIPTION

Identification number:	101-SL-001
Type:	Stop logs
Number:	1
Location:	Screening
Height:	3150 mm frame

	2900 mm plate
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal) OR Aluminium
Peripheral equipment:	Lifting tools
Stop logs shall tighten to frames; stop logs equipped with jointing material in EDPM rubber	

Identification number:	101-SL-002
Type:	Stop logs
Number:	1
Location:	Screening
Height:	2700 mm frame 1900 mm plate
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal) OR Aluminium
Peripheral equipment:	Lifting tools
Stop logs shall tighten to frames; stop logs equipped with jointing material in EDPM rubber	

Identification number:	101-SL-003
Type:	Stop logs
Number:	1
Location:	Screening
Height:	3450 mm frame 3000 mm plate
Width	1600 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal) OR Aluminium
Peripheral equipment:	Lifting tools
Stop logs shall tighten to frames; stop logs equipped with jointing material in EDPM rubber	

Identification number:	101-SL-004/101/201/301

Type:	Stop logs
Number:	4 frames
Location:	Screening
Height:	3950mm frame
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Peripheral equipment:	Lifting tools
Stop logs shall tighten to frames; stop logs equipped with jointing material in EDPM rubber	

Identification number:	102-SL-101/201/301/401
Type:	Stop logs
Number:	4 frames, 3 plates interchangeable between area 101 and 102
Location:	Screening
Height:	4200 frame 3400 mm plate
Width	1 500 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal) OR Aluminium
Peripheral equipment:	Lifting tools
Stop logs shall tighten to frames; stop logs equipped with jointing material in EDPM rubber	

Identification number	103-SL-101, 103-SL-201, 103-SL-301 and 103-SL-401
Type:	Stop logs
Number:	4
Location:	Grit and grease removal tanks
Height:	1 900 mm frame 1 600 mm plate
Width	900 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal) OR Aluminium
Peripheral equipment:	Lifting tools
Stop logs shall tighten to frames; stop logs equipped with watertight joint material in EDPM rubber	

PART 3 – TECHNICAL SPECIFICATIONS

Identification number	105-SL-101/102, -201/202, -301/302, -401/402
Type:	Stop logs
Number:	8 frames, 2 plates
Location:	Grit and grease removal tanks
Height:	1 900 mm frame 1 500 mm plate
Width	1000 mm
Cast in Place frame Materials:	304 SS
Plate Materials:	Anticorrosion Coated Steel (coating type ACQPA, Im 2A NI575, or equal) OR Aluminium
Peripheral equipment:	Lifting tools
Stop logs shall tighten to frames; stop logs equipped with watertight joint material in EDPM rubber	

1.4. QUALITY ASSURANCE

1.4.1. DESIGN CRITERIA

- A. Refer to Section 01020.
- B. The stop logs shall be designed to withstand without damage an MCE (maximum credible earthquake).

1.4.2. SOURCE QUALITY CONTROL

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - a) At the end of manufacture, the stop log shall be presented, unpainted, for checking. The seals and the embedded parts shall be presented separately.
 - b) Stop logs and embedded parts:
The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth. All dimensions of stop log members shall be checked.
The operation of by-pass valves shall be checked.
The Engineer reserves the right to participate in these tests.
 - a) Welds:
Refer to Section 01020.

1.5. SUBMITTALS

Refer to Section 01 000 -General requirements

1.6. GUARANTEE

A. Vibration

The operation of the stop log shall be guaranteed free of vibration. No tolerances are allowed.

B. Sealing

1. The equipment shall satisfy the guarantees specified hereunder, without any special means having to be used for sealing.
2. Local leaks and average leaks per linear metre of seal shall not exceed the following values:
 - a) local leaks: 0.025 litres per second,
 - b) average leaks: 0.010 litres per second.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. MANUFACTURE

2.1.1. EMBEDDED PARTS

1. The lower embedded parts shall include:
 - a) On the downstream (or upstream) side the sliding beams and the stainless steel sealing plates,
 - b) On the upstream (or downstream) side the back rails,
 - c) The sill made of a steel section fitted with a stainless steel support plate and mating with the shape of the skin plate,
 - d) The lintel cross beam on the downstream (or upstream) side, fitted with a stainless steel sealing plate. The top part of this lintel beam shall be provided with a funnel to ensure an efficient sealing contact when the stop log reaches the end of the closing operation,
 - e) Lateral guide rails.
2. The upper embedded parts shall include:
 - a) The lateral guide rails up to the top of the slot.
 - b) At the top of the slot, the system to store the stop log in open position. This system shall include the movable wedging pieces and their fixed supports together with anchors.
 - c) Above the top of the slot, the systems used for wedging the stop log during storage of the stop log in maintenance position. This system shall include the movable wedging pieces and their fixed supports together with anchors.

2.1.2. STOP LOG LEAF

1. The stop log shall be of welded construction and, to facilitate transport and operation, could be in two parts.

PART 3 – TECHNICAL SPECIFICATIONS

2. The stop log shall have downstream (or upstream) skin plate and seals,
3. The leaf shall be supplied with the necessary supports for storage of the stop log in open and maintenance position.
4. The upper girder of the leaf shall accommodate the necessary lifting lugs for connection to the lifting equipment. Lifting lugs shall be in the same plane as the centre of gravity of the stop log.
5. Two guide blocks shall be provided on each side of each stop log or section.

Their location shall be such that the highest and lowest bumper plates are separated from each other as much as possible.

The stop log shall be provided with sufficient space for sideward movement but the bumper plates shall hold the stop log in a centered position, no more than 5 mm from the centerline of travel.

All stop log members shall have a minimum clearance from embedded parts of 10 mm.
6. The Contractor shall take the necessary steps to allow easy dismantling of the seals.

2.2. SPECIAL TOOLS AND SPARE PARTS

The Contractor shall supply the following spare parts:

1. One complete set of seals with 20% stainless steel bolts for the stop log leaf.
2. One complete set of seals for the by-pass valve.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

- A. The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.
- B. The Contractor shall check the dimensions and setting of the sluice.

3.2. FIELD QUALITY CONTROL

- A. Inspections before and after concreting
 1. Inspections:
 - a) Position of the sill,
 - b) Distance between the lateral embedded parts,
 - c) Perpendicularity of the lateral embedded parts with the sill and the frontal beam,
 - d) Flatness of the embedded parts, verticality, horizontality,
 - e) Position of storage and maintenance systems.
 2. Erection tolerances: refer to Section 01020.
- B. Dry tests
 1. Testing of the various operations required for sluice closure and opening (Seal friction surfaces shall be wetted),
 2. Checking the position of seals with respect to lateral embedded parts and sill,

3. Checking the position of lateral guide systems with respect to lateral embedded parts,
4. Checking the position and operation of the storage system,
5. Examination of paintwork.

C. Final tests

With the normal operation water level:

1. Inspection of seals and seal leakage.
2. Testing of the various operations required for closure and opening of the sluice.
3. Examination of paintwork.

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SECTION 14201

CENTRIFUGAL PUMPS

1. GENERAL

1.1. WORK INCLUDED

The works to be included in this section consist of the design, manufacture, delivery, off-loading, erection, testing and commissioning of the mechanical equipment for the centrifugal pumps to be designed by the Contractor.

The equipment shall be complete with all base plates, foundation bolts, heat exchanger and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORKS

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection;
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A. Concrete works covered by the Civil Works Section;
- B. Section 19100 - Electrical Equipment;
- C. Section 17100 – Instrumentation;

1.3. DESCRIPTION

<u>Identification</u>	103-PP-501/502/503
Number:	2 + 1 non-installed stand-by
Location	Grit and grease removal tanks – Grit extraction

PART 3 – TECHNICAL SPECIFICATIONS

	pumps
Type	Monobloc – horizontal installation Dry installation
<u>Operating conditions</u>	
Duty	Discontinuous – Max 6 starts per hour
Drive	Constant speed
Ambient environment	Indoor
Ambient temperature	5 to 40 °C
Ambient relative humidity	
Fluid service	
Concentration of grits	3 g/l
Fluid temperature	
Fluid pH	6-9
Fluid specific gravity	
<u>Description</u>	
Impeller type	Vortex
Unit flow	100 m ³ /h
Total head	3 m
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies. Particular requirements are as follows : Impeller : Abrasive resistant cast iron EN JL 1040 Shaft : Stainless steel X20Cr13 1.4021
Motor	2.4 kW – 1000 rpm – TRI – 400 V – 50 Hz – IP 55 – F
Accessories (per installed pump)	

Foundations steel rail
One suction and discharge pipe
Branch connection on suction pipes for injection of industrial water (pipe declogging)
Branch connection on suction pipes for injection of pressurized air (decompaction of accumulated grits)
Upstream and downstream isolation valves (gate valves)
Non-return valves (ball valve)
Pressure gauges

<u>Identification</u>	103-PS-001 and -002
Number:	1 + 1 stand-by (installed)
Location:	Grit Tank - Foul water sump
Type	Submersible centrifugal pumps – Vertical installation
<u>Operating conditions</u>	
Duty	Max 6 starts per hour
Drive	Constant speed
Fluid service	Foul water with up to 1 % solids content consisting of grit, organic and inorganic materials and greases.
Fluid temperature	5-40°C
Fluid pH	6-9
Fluid specific gravity	1
<u>Description</u>	
Unit capacity	250 m ³ /h

PART 3 – TECHNICAL SPECIFICATIONS

Total head	8 m max
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies. Particular requirements are as follows : Body and Impeller : gray cast iron EN JL 1040
Motor	12 kW – 400 V – 50 Hz – IP 68 – F
Accessories (per installed pump)	
Discharge connection	
Discharge pipe	
Isolation valve (gate valve, manual) and check valve (ball valve)	
Double guide bars, attachment for guide bars, elevating chain incl. suspension attachment	
10 m oil resistant electrical cable and bracket	
Cable fixing facilities and cable protection	
1 lifting device	

<u>Identification</u>	105-PP-801
Number:	1
Location:	Sedimentation Tank Gallery
Type	Monobloc – horizontal installation , Dry installation
<u>Operating conditions</u>	
Duty	Max 6 starts per hour
Drive	Constant speed
Fluid service	Decanted water
Fluid temperature	5-25°C
Fluid pH	6-9

Fluid specific gravity	1
<u>Description</u>	
Unit capacity	4 m ³ /h
Total head	6 Bar
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies. Particular requirements are as follows : Body and Impeller : gray cast iron EN JL 1040
Motor	1.5 kW – 400 V – 50 Hz – IP 68 – F
Accessories (per installed pump):	
Foundation	
One suction and discharge pipe, including necessary elbows and 2 ball valves and 1 check valve according to P&IDs	
Pressure gauges installed between the pump and the check valve	
2 particle filters (500 micron) – 1 duty one standby – with manual backwash.	
Lifting ring	
25 m of cable	

<u>Identification</u>	105-PP-811
Number:	1
Location:	Sedimentation Tank Gallery
Type	Monobloc – horizontal installation , Dry installation
<u>Operating conditions</u>	
Duty	Max 6 starts per hour
Drive	Constant speed

Fluid service	Decanted water
Fluid temperature	5-25°C
Fluid pH	6-9
Fluid specific gravity	1
<u>Description</u>	
Unit capacity	45 m ³ /h
Total head	3 Bar
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies. Particular requirements are as follows : Body and Impeller : gray cast iron EN JL 1040
Motor	7.5 kW – 400 V – 50 Hz – IP 68 – F
Accessories (per installed pump):	
One suction and discharge pipe, including necessary elbows and 2 ball valves and 1 check valve according to P&IDs	
Pressure gauges installed between the pump and the check valve	
2 particle filters (500 micron) – 1 duty one standby – with manual backwash.	
Lifting ring	
25 m of cable	

<u>Identification</u>	205-SP-001, 205-SP-002
Number:	1+ 1 stand-by (installed)
Location:	Sludge building - Foul water sump
Type	Submersible centrifugal pumps – Vertical installation

<u>Operating conditions</u>	
Duty	Max 6 starts per hour
Drive	Constant speed
Fluid service	Foul water with up to 1 % solids content consisting of grit, organic and inorganic materials and greases.
Fluid temperature	5-40°C
Fluid pH	6-9
Fluid specific gravity	1
<u>Description</u>	
Unit capacity	200 m ³ /h
Total head	9 m
Materials	General requirements are indicated in part 2 : Products – Components and sub-assemblies. Particular requirements are as follows : Body and Impeller : gray cast iron EN JL 1040
Motor	10 kW – 1500 rpm – 400 V – 50 Hz – IP 68 – F
Accessories (per installed pump)	
Discharge connection (cast iron)	
Discharge pipe	
Isolation valve (gate valve, manual) and check valve (ball valve)	
Double guide bars, attachment for guide bars, elevating chain incl. suspension attachment	
10 m oil resistant electrical cable and bracket -	
Cable fixing facilities and cable protection	
1 lifting device (rudder in galvanized steel and hoisting winch in stainless steel X2CrNi18-09 1.4307 (304L))	

PART 3 – TECHNICAL SPECIFICATIONS

1.3.1. MAIN CHARACTERISTICS

- a. All pumps shall be driven by electric motors in accordance with the requirements of the electrical specifications.
- b. The direction of rotation of all the pumps shall be clockwise when viewed from the motor end of the pump set assembly.
- c. All pumps of same type shall be identical in design and construction in all respects including performance, parts, mountings, connecting flange dimensions and materials.
- d. The pumps shall be sufficiently robust to withstand all forces under the most arduous conditions associated with normal and abnormal operations. These shall include:
 - Normal starting and stopping against an open delivery valve.
 - Starting against closed valve without overheating.
 - Reverse rotation due to backflow in case of flap valve failure.
 - Transients due to power failure and emergency shutdown.
- e. The pump rotating assembly design shall be such that the first critical speed of the pump with its motor and the transmission assembly, when running as one system, is at least 150 percent of the maximum operating speed of the pump.
- f. Each component casting of the water pump body shall have a wall thickness of 10mm minimum over and above that required to meet the strength requirements, to compensate for the corrosive and abrasive action of the sewage.
- g. The design and construction of the rotating assembly shall take into account the possibility of uplift forces caused by the pressure transients during pump start-up or shut-down. The Contractor shall show how this force is counteracted.
- h. The pumps shall be capable to work for long periods continuously without cleaning or attention and special precautions shall be taken to avoid wear on working surfaces due to grit.

1.3.2. OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

1.3.2.1. PUMP DUTIES

Each of the pumps shall be capable of operating continuously without damaging effects due to cavitation (if any); If the Contractor considers that additional measures or controls are necessary to protect the Plant from any long term damaging effects, then all such equipment and controls shall be provided and shall be deemed to have been included in the contract price. The details shall be submitted with the Tender.

1.3.2.2. PUMP SUCTION ABILITY (NPSHR)

The pump shall be capable of operating satisfactorily in the specified operating range. The pump NPSHR shall be less than the NPSHA under any operating condition at Site to avoid cavitation. If the pump requires any increase of the system head so as to achieve satisfactory operation at any point in the specified operating range, then this shall be clearly stated in the Tender. The method and details of creating the additional system head shall be stated and drawings showing any changes required in the civil layout shall be submitted. Where such requirements affect the hydraulics of the complete system, hydraulic calculations shall be carried out and included in the Tender. If the change implies higher energy cost during operation of plant, then this will be taken into account during tender assessment.

1.3.2.3. PUMP RATED SPEED (NR)

The maximum rated speed of the pumps shall be designed by the Contractor.

1.3.2.4. HEAD-FLOW CHARACTERISTICS

The pump "Head-Flow" characteristics in the specified operating range shall be stable so that a tangent drawn at any point on the curve will be downwardly directed in the direction of increasing flow.

1.3.2.5. PUMP SHAFT POWER AND PUMP EFFICIENCY

The pump shaft power characteristics shall be stable within the duty range and shall be non-overloading at the pump operating speed. The pump efficiency at the design operating point shall be designed by the Contractor.

1.3.2.6. REVERSE ROTATION CAPABILITY

Under shut down conditions, reversal of the pump rotation will take place and the pump, motor and shafting shall be designed accordingly.

1.4. QUALITY ASSURANCE

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routing tests.
3. Workshop inspections and tests:

Refer to Section 01000 – General requirements:

- a) At the end of manufacture, the pumps shall be presented, unpainted, completely erected for dimensional checking.
- b) One pump of each type with its driving motor shall be tested at the manufacturer's plant to demonstrate complete compliance with the Specifications. In case the tests are not satisfactory, necessary modifications shall be done by the manufacturer and all pumping sets will be tested.

The Contractor shall submit the results of workshop tests.

1.5. SUBMITTALS

In addition to submittals required under Section 01000 - General requirements, the Contractor shall provide the following curves for each pumping unit:

- Efficiency (%)
- Power (kW)
- Required NPSH

Moreover, the Contractor shall determine in his bid the:

- Rotating speeds (tr/mn),
- Power of the associated motors (kW),
- Weights of the units and of each essential component,

2. PRODUCTS – COMPONENTS AND SUB-ASSEMBLIES

2.1. GENERAL

All pumping units shall be supplied as complete pumping systems, including the pump, its driving motor, the drive shaft and couplings, local control panels and all necessary appurtenances (including protection devices, switches, etc.).

Pumps and motors shall be flexible-coupled. That portion of the shaft extending through the mechanical seal (s) shall be equipped with a replaceable sleeve (sealed or positive locked to the shaft) such that the entire shaft need not be replaced when it is scored or worn in this area. Pump shafts shall be designed for a maximum deflection at the shaft seal of 0.05 mm (0.002 in). All couplings, connections, external sealing, etc. shall be weather protected, suitable for outdoor installation.

PART 3 – TECHNICAL SPECIFICATIONS

The submersible pumps shall be automatically and firmly connected to the discharge connection, guided by no less than two guide bars extending from the top of the station to the discharge connection. There shall be no need for the personnel to enter the wet-well. Sealing of the pumping unit to the discharge shall be accomplished by a machined metal to metal watertight contact. Sealing of the discharge interface with O-ring, gasket or diaphragm which has to be replaced will not be acceptable. No portion of the pump shall need any support directly on the sump floor.

Pump shafts shall run in ball bearings. The bearings shall be grease-lubricated and shall be contained in dust-proof and moisture-proof housing. The bearings and frame design shall be such that the bearings can be re-lubricated by use of external greasing devices. The pump design shall ensure that the outboard bearing can carry a combined thrust and radial load. Bearings shall be adequately designed to carry all radial and thrust loads through the normal operating range of the pump. Bearings for pumps in continuous operation (or in continuous rotation of operation) shall have an L-10 life of at least 40,000 hours at the operating point.

Mechanical seals, not packing, shall be used for all pumping units. Seals shall be of the type not requiring water sealing or flushing water.

Oil level shall be maintained by a constant level oiler with visible oil supply.

All openings in the pump shall be large enough to permit passage of solids with maximum diameter of 60 mm. Impellers must be of the enclosed type. All submersible pumps shall be of the centrifugal type easily removable for inspection or service and requiring no bolts nuts or any other fastenings.

Connections to concrete foundations for all pumps shall be sufficient to withstand a displacing force equal to that developed by an internal pressure equal to three times shut-off head at maximum operating speed.

Pumping units shall be designed such that, on any point along the full speed operating curve of the pump, no components are over loaded. Pumping units shall be designed to operate without cavitations or damaging vibration over the entire specified range of flow and head conditions and (where appropriate) over the range of speeds specified.

Major pump components shall be of gray cast iron with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pump- age, other than stainless steel or brass shall be protected by a factory-applied spray coating of alkyd primer with oxiranesther paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be of controlled compression of rubber O-rings in two planes and O-rings contact of four sides without the requirement of a specific torque limit.

Neither rectangular sectioned gaskets neither requiring specific torque nor scaling compound shall be considered as equal.

Pumping units shall have no dangerous critical or resonance frequencies. The Contractor shall be responsible for the analysis of critical speeds and the complete mass elastic system, and shall submit calculations in this regard to the Engineer or his representative for approval prior to erection.

Pumping units shall be suitable for connection to No.-Flow shut-off switches, such switches to be supplied with all check valves supplied.

PART 3 – TECHNICAL SPECIFICATIONS

Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 40°C.

2.1.1. CABLE ENTRY SEAL

The Cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomere grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable the assembly shall provide ease of changing the cable. The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.1.2. MOTORS

The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air-filled watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155°C. The stator shall be dipped three times in Class F varnish and shall be heat-shrink fitted into the stator housing. The motor shall be designed for continuous duty handling pumped media of 40°C and capable of up to 15 evenly spaced starts per hour. Thermal switches set to open at 125°C and closed at 70°C shall be embedded in the stator load coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomer o-ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable. The motor and pump shall be designed and assembled by the same manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15 the motor shall have a voltage tolerance of plus or minus 10% the motor shall be designed for operation up to 40°C ambient temp. and with a temp. rise not to exceed 85°C. This chart shall also include data on starting and no-load characteristics. The motor and the cable are capable of continuous submergence underwater without loss of watertight integrity acc. To protection class IP68 (20m), the rated power shall be adequate so that the pump is not overloaded throughout the entire indicated pump performance curve.

Power cable includes two conductors 1.5 mm for the monitoring of thermal switches and optional protecting sensors.

2.1.3. BEARING

The pump motor shaft shall rotate on two permanently grease lubricated bearings. The upper bearing shall be a single row roller bearing. The lower bearing shall be a two row angular contact ball bearing to compensate for axial and radial forces.

2.1.4. MECHANICAL SEAL

Each pump shall be provided with a tandem mechanical shaft seal system consisting of two independent seal assemblies. The seals shall operate in an oil-reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located

PART 3 – TECHNICAL SPECIFICATIONS

between the pump housing and the oil-chamber, shall contain one stationary and one positively driven rotating tungsten carbide ring. The upper, secondary seal unit, located between the oil-chamber and the motor housing, shall contain one stationary tungsten-carbide seal ring and one positively driven rotating tungsten-carbide seal ring. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotating for sealing. For special applications other seal face material shall be available. Other seal types shall not be considered acceptable or equal to the dual independent seal specified. Each pump shall be provided with an oil chamber for the shaft sealing system, the drain and inspection plug, for the oil, shall be accessible from the outside.

2.1.5. IMPELLER

The impeller shall be dynamically balanced, double shrouded non-clogging design having a long through let without acute turns. The impeller shall be capable of handling solids, fibrous materials, heavy sludge and other matter found in normal wastewater. Whenever possible, a full vanes, not vortex, impeller shall be used for maximum hydraulic efficiency, thus, reducing operating costs. The impeller shall be, retained with an lien head bolt and shall be capable of passing min 60 mm diameter solid. All impellers shall be coated with alkyd resin primer. Mass moment of inertia shall be provided by the pump manufacturer upon request.

2.1.6. WEAR RINGS

A wear ring system shall be used to provide efficient sealing between the volute and the suction inlet of the impeller. The wear ring shall be stationary and made of brass or rubber- clad steel frame, which is driven, fitted to the volute inlet. These pumps shall also have a stainless steel impeller wear ring heat – shrink fitted to the suction inlet of the impeller to mate the stationary wear ring.

2.1.7. VOLUTE

Pump volute shall be single-piece non-concentric design with smooth passages large enough to pass any solids that may enter the impeller. Minimum inlet and discharge size as specified. The volute shall have a mating flange machine, and provided with a blind-flange, correct positioned for a flushing valve.

2.2. FABRICATION

If applicable, particular requirements mentioned above in part 1 must be enforced.

2.2.1. CASING

The casing shall be gray cast iron EN JL 1040 or equivalent, with smooth waterway and fitted with wearing rings. Wearing rings shall be provided for pumps running more than 1000 hours a year. The wearing rings shall be of bronze casting CuSn 12 or equivalent.

2.2.2. IMPELLER

The impeller shall be enclosed, accurately machined, and statically and dynamically balanced. The impeller shall be made of the following materials:

- Bronze casting CuSn12 or equivalent.
- gray cast iron EN JL 1040
- Stainless steel, AISI 304 or equivalent

2.2.3. SHAFT

The pump shaft shall be of alloyed steel precision-ground, and provided with renewable bronze or stainless steel sleeve where it passes through the stuffing box and is in contact with water. The shaft shall be rigidly supported by at least two (2) sets of heavy-duty antifriction ball bearings. Lubrication of bearings shall be done with grease.

2.2.4. SHAFT COUPLING

The shaft coupling between pump and motor shall be of the flexible type and shall be provided with guards.

2.2.5. VOLUTE AND BODY

Volute and body shall be gray cast iron EN JL 1040.

2.2.6. NUTS, BOLTS AND OTHER SUPPORTS

All exposed nuts, bolts, double guide bars, attachment for guide bars, elevating chain incl. suspension attachment shall be in stainless steel X2CrNi18-09 1.4307 (304L).

2.3. SPARE PARTS AND TOOLS

The Mandatory Spare Parts are for each submersible pump:

- 1 set of o-ring
- 1 security ring
- 1 stuffing
- 1 wrench

- 1 packing ring

The Mandatory Spare Parts for each electropumps are:

- 1 rotor
- 1 statoric ring
- 1 packing

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

- Holes position
- Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

- Examination of paintwork.

3.2.3. COMMISSIONING TESTS

3.2.3.1. GENERAL

a. The Tests on Completion shall consist of the following:

1. Installation inspection;
2. Pre-commissioning tests
3. Commissioning tests;
4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

b. The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other

PART 3 – TECHNICAL SPECIFICATIONS

measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.3.2. INSTALLATION INSPECTION

- a.** When the Contractor is satisfied that the pump sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.
- b.** The pump sets will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3.3. PRE-COMMISSIONING TESTS

- a.** Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
- b.** All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.
- c.** Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.2.3.4. COMMISSIONING TESTS

- a.** Tests shall be carried out on each pump set and shall include but not necessarily be limited to the following:
 - performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;
 - vibration monitoring to demonstrate compliance with specified vibration severity limits;
 - reverse rotation of the pump set due to backflow;
 - simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.
- b.** Performance proving tests shall be carried out on one pump set at a time by pumping clean water. The Contractor shall submit to the Engineer the way he intends to carry out these tests, particularly concerning water supply and output. Performance data shall include H-Q curves, power inputs, pump set efficiency curves and rotation speeds. Flow rates shall be measured using flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.
- c.** Pressure measurements shall be taken at a number of locations as directed by the Engineer, including the outlet flange of the discharge bend of pump. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated, including losses in the discharge pipe work.
- d.** The purpose of the performance proving tests is to confirm the factory tested results and verify the performance of the pump sets under site conditions over the full operating range.

In the event the proving test results are not satisfactory compared to the factory tested results, the Contractor shall immediately rectify the discrepancy.

- e. The Contractor shall demonstrate the total plant losses are within the values calculated by the Contractor. In the event that the measured head losses are higher than the calculated values, the Contractor shall rectify the discrepancy immediately.
- f. The pump sets, associated ancillary equipment and any component of the piping system will be liable for rejection if they fail to achieve satisfactory performances as required by the Contract.

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SECTION 14202

PROGRESSIVE CAVITY PUMPS

1. GENERAL

1.1. WORK INCLUDED

The works to be included in this section consist of the design, manufacture, delivery, off-loading, erection, testing and commissioning of the mechanical equipment for the progressive cavity pumps to be designed by the Contractor.

The equipment shall be complete with all base plates, foundation bolts, heat exchanger and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORKS

Supplies and works included under this section shall comply and co-ordinated with all others parts and section of the contract.

1.3. DESCRIPTION

<u>Identification</u>	
Number	3
Location	Primary settling tank – sludge feed to dewatering
Model	Progressive cavity pumps – horizontal installation
<u>Operating conditions</u>	
Duty	Continuous – 16 h/day – 7 days a week
Drive	Manual variable speed geared motor

Ambient environment	Indoor
Ambient temperature	5-40°C
Ambient relative humidity	
Fluid service	Primary sludge up to 35 g/l of suspended solids concentration
Fluid temperature	5-40°C
Fluid pH	6-9
Fluid specific gravity	1,05
<u>Description</u>	
Unit capacity	20 - 40 m ³ /h
Maximal pressure	3 bars
Materials	Body : gray cast iron EN JL 1040 Rotor : Stainless steel X20Cr13 1.4021 Stator : Buna-N synthetic rubber with a minimum shore durometer hardness of 60 bonded to a steel tube. Shaft : Stainless steel X20Cr13 1.4021
Motor	11 kW – 400 V – 50 Hz – IP 55 – F
Accessories (per installed pump)	
One suction and discharge pipe	
Branch connection on suction and discharge pipes for injection of industrial water (pipe declogging)	
Branch connection on suction and discharge pipes for injection of pressurized air (decompaction of accumulated sludge)	
Upstream and downstream isolation valves (gate valves)	
Non-return valves (ball valve)	
Pressure gauges	

Dry Running Protection Device

1.3.1. MAIN CHARACTERISTICS

- a. All pumps shall be driven by electric motors in accordance with the requirements of the electrical specifications.
- b. The direction of rotation of all the pumps shall be clockwise when viewed from the motor end of the pump set assembly.
- c. All pumps of same type shall be identical in design and construction in all respects including performance, parts, mountings, connecting flange dimensions and materials.
- d. The pump rotating assembly design shall be such that the first critical speed of the pump with its motor and the transmission assembly, when running as one system, is at least 150 percent of the maximum operating speed of the pump.
- e. Each component casting of the pump body shall have a wall thickness of 10mm minimum over and above that required to meet the strength requirements, to compensate for the corrosive and abrasive action of the sewage.
- f. The pumps shall be capable to work for long periods continuously without cleaning or attention and special precautions shall be taken to avoid wear on working surfaces dues to grit.

1.3.2. OPERATING CONDITIONS AND PERFORMANCE REQUIREMENTS

1.3.2.1. PUMP DUTIES

Each of the pumps shall be capable of operating continuously without damaging effects. If the Contractor considers that additional measures or controls are necessary to protect the Plant from any long term damaging effects, then all such equipment and controls shall be provided and shall be deemed to have been included in the contract price. The details shall be submitted with the Tender.

1.3.2.2. PUMP SUCTION ABILITY (NPSHR)

The pump shall be capable of operating satisfactorily in the specified operating range. The pump NPSHR shall be less than the NPSHA under any operating condition at Site to avoid cavitation. If the pump requires any increase of the system head so as to achieve satisfactory operation at any point in the specified operating range, then this shall be clearly stated in the Tender. The method and details of creating the additional system head shall be stated and drawings showing any changes required in the civil layout shall be submitted. Where such requirements affect the hydraulics of the complete system, hydraulic calculations shall be carried out and included in the Tender. If the change implies higher energy cost during operation of plant, then this will be taken into account during tender assessment.

1.3.2.3. PUMP RATED SPEED (NR)

The maximum rated speed of the pumps shall be designed by the Contractor.

1.3.2.4. PUMP SHAFT POWER

The pump shaft power characteristics shall be stable within the duty range and shall be non-overloading at the pump operating speed.

1.3.2.5. REVERSE ROTATION CAPABILITY

Under shut down conditions, reversal of the pump rotation will take place and the pump, motor and shafting shall be designed accordingly.

1.4. QUALITY ASSURANCE

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routing tests.
3. Workshop inspections and tests:

Refer to Section 01000 – General requirements:

- a) At the end of manufacture, the pumps shall be presented, unpainted, completely erected for dimensional checking.
- b) One pump of each type with its driving motor shall be tested at the manufacturer's plant to demonstrate complete compliance with the Specifications. In case the tests are not satisfactory, necessary modifications shall be done by the manufacturer and all pumping sets will be tested.

The Contractor shall submit the results of workshop tests.

1.5. SUBMITTALS

In addition to submittals required under **Section 01000 -General requirements**, the Contractor shall provide the following curves for each pumping unit:

- Efficiency (%)
- Horsepower (kW)

Moreover, the Contractor shall determine in his bid the:

- Rotating speeds (tr/mn),
- Power of the associated motors (kW),
- Weights of the units and of each essential component,

2. PRODUCTS – COMPONENTS AND SUB-ASSEMBLIES

2.1.1. GENERAL

All pumping units shall be supplied as complete pumping systems, including the pump, its driving motor, the drive shaft and couplings, local control panels and all necessary appurtenances (including protection devices, switches, etc.).

Pumps and motors shall be flexible-coupled. That portion of the shaft extending through the mechanical seal (s) shall be equipped with a replaceable sleeve (sealed or positive locked to the shaft) such that the entire shaft need not be replaced when it is scored or worn in this area. Pump shafts shall be designed for a maximum deflection at the shaft seal of 0.05 mm (0.002 in). All couplings, connections, external sealing, etc. shall be weather protected, suitable for outdoor installation.

Pump shafts shall run in ball bearings. The bearings shall be grease-lubricated and shall be contained in dust-proof and moisture-proof housing. The bearings and frame design shall be such that the bearings can be re-lubricated by use of external greasing devices. The pump design shall ensure that the outboard bearing can carry a combined thrust and radial load. Bearings shall be adequately designed to carry all radial and thrust loads through the normal operating range of the pump. Bearings for pumps in continuous operation (or in continuous rotation of operation) shall have an L-10 life of at least 40,000 hours at the operating point.

Mechanical seals, not packing, shall be used for all pumping units. Seals shall be of the type not requiring water sealing or flushing water.

Oil level shall be maintained by a constant level oiler with visible oil supply.

All openings in the pump shall be large enough to permit passage of solids with maximum diameter of 60 mm.

Connections to concrete foundations for all pumps shall be sufficient to withstand a displacing force equal to that developed by an internal pressure equal to three times shut-off head at maximum operating speed.

Pumping units shall be designed to operate without damaging vibration over the entire specified range of flow and head conditions and (where appropriate) over the range of speeds specified.

Major pump components shall be of gray cast iron with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pump- age, other than stainless steel or brass shall be protected by a factory-applied spray coating of alkyd primer with oxiranesther paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be of controlled compression of rubber O-rings in two planes and O-rings contact of four sides without the requirement of a specific torque limit.

Neither rectangular sectioned gaskets neither requiring specific torque nor scaling compound shall be considered as equal.

Pumping units shall have no dangerous critical or resonance frequencies. The Contractor shall be responsible for the analysis of critical speeds and the complete mass elastic system, and

shall submit calculations in this regard to the Engineer or his representative for approval prior to erection.

Pumping units shall be suitable for connection to No.-Flow shut-off switches, such switches to be supplied with all check valves supplied.

Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 40°C.

2.1.2. CABLE ENTRY SEAL

The Cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomere grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable the assembly shall provide ease of changing the cable. The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.1.3. MOTORS

The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air-filled watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155°C. The stator shall be dipped three times in Class F varnish and shall be heat-shrink fitted into the stator housing. The motor shall be designed for continuous duty handling pumped media of 40°C and capable of up to 15 evenly spaced starts per hour. Thermal switches set to open at 125°C and closed at 70°C shall be embedded in the stator load coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomer o-ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable. The motor and pump shall be designed and assembled by the same manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15 the motor shall have a voltage tolerance of plus or minus 10% the motor shall be designed for operation up to 40°C ambient temp. and with a temp. rise not to exceed 85°C. This chart shall also include data on starting and no-load characteristics. The motor and the cable are capable of continuous submergence underwater without loss of watertight integrity acc. To protection class IP68 (20m), the rated power shall be adequate so that the pump is not overloaded throughout the entire indicated pump performance curve.

Power cable includes two conductors 1.5 mm for the monitoring of thermal switches and optional protecting sensors.

PART 3 – TECHNICAL SPECIFICATIONS

2.1.4. BEARING

The pump shall be provided with grease lubricated thrust and radial bearings designed for all loads imposed by the specified service. Bearing life for all pump and motor bearings shall be 100,000 hours minimum

2.1.5. MECHANICAL SEAL

Each pump shall be provided with a tandem mechanical shaft seal system consisting of two independent seal assemblies. The seals shall operate in an oil-reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump housing and the oil-chamber, shall contain one stationary and one positively driven rotating tungsten carbide ring. The upper, secondary seal unit, located between the oil-chamber and the motor housing, shall contain one stationary tungsten-carbide seal ring and one positively driven rotating tungsten-carbide seal ring. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotating for sealing. For special applications other seal face material shall be available. Other seal types shall not be considered acceptable or equal to the dual independent seal specified. Each pump shall be provided with an oil chamber for the shaft sealing system, the drain and inspection plug, for the oil, shall be accessible from the outside.

2.1.6. ROTOR AND STATOR

The pump shall be two-stage design employing a convoluted rotor operating in a similarly convoluted stator. The convolutions shall be configured to form a cavity between the rotor and stator which shall progress from the pump's inlet to discharge port with the operation of the rotor. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a good seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber.

2.2. FABRICATION

If applicable, particular requirements mentioned above in part 1 must be enforced.

2.2.1. PUMP BODY

The pump body shall be gray cast iron EN JL 1040 or equivalent.

2.2.2. ROTOR

The rotor shall be made of Stainless steel, AISI 304 or equivalent.

2.2.3. STATOR

The rotor shall be made of Buna-N synthetic rubber with a minimum shore durometer hardness of 60 bonded to a steel tube.

2.2.4. SHAFT

The pump shaft shall be of alloyed steel precision-ground, and provided with renewable bronze or stainless steel sleeve where it passes through the stuffing box and is in contact with water. The shaft shall be made of Stainless steel, AISI 304 or equivalent.

2.2.5. NUTS, BOLTS AND OTHER SUPPORTS

All exposed nuts, bolts, shall be in stainless steel X2CrNi18-09 1.4307 (304L).

2.3. SPARE PARTS AND TOOLS

The Mandatory Spare Parts are for each size of pump furnished:

- One stator,
- One rotor,
- One connecting rod,
- One set connecting rod joint assembly,
- One bearing assembly,
- One set of V-belts
- Two sets of drive pins, washers, and screws,
- Two sets of gaskets and o-rings,
- One mechanical seal.

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

A. The following inspections shall be carried out before and after concreting:

- a.** Holes position
- b.** Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

1. Examination of paintwork.
2. Machine must run for two hours without water and without any noticeable problem (noise, axial position...).

3.2.3. COMMISSIONING TESTS

3.2.3.1. GENERAL

- a.** The Tests on Completion shall consist of the following:

1. Installation inspection;
2. Pre-commissioning tests
3. Commissioning tests;
4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive programme and detailed proposals of the Tests on Completion.

- b.** The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.3.2. INSTALLATION INSPECTION

- a.** When the Contractor is satisfied that the pump sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.
- b.** The pump sets will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3.3. PRE-COMMISSIONING TESTS

- a.** Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
- b.** All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.
- c.** Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.2.3.4. COMMISSIONING TESTS

- a.** Tests shall be carried out on each pump set and shall include but not necessarily be limited to the following:
- performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;
 - vibration monitoring to demonstrate compliance with specified vibration severity limits;
 - reverse rotation of the pump set due to backflow;
 - simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.
- b.** Performance proving tests shall be carried out on one pump set at a time by pumping clean water. The Contractor shall submit to the Engineer the way he intends to carry out these tests, particularly concerning water supply and output. Performance data shall include power inputs, pump set efficiency curves and rotation speeds. Flow rates shall be measured using flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.
- c.** Pressure measurements shall be taken at a number of locations as directed by the Engineer, including the outlet flange of the discharge bend of pump. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated, including losses in the discharge pipe work.
- d.** The purpose of the performance proving tests is to confirm the factory tested results and verify the performance of the pump sets under site conditions over the full operating range. In the event the proving test results are not satisfactory compared to the factory tested results, the Contractor shall immediately rectify the discrepancy.
- e.** The Contractor shall demonstrate the total plant losses are within the values calculated by the Contractor. In the event that the measured head losses are higher than the calculated values, the Contractor shall rectify the discrepancy immediately.
- f.** The pump sets, associated ancillary equipment and any component of the piping system will be liable for rejection if they fail to achieve satisfactory performances as required by the Contract.

oOo

SECTION 14410

SCREW CONVEYORS

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of screw conveyors.

The equipment shall be complete with all base plates, foundation bolts and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A.** Section 01000 - General requirements;
- B.** Section 01010 - Corrosion protection;
- C.** Section 01020 - Basic mechanical requirements;
- D.** Section 01030 - Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A.** Concrete works covered by the Civil Works Section;
- B.** Section 19 100 - Electrical Equipment;
- C.** Section 17 100 – Instrumentation;
- D.** Section 11 305 – Fine Screening;
- E.** Section 11 373 – Belt filters;
- F.** Section 11 379 – Liming;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

1.3.1.1. FINE SCREENING COMPACTING SCREW

Refer to Section 11 305 – Fine Screening.

1.3.1.2. SKIPS FEEDING SCREW CONVEYOR

<u>Identification</u>	203-SW-001/002
Number:	2
Location	Skips area
Model	Shaftless screw conveyor
<u>Operating conditions</u>	
Duty	Continuous 16 h/day – 7 days a week
Ambient environment	outdoor
Ambient temperature	-25 to 40°C
Fluid service	Limed sludge between 30 to 35 % of suspended solids concentration and lime
Fluid temperature	10-50°C
Fluid pH	7-14
Fluid specific gravity	1,1
<u>Description</u>	
Capacity	20 wet t/hour
Trough diameter	550 mm
Trough length	12 m
Lead angle	0°
Maximum screw operating speed	20 rpm

Materials	General requirements are indicated in part 2: Products – Components and sub-assemblies.
Motor	10 kW – 1450 rpm – TRI – 400 V – 50 Hz – IP 68 – F
Accessories (per installed screw conveyor)	Removal cover on trough Torque limiter Inlet hopper SS 304L Waste distribution device in two dumpsters (manual rotation)

1.3.2. OPERATING CONDITIONS

Screws are sized in case four dewatering and liming units would simultaneously operate.

Screw conveyors shall be provided as a completely integrated system designed for continuous and automatic operation.

Skip that should be fed is chosen by the operator, there is no level sensor above skips.

Units shall not need preventive cleaning

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

- A.** Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
- B.** Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
- C.** Workshop inspections and tests:
 - a.** The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b.** The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

Screw conveyors	Screw conveyor troughs : stainless steel 304 Screw Conveyor Flights: carbon steel Removal troughs cover : EPHD or stainless steel 304 Inlet and outlet hoppers : stainless steel 304 Bearing end plates: stainless steel 304 Support Saddles: stainless steel 304 Gear box : cast iron EN JL 1040 and epoxy

2.2. SCREW CONVEYORS

The flight, shaft, and complete drive components shall be structurally designed for a conveyor capacity of 100 percent trough loading at maximum motor horsepower. The torque capacity of the drive unit shall be sufficient to start the conveyor with the trough 100 percent loaded.

Flushing connection shall consist of a 304 stainless steel pipe nipple welded to trough at invert.

Trough cover shall be hinged to the trough at the top of the trough U-flange. The cover shall be removal and be attached to the screw conveyor trough, with cover support brackets along one edge. Each cover shall also have a handle made of stainless steel, The handle rod shall be fully welded to cover. Each cover section shall have two toggle clamps.

Trough covers at discharge end of the conveyors shall be furnished with relief hatches with position switch to provide alarm indication in event of cover opening.

Each screw conveyor shall be driven by an electric motor connected to the shaft with a V-belt in the piggy back arrangement. The drive system shall be designed by the manufacturer for starting the conveyor fully loaded with the trough 100 percent filled. Shear pin or couplings shall ensure that jamming of any component does not cause mechanical damage to the equipment.

Tail end bearings shall be grease lubricated, double pillow block and shall be mounted outside the conveyor trough. End bearings shall be completely serviceable from outside the conveyor. Grease zerk fitting for non-drive end bearings shall be extended with stainless steel tubing to surface of adjacent grating platform to allow remote lubrication. A packing gland seal with 3 rings of packing shall be provided around the shaft where the shaft passes through the trough ends. The bearing and seals shall be capable of supporting the applicable thrust loads by means of snap rings and shall prevent angular misalignment of the shafts. Bearings shall have an L-10 life of 100,000 hours.

Controls and Accessories:

- To detect zero speed of the screw, each conveyor drive shall be provided with a zero speed switch.
- Relief hatches shall be furnished with position switches that detect cover opening.
- Conveyors shall be provided with a cable operated safety stop switch on both sides of the trough. Two single pole, double throw switches shall be provided for each cable operated safety stop switch.

Conveyors and gate valves shall be operated by Local Control Stations.

2.3. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts are for each screw :

- One set V-belts or timing belts.
- One set of end bearings and packing

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

- A.** The following inspections shall be carried out :
 - a.** Holes position
 - b.** Flatness, verticality, horizontality of the embedded parts,
- B.** Erection tolerances:

Refer to Section 01020

3.2.2. DRY TESTS

- a.** When the Contractor is satisfied that the unit sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.
- b.** The unit will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3. COMMISSIONING TESTS

3.2.3.1. PRE-COMMISSIONING TESTS

- a.** Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
- b.** All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.
- c.** The backdrive shall be modulated and other control inputs simulated for a minimum of 8 hours to provide an initial test of control responses. A controlled shutdown and emergency shutdown cycle shall be included.
- d.** All programmed sequence control, protection, alarms, and other specified control features in dewatering units shall be demonstrated. Control logic inputs and outputs shall be simulated for all equipment and devices composed or linked to dewatering units.

3.2.3.2. COMMISSIONING TESTS

Operational test will consist of control the smooth running during dewatering and liming units commissioning tests.

SECTION 14 412

BELT CONVEYORS

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of screw conveyors.

The equipment shall be complete with all base plates, foundation bolts and all other items of equipment necessary to make the installation complete and perfect in every detail.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A.** Section 01000 - General requirements;
- B.** Section 01010 - Corrosion protection;
- C.** Section 01020 - Basic mechanical requirements;
- D.** Section 01030 - Basic electrical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A.** Concrete works covered by the Civil Works Section;
- B.** Section 19 100 - Electrical Equipment;
- C.** Section 17 100 – Instrumentation;
- D.** Section 11 301 – Coarse Screening;

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Screenings belt conveyor: refer to specification 11 301 (Coarse screening)

Dewatered sludge belt conveyor:

PART 3 – TECHNICAL SPECIFICATIONS

<u>Identification</u>	203-BC-001
Number:	1
Location	Sludge building – liming room
Model	Double way belt conveyor
<u>Operating conditions</u>	
Purpose	In case of unavailability of one the sludge screw conveyors (203-SW-001 or 002), this equipment will transfer the sludge to the remaining screw.
Ambient environment	Indoor
Ambient temperature	5 to 40°C
Fluid service	Limed sludge between 30 to 35 % of suspended solids concentration and lime
Fluid temperature	10-50°C
Fluid pH	7-14
Fluid specific gravity	1,1
<u>Description</u>	
Capacity	10 wet t/hour
Belt width	800 mm
Approximative Trough length	9 m
Lead angle	0°
Materials	General requirements are indicated in part 2: Products – Components and sub-assemblies.
Gear Motor	Motor : 2,2 kW – 1450 rpm – TRI – 400 V – 50 Hz – IP 55 – F
Accessories	Lateral guide for the belt Lateral edges Adjustable supports

	Torque controller 2 Removable SS sloping plates for sludge transfer from the outlet of the sludge/lime mixer to the belt conveyor.

1.3.2. OPERATING CONDITIONS

Belts conveyors shall be provided as a completely integrated system designed for continuous and automatic operation.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

- A.** Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
- B.** Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
- C.** Workshop inspections and tests:
 - a.** The seals and the embedded parts shall be presented separately and unpainted for checking.
 - b.** The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

1.5. SUBMITTALS

The supplier should submit the following documents (non-exhaustive list):

- 1. Installation, maintenance and operation manuals with requirements of accuracy
- 2. Manufacture and quality assurance measures
- 3. Protective coating list of all parts
- 4. Commissioning tests list.
- 5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
- 6. Internal wiring diagrams and control principle drawing of control box
- 7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

Belt conveyor	Belts : PVC or rubber Frame and edge : stainless steel inox 304L Inlet hoppers : stainless steel 304L Bearing end plates: stainless steel 304L Support Saddles: stainless steel 304 Gear box : cast iron EN JL 1040 and epoxy

2.2. SPARE PARTS AND SPECIAL TOOLS

The Mandatory Spare Parts are for each belt:

- One belt.
- Four rollers
- One set of end bearings and packing

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

3.2.1. INSPECTIONS BEFORE AND AFTER CONCRETING

- A.** The following inspections shall be carried out :
- a.** Holes position
 - b.** Flatness, verticality, horizontality of the embedded parts,
- B.** Erection tolerances:

Refer to Section 01020

PART 3 – TECHNICAL SPECIFICATIONS

3.2.2. DRY TESTS

- a. When the Contractor is satisfied that the unit sets have been properly installed he shall inform the Engineer who will carry out the installation inspection.
- b. The unit will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.3. COMMISSIONING TESTS

3.2.3.1. PRE-COMMISSIONING TESTS

- a. Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
- b. All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.
- c. The backdrive shall be modulated and other control inputs simulated for a minimum of 8 hours to provide an initial test of control responses. A controlled shutdown and emergency shutdown cycle shall be included.
- d. All programmed sequence control, protection, alarms, and other specified control features in dewatering units shall be demonstrated. Control logic inputs and outputs shall be simulated for all equipment and devices composed or linked to dewatering units.

3.2.3.2. COMMISSIONING TESTS

Operational test will consist of control the smooth running during dewatering and liming units commissioning tests.

SECTION 15 420

AIR LIFT

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of the overall grit extraction system equipment, including but not limited to:

1. Air compressors,
2. Pipes.
3. Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections,..) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.

4. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts,..) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Civil Works Section.

5. Covers above the slots shall be provided by the Contractor.

1.2. RELATED WORKS

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection;
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;

1.2.2. WORK UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A. Concrete works covered by the Civil Works Section;
- B. Electrical works covered by the Electrical Equipment Section;

- C. Section 11210 – Grit Scraper and Suction Bridges;
- D. Section 17100 – Instrumentation

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Identification number:	103-BL-501/502
Type:	Air Lift
Number:	2
Location:	Grit and grease removal tanks
Capacity:	55 m ³ /h
Motor :	3 kW – 380 V – 50 Hz – IP55
Pipes :	2 suction pipes ND125 and ND150 at the bottom of the tanks 2 air pipes ND26/34 1 connection pipes between the two air-lifts in order to have only one air compression in operation 2 discharge pipes ND125
Materials:	Stainless Steel 304L

1.3.2. OPERATING CONDITIONS

Grit accumulated in the grit chamber well shall be removed by an air lift system.

The mixture of sand, air and water lifted up is conveyed to a grit classifier.

Compressed air is provided by an air compressor located near the grit tank. Each compressor shall operate with one tank.

Air pipes shall be equipped with manual ball valves and solenoid valves.

Moreover the Contractor shall provide characteristic curves of proposed compressors in the Schedules of Particular:

- Pressure increasing in bars
- Input flow in m³/min
- Absorbed power in kW

In addition, the following items shall be précised in his bid:

- Rotating speed in rd/min
- Nominal power of the driving motor
- Weight of the overall equipment and of each main part
- Input and output ports diameters
- Main operation loads, particularly when they are in relation with Civil works fastenings.

1.3.3. CONTROL AND MONITORING

The operation mode of air compressors should have both:

1. Manual control and PLC automatic control.
2. Local control and distance control.

Air compressor local control facilities shall be located in the grit chambers control box with mixers and classifiers commands.

The box will be composed at least of the following controls and instructions, for each equipment:

3. Manual / auto commutator
4. Lighted button “ON”
5. Lighted button “OFF”
6. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way these equipments will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the grit extraction control.

Moreover the following detectors shall be installed and connected to the PLC:

7. Malfunctions and alarms.

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - a) At the end of manufacture, the stop log shall be presented, unpainted, for checking. The seals and the embedded parts shall be presented separately.
 - b) Stop logs and embedded parts:

The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth. All dimensions of stop log members shall be checked. The operation of by-pass valves shall be checked. The Engineer reserves the right to participate in these tests.
 - a) Welds:

Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. AIR COMPRESSOR

The air compressor should be equipped with appropriate:

- Inlet dust filter,
- Silencer,
- Discharging pressure valve,
- Pressure protection device
- Pipe flexible joints.
- Motor
- Acoustic housing
- Control box

2.1.2. MOTOR

The motor shall be:

- IP55 protected
- 380 Volts,
- 50-Hertz
- Class F insulation.

The motor system should be installed on a public assembly type of steel foundation, and it shall be equipped with driving belt adjustable device, as well as the protection cover for the belt and the wheel.

2.2. PIPES

Inlet and outlet pipes shall be made of stainless steel 304L.

2.3. SPARE PARTS AND SPECIAL TOOLS

The Contractor shall supply the following spare parts:

- Equipment maintenance

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. FIELD QUALITY CONTROL

A. Inspections before and after concreting

1. The following inspections shall be carried out before and after concreting:

- Equipment position
- Flatness, verticality, horizontality of the embedded parts,

2. Erection tolerances:

Refer to Section 01020

B. Dry tests

1. Testing of all operation characteristics during 24 hours and without water:

- For each compressor taken individually,
- For each compressors combination eventually necessary to get the overall installation flow.

During these tests, vibrations, temperature increasing and noise shall particularly be checked.

2. Examination of paintwork.

C. Commissioning tests

1. Examination of paintwork.
2. Checking of operation conditions for nominal flow and during 24 hours.
3. The supplier shall provide extraction effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing

water ditches, in order to check the effectiveness of sediment flushing and solid conveying. Each extraction system shall fit individually with requirements.

4. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.
5. Leakage shall not be observed out of the pipes.

oOo

SECTION 15550

HVAC

1. GENERAL CONDITIONS / REQUIREMENTS

1.1. INTRODUCTION

The General Specifications included as part of this Specification indicates the minimum standard of work, workmanship and materials that will be accepted in the provision of a normal installation. It is not intended to cover the requirements of installations of a specialist nature. The General Specifications shall be read and considered in conjunction with, Particularly Mechanical and Electrical Specifications and Drawings that are issued for and appertain solely to the particular installation concerned; in the event of conflict the more stringent condition shall apply and the Engineer's decision shall be final.

The Contractor shall include for the complete installation, testing and commissioning of the mechanical, associated electrical and plumbing systems outlined on the drawings and described in this specification.

1.2. EQUIPMENT RATINGS

All equipment selected for use on this Contract shall be suitable for continuous and reliable operation under the external design conditions stated. In addition, items of equipment installed in enclosed spaces may be subject to temperatures in excess of those prevailing externally and this shall be taken into account. Where ratings are given in this Specification and/or shown on the Drawings, they are the actual ratings to be achieved after the application of all de-rating factors.

All equipment and enclosures that may be subject to internal condensation shall be fitted with suitably rated electrically operated thermostatically controlled anti-condensation heaters.

1.3. COORDINATION

The Contractor shall be responsible for all aspects of project coordination as set out in the General Conditions.

1.4. EQUIPMENT

All equipment to be installed under this contract shall comply with the requirements of the General Conditions.

1.5. SHOP DRAWINGS

The Contractor shall prepare shop drawings for the installation as per the requirement of the General Conditions.

1.6. RECORD DRAWINGS AND MANUALS

The Contractor shall prepare record drawings and manuals as per the requirement of the General Conditions.

1.7. SERVICES FOR TESTING

All fuel, oil, gas, water and electricity for the purposes of testing and commissioning shall be provided by the Contractor up to the date of the issue of the Certificate of Temporary Acceptance. This shall include the initial charging of all systems and equipment with water, oil and gas, etc.

1.8. SPARE PARTS AND TOOLS

After completion of the Works and during the specified maintenance period the Contractor shall be responsible for the supply and installation at the fixed time recommended by the manufacturers of all spare parts and components, required for the ideal running of all engineering services installation.

The contractor will be responsible to provide the list of recommended spare parts for all equipments used in the project and to provide such spare parts for two years after the maintenance period.

2. STANDARDS

2.1. INTRODUCTION

This General Specification indicates the minimum standard of work, workmanship and materials necessary for the execution of the Contract to the approval of the Engineer and the true intent of this Specification and associated Drawings.

2.2. STANDARDS FOR INSTALLATIONS

The installation shall conform to:

- a) The general and specific requirements of the local water authority, public health officer, local drainage inspectorate and other local statutory authorities.
- b) Local authority by laws and other regulations.
- c) General and specific requirements of the local fire officer.
- d) Health and Safety at Work Act., U.K.
- e) Central supply of liquefied petroleum Gases to Buildings.
- f) Factory Act Requirements and Regulations, U.K.
- g) Relevant codes of practice of the British Standards Institution.
- h) The requirements of the insurance companies concerned.
- i) The regulations for the electrical equipment of buildings, (current edition) published by the Institution of Electrical Engineers, London.
- j) The recommendations of the manufacturers of all materials, plant and equipment.
- k) CIBSE Regulations for water supply and drainage services.

2.3. SAFETY AND FIRE PRECAUTIONS

The Contractor shall ensure that safe methods of working are followed when using any equipment of materials which may involve a danger to life or to property and he is to take all necessary precautions to safeguard against damage by fire or explosion where the execution of the works may involve the presence of flame or sparks.

2.4. CONTRACTOR'S PLANT AND TOOLS

The Contractor, unless otherwise specified, shall provide all materials, tackles, slings, scaffolding, ladders, haulage, labour and apparatus necessary for the supply, delivery and erection of the plant on site.

The Contractor shall be responsible for providing at his own expense, all the requirements such as hand tools, hand lamps, and transformers, where necessary, to carry out the works including all cabling and intermediate connections from supply point to location of work. All wiring, cabling, etc., serving temporary installations are to be designed, installed and operated, as to be safe and in full accordance with the appropriate regulations.

As soon as any part of the Contractor's Site establishment or plant is no longer required for carrying out the Works, the Contractor shall disconnect and remove the same to the satisfaction of the Engineer.

2.5. PIPE WORK CONNECTIONS

The Contractor shall include for all pipe work and connections to all sanitary fittings, and specialist equipment as detailed in the specifications.

2.6. MATERIALS

All materials, plant and equipment shall comply fully with any relevant British Standard Specification or Code of Practice current at the time of tendering.

The Engineer reserves the right to inspect materials, plant and equipment on Site at reasonable times and to reject any of the same not complying with the Specifications.

The cost of dismantling and re-erection of the installation occasioned by the removal of rejected materials, plant or equipment shall be borne by the Contractor.

2.7. STANDARDS

Corresponding parts of all apparatus shall be interchangeable and where mechanical or electrical details are used or which any part of parts are covered by a British Standard Specification, all such parts are to be made in accordance with such specification as shall be issued at the date at which the parts have been ordered.

Except where otherwise specified, all bolts , nuts and stud screws thread shall be metric and all pipe threads to be to B.S. pipe threads standards.

2.8. TRADE CUSTOMS AND PRACTICE

The Contractor shall be entirely responsible for arranging and ensuring that the various classes of work comply with local trade customs and practice and shall provide accordingly in his Works.

2.9. DIMENSIONS

The Contractor shall take his own dimensions on Site for all plant and material to be supplied by him and shall be entirely responsible for the accuracy of his measurements.

2.10. SETTING OUT

The Contractor shall set out the Works in accordance with his installation working drawings.

2.11. NAMEPLATES

All plant and apparatus supplied under this Contract shall be provided with brass nameplates, bearing the maker's name shop or reference number, size, type, test and working pressure, speed and other relevant particulars engraved thereon.

2.12. INTERRUPTION OF SERVICES

The Contractor shall not, without permission of the Engineer interrupt or interfere with the operation of existing services such as water, electric lighting and power, buried cables, sewers, drains, etc., nor, in the case of works of statutory authorities or private owners, without the permission of these authorities or owners.

In the event of any such damage, the Contractor shall be responsible for the making good of same to the satisfaction of the Engineer, authorities or owners, as the case may be.

2.13. MISUSE OF MATERIALS

No materials brought on to Site for incorporation in the Works shall be used for scaffolding or any other temporary purpose.

2.14. VOUCHERS

The Contractor, at the request of the Engineer, must produce invoices, paid or unpaid, or accounts if required as proof that the goods are in all respect as herein specified.

2.15. OBSTRUCTIONS

No extra charge shall be made for moving or circumventing any obstruction or other Contractor's equipment that may be laid on the Site and the Contractor must, therefore, allow in his tender for these and any other contingencies likely to arise.

2.16. INSPECTION, TESTING AND REJECTION

The Engineer shall be entitled during manufacture to inspect, examine and test the materials and workmanship for all plant to be supplied under the Contract, whether at the Contractor's or manufacturer's premises or on the Site. Such inspection, examination or testing shall not release the Contractor from any obligation under the Contract. The whole of the installation shall be tested on completion (in the presence of and to the satisfaction of the Engineer or his representative) in the relevant Sections of this Specification as applied to the particular installation concerned.

The Contractor must furnish certificates of test, in duplicate, to the Engineer, for all plant or materials specified to be tested at maker's works.

The tests on Site specified hereinafter are to be carried out in the presence of the Engineer or his Representative. The accuracy of all tests is to be to the satisfaction of the Engineer, whose decision shall be final.

The Contractor shall provide free of charge on the Site at his own expense and/or the manufacturer's works, such labour, materials, apparatus and instruments as the Engineer may consider requisite from time to time and as may reasonably be demanded to efficiently test the plant, materials or works as far as completed, until the plant is accepted as a whole by the Engineer. The Contractor shall at all times give facilities to the Engineer or his authorized representative to accomplish such testing.

The Contractor shall demonstrate, if required, the accuracy of any instrument used for testing. At least seven days' notice must be given by the Contractor of any test carried out on the Site to enable the Engineer or his authorized representative to be present if they so desire.

Testing of pipes and other apparatus as specified under the various Sections of Specifications may be required to be carried out in parts against testing as a whole and the Contractor must provide accordingly in his tender.

Should the Works on testing not conform to the Specifications, the Contractors must make them so conform at his own expense and, if he fails to do so within a reasonable period, not exceeding fourteen days, the Engineer shall be at liberty to call upon him to remove the defective part and reinstate without cost to the Employer.

2.17. PRESSURE GAUGES

Pressure gauge's shall be Bourdon tube type with 100mm diameter dial with needle pointer, normal operating pointer, brass casing, bronze syphon and bronze gauge cock, all suitable for the working pressure of the system. Each gauge shall be calibrated in kPa from Zero to 1.5 times the working pressure at the point selected, all to the Engineer's approval. All pressure gauges shall be fully tropicalized and fitted with a red indicating needle set to show the normal operating position.

2.18. TESTING AND COMMISSIONING - GENERAL

- At least three (3) working days written notification of all site tests shall be given to the Engineer.
- Fuel, water and electricity necessary for the operation of systems in preliminary runs and for adjustments and tests will be provided free of cost by the Contractor.
- The Contractor shall supply all labour, apparatus and instruments necessary for the prescribed tests. The accuracy of the Contractor's instruments shall be demonstrated if required.

- Any defects of workmanship, materials, performance, design of equipment, maladjustments or other irregularities, which become apparent during the tests, shall be rectified by the Contractor and the tests repeated at the Contractor's expense, to the satisfaction of the Engineer.

2.19. PRE-COMMISSIONING CLEANING

Tubes and all items of equipment shall be delivered stored and maintained in storage with their open ends effectively plugged, capped or sealed. All fittings, valves and sundry items shall be stored in clean bins or bagged and stowed in suitable racks. All such stored items shall be maintained under weatherproof cover to be supplied by the Contractor until they are ready for incorporation in the works. Particular care shall be taken to ensure the electrical equipment and components are kept clean and dry.

Before installations are handed over or subjected to the inspection and tests required the entire installation shall be thoroughly cleaned, both internally and externally.

All water installations shall be flushed out with clean water. This shall be preceded by chemical cleaning. During the flushing out process provision shall be made to exclude filters, pumps and any other items of plant, which could be damaged by the cleaning operation. The entire operation shall be carried out to the satisfaction of the Engineer.

Cold water services shall, after pre-commissioning cleaning and hydraulic testing, be sterilized by the application of chlorine as detailed in BS 6700.

2.20. SITE TESTS

The Contractor shall be responsible for site tests on static systems in order to ensure safe operating conditions consistent with design performance. Such tests shall include inspection and testing of welds and pressure testing for soundness of hydraulic systems.

2.21. COMMISSIONING

All aspects of the commissioning procedure shall follow the recommendations in the relevant CIBSE Commissioning Codes. Commissioning shall include:

- Preliminary checks to ensure that all systems and system components are in satisfactory and safe condition before start up.
- Preliminary adjustments and setting of all plant and equipment consistent with eventual design performance.
- Energizing and setting to work all plant.
- Final regulation and demonstration that the installation delivers the correct rate of flow of fluids at the conditions specified in the Contract Documents.

The entire commissioning procedure shall be performed to the satisfaction of the Engineer. The results of the commissioning shall be recorded by the Contractor and shall be endorsed by the Engineer. The items on the certificate shall be read in conjunction with the appropriate Clauses of this Specification and the design requirements of the drawings and the certified results and statements pertaining to the commissioning procedure shall be interpreted accordingly.

3. VENTILATION

3.1. SCOPE

The works covered under this contract include all the supply, install, test, commission and maintain in good operating condition of the complete ventilation system described in this specification and shown on the drawings in accordance with the drawings, schedule and specification including but not limited the following: -

- To check the design and to undertake the responsibility of giving the design conditions in the occupied areas.
- To provide power supply to all ventilation and AC units.
- To provide complete control wiring.

The following equipment shall be provided:

N°	Type	Service	Capacity / Dimensions
103-FN-001	Pump room exhaust ventilation 2-speed Fan	ambient air	1000 and 350 m3/h
105-FN-001	Pump Gallery exhaust ventilation 2-speed Fan	ambient air	6000 and 2000 m3/h
300-FN-001	2 speed Fan	Foul air	ND 300, 3100 and 2100 m3/h
200-FN-001	Exhaust ventilation 2-speed Fan	ambient air	8000 and 2700 m3/h
200-FN-002	Exhaust ventilation 2-speed Fan	ambient air	8000 and 2700 m3/h
206-FN-001	2 speed Fan	Foul air	ND 400, 8600 and 2800 m3/h

3.2. PRELIMINARIES

The specification and drawing shall be interpreted in accordance with the guidelines of the codes of practice of the CIBSE and ASHRAE Standard where such codes are relevant. Any Detail not shown or specified but necessary for the proper installation and operation shall be included in the work. The contractor shall set sleeves for pipes and ducts accurately before the concrete floors/walls are poured.

3.3. GENERAL SPECIFICATION

3.3.1. DESIGN ELEMENTS

The installation is based on the following design conditions. The capacities and dimensions given in drawings will be considered as the minimum to be accepted.

- Outdoors design condition: refer to General Conditions

- Indoor Design Condition:

Temperature: 10 to 25 °C

Relative humidity: 50 + 5% RH

Noise Level 35 NC

Power Supply: - 380/50/3ph or 220/50/1ph

3.3.2. OPERATION AND MAINTENANCE INSTRUCTIONS

Three sets of operation and maintenance manual of the ventilation, equipment shall be furnished and Handover to the client. The contractor shall also to furnish the name & telephone Nos. of manufacturers in order to expedite the further replacement of the parts.

3.4. EXHAUST (EXTRACT) FANS

Fan casings shall be of rigid and airtight construction, manufactured in materials resistant to corrosion from the operating environment and conditions. Fans shall be tested to BS 848 Parts 1 and 2.

All fans shall be statically balance dynamic balancing shall be included where scheduled.

Fans final duties shall be verified taking into account certified resistances of system components.

Where air filters are included in a system the fans shall be selected to deliver the design air volume against the system resistance including dirty filters.

Fans and motors shall be suitable for continuous operation and any start/stop programmers specified. Motor and fan bearings shall have a minimum design operational life of 40,000 hours with one start and stop per hour.

All cases fan assemblies shall be resiliently mounted to prevent vibration transmission to elements which they are fixed. Centrifugal fan assemblies with indirect drives shall have fan and drive motor mounted on a common and continuous rigid sub-frames resiliently mounted.

Fan scrolls and casings shall have drain plugs and inspection/cleaning doors where specified.

Flexible connections shall be made between the fan outlet and the unit casing in woven fire-retardant material.

Lubricators shall be provided to all fan and motor bearings (except sealed type where accepted or use), be extended if necessary to accessible positions, and have seal caps.

Rigid protective screens of woven steel wire and mesh shall be provided to all inlet and discharge opening for fans not protected by ductwork system connections.

Suspended fans shall be supported on a suspended sub-frame with vibration isolation provisions between the fan (and drive) and the sub-frame.

The assembly shall prevent significant movement of the fan relative to any ductwork system due to fan torque and thrust.

Fans and motors are installed at the (Explosive Areas) shall be of explosion proof type.

3.4.1. MATERIALS OF CONSTRUCTION

Casings

Casings and bearing and motor supports shall be constructed from mild steel to BS 1449.

Axial fan casings shall be of hot dipped galvanized mild steel or aluminum alloy.

Impellers

Multi-vane impellers for centrifugal fans shall be constructed from mild steel to BS 1449.

Axial fan impellers shall be hot dipped galvanized mild steel, aluminum or molded reinforced plastics.

Axial fan impellers, blade and hub assemblies of die cast aluminum alloy shall be X-ray checked for flaws before passing for assembly. Blades shall be of aerofoil section.

Alternative acceptable materials shall be fully inspected.

Shafts shall be constructed from machined bright steel, sized to ensure that the maximum running speed is not more than 60% of the first critical speed determined by the bearing arrangement.

Centrifugal fan impellers may be fixed to shafts with machine or grub screw's or shaft powers less than 750 W provided the screw bear onto machined flats on the shaft.

Impellers with shaft power greater than 1 KW shall be keyed to the shaft.

Shaft ends shall be recessed for tachometer drive.

3.4.2. CENTRIFUGAL FANS

Scrolls

Fan scrolls shall be mild steel with welded joints and welded angle stiffeners. On fans with static pressure of less than 1 kPa the scroll may be formed from mild steel with lock formed Joints and spot-welded scroll supports and bases. On fans less than 800 mm diameter and of speeds below 20 Hz, stiffeners may be the folded edges of welded side plates used to form the pedestal and scroll. Arrangements of fan scrolls shall allow removal of the impeller where scheduled. Inlet and discharge connections shall be flanged with an airtight joint between the scroll and flange. Where the difference in static pressure between the fan inlet and surrounding is less than 500 Pa inlet connection may be a plain circular spigot.

Scrolls shall be properly prepared and prime coated and finished with a fully protective paint scheme to prevent corrosion and deterioration.

Kitchen exhaust fans shall have a removable airtight impeller inspection and cleaning door in the casing.

Impellers.

Forward curved impellers for shaft powers below 1 KW may be strip, if the fan efficiency and required impeller balance grade achieved. For shaft powers above 1kw, impeller blades shall mild steel riveted or welded to the cage. Braces shall be bolted, the cage and hub, but stressed wire or screwed stud bracing shall Backward curved impeller blades shall be of mild steel and

have true aerofoil performance, riveted or welded to the cage, except for shaft powers below 1 KW where the impeller may be die-cast aluminum alloy or similar if the fan efficiency and required impeller balance grade can be achieved. Double inlet double width fans shall have two identical impellers mounted back-to-back on a common shaft.

Bearings

Impeller bearings shall be ball or roller (except where specified otherwise) and shall be self-aligning Plummer blocks (or similar split bearing housings) shall be used on fans with shaft powers greater than 10 KW. Bearing shall be replaceable on belt-driven fans of input shaft power 5 KW and above.

Rubber bushed mountings with lateral deflections shall not be used on belt driven fans.

Fans with overhung impellers shall have two bearings mounted on a pedestal to which the fan casing is also rigidly attached. Fans with bearings on both sides of the impeller shall have bearer bars attached to the framework of the scroll stiffening and base. Bearings and bearer bars shall be designed to withstand any end thrust due to aerodynamic forces on the impellers.

Lubricants may be grease or oil. All lubricants used shall be mutually compatible.

Lubrication points shall be self-sealing or have captive dust caps and shall be extended to accessible positions. Oil reservoirs shall be located in positions at the same static pressure as the bearing served.

3.4.3. AXIAL FLOW FANS

Construction

Axial flow fan casings shall be of rigid construction of mild steel treated against corrosion, or aluminum alloy, stiffened and braced where necessary to minimize drumming and vibration. Casings shall be fully airtight and flanged at each end. Mounting feet shall be provided where necessary for bolting to a base or support. For in-duct mounting the length of the fan casing shall be greater than the combined length of the impellers and motors. For open inlet application a bell-mouth inlet shall be fitted. Electrical connections to the motors shall be by means of flexible conduit to an external galvanized mild steel or plastics terminal box secured to the casing.

Provision shall be made for inspection of fan impeller and motor. A removable inspection panel incorporating an air seal shall be fitted to casings 450 mm diameter and above.

Impellers shall be of steel treated against corrosion, aluminum or moulded reinforced plastics. The blades shall be securely fixed to the hub. Alternatively the blades and the hub may be formed in one piece. The hub shall be securely fixed to the shaft. Blades shall be aerofoil section. Where specified pitch adjustment facilities shall be provided.

3.4.4. IN-LINE CENTRIFUGAL AND MIXED FLOW FANS

Fan casings shall be rigidly constructed of mild steel protected against aluminum alloy and shall be stiffened and braced where necessary drumming and vibration.

Mounting feet shall be provided where specified for bolting to a base or supports.

Each inlet and outlet shall terminate in flange to BS 6339 to facilitate removal.

Stator vanes shall be of mild steel or aluminum alloy

Provision shall be made for inspection of fan impeller and motor. Casings shall have an access panel incorporating an air seal to facilitate cleaning and maintenance. A removable access panel incorporating an air seal shall be fitted to casings 450 mm diameter and above.

Fans connected at both ends to ducted systems shall have circular cross section casings which cover the overall length of the impeller, impeller hub, motor and any inlet cones and discharge straightening vanes.

Impeller shall be mild steel or aluminum with blades welded or riveted to impeller hub and shroud. Impellers with all outside diameter 500 mm or less may be die-cast aluminum with a fitted shroud.

Electrical connections to fans with direct drive motors or motors mounted inside the casing shall be through flexible conduit to an external galvanized mild steel or plastics terminal box secured to the fan casing.

Fans driven by externally mounted motors shall have twin ball or roller bearing mounted steel impeller shafts. The drives shall be so arranged to minimize air leakage and allow access to pulleys and belts.

3.4.5. PROPELLER FANS

Propeller fans shall be ring mounted or diaphragm mounted as specified. Impellers shall be of steel, aluminum or plastics and the blades shall be securely fixed to the hub, or the hub and blades shall be formed in one piece. Shafts shall be fitted with lipped slinger rings shaped to suit the fan-mounting attitude. Vertical shaft fans with the impeller mounted above motor shall be fitted with an impeller spinner with a watertight seal against the motor shaft.

3.4.6. ROOF MOUNTED FAN

The roof fan shall meet the appropriate requirements of the preceding clauses relating to fans generally and to particular types of fans. Cowls and bases shall be of materials which are resistant to the weather and solar radiation, and which are appropriate to the location of the fan. Casings shall be complete with integral weather-proofing provisions suitable for direct fixing to the building structure in accordance with the manufacturers instructions. Adequate access to electrical supply terminals and lubrication points shall be provided by means of hinged cowls, or otherwise as appropriate. Back draught dampers and/or fire release dampers shall be provided where specified.

3.4.7. FANS ACCESSORIES

3.4.7.1.1. GUARDS AND DRIVE GUARD

Guards shall comply with BS 5304 and be provided to all fan open intakes and exhausts and all forms of open power transmission systems including belt drives, drive shafts and drive couplings.

Rigid removable guards shall be installed to fully enclose indirect drive system to prevent inadvertent contact with dangerous parts of machinery. Construction and installation shall ensure strength and rigidity. It shall not be possible to remove any guard or access panel without the use of a tool.

Belt drive guards shall be of galvanized or plastic coated woven- steel wire of not less than 2.5 mm diameter attached to a rigid galvanized or plastic coated steel rod or angle framework. The mesh size and/or the location of the guard shall prevent finger penetration. Alternative construction may be from galvanized sheet steel not less than 0.8 mm thick stiffened as necessary to ensure a rigid enclosure.

PART 3 – TECHNICAL SPECIFICATIONS

Removable access panels shall be provided to permit tachometer readings to be made of motor and driven shafts and belt tension to be tested. The sizes of guards including the dimensions and locations or access panels shall provide for the extreme motor position.

For duplicate motor installation the guard provided shall be arranged to protect both drives. All fixings and mountings shall be installed to facilitate change-over of the drive

Extended fan shafts shall be protected with a galvanized steel wire mesh or sheet metal guard shaped to suit the components and removable for maintenance. Guard construction shall be as for belt drives.

3.4.7.1.2. SPEED VARIATION UNITS

Variable speed/variable torque output units shall be of the electromagnetic induction type utilizing a standard, as specified, constant speed, 415V/240V, and 50 Hz squirrel cage motor with an eddy current coupling. The output shaft rotation shall be induced by eddy currents generated in a tube assembly fitted over tow motor output shaft.

The eddy current coupling shall be maintenance free with a single, stationary excitation coil and no brush gear or center bearing. The control board shall be a single printed circuit board.

All separate items shall be fitted in enclosures to IP43 of BS 5420.

3.4.7.1.3. FREQUENCY CONVERTER

Frequency converter drives shall be suitable for use on standard squirrel cage motors as specified and be of the pulse width modulation type the control range shall be 0.5 to 120 Hz the motor name plate current shall not be exceeded on start up

Frequency Converter drives shall be capable of connection to a motor already rotating in the correct direction at any speed up to the specified maximum without breaking the motor to a standstill, and connection to motor driven fan wind milling in reverse direction without causing tripping, and resulting the fan correctly to the set conditions of speed and direction

Drives shall withstand 500 milliseconds mains interruption without causing tripping and be fully protected against any electrically induced disorders without operating fuses.

Drives shall be suitable for the local and remote control and provide means of running at a fixed (selectable) speed on closure of a remote volt-free contact, overriding the speed control reference.

Frequency Converters shall have digital display of all operating conditions and recall of design limits. These shall be key board adjustable where applicable.

Volt-free contacts shall be provided to monitor all alarm functions.

4 -20mA analogue output signal shall be provided, programmable for, but not limited to, the following:

- (1) Output frequency
- (2) Reference signal
- (3) Output current
- (4) Motor torque
- (5) Motor power

The manufacturer of the frequency inverter drive shall ensure that the inverter and motor are entirely compatible and shall provide details regarding the production of harmonics, mains borne and airborne (radiated, magnetic or electro-static) interference. Written guarantees shall be given that disturbance levels will not exceed the limits of the EEC Electromagnetic Compatibility (FMC) Standards-Frequency inverters shall comply in all respects with the relevant British and European Standards.

Switched Reluctance Type Motors

Switched reluctance motors shall be designed and be suitable for operation with advanced solid state controllers.

The motor shall have 8 pole stators and 6 pole rotors with no bars or windings on the rotor.

The motor shall have high load capacity bearings which shall be maintenance free and shall be capable of emergency braking (fail safe) without damage to any part of the motor or controller.

The controller shall be suitable for operation on 415V three-phase 50Hz $\pm 6\%$ or an alternative voltage and frequency, details to be as listed on the Equipment –Data Sheets.

The controller shall be suitable for a signal input of 4- 10 mA (20mA $\Rightarrow$ 1500rpm).

The signal shall be positive with reference to earth.

The controller shall have additional outputs for analogue and digital tachometer indication and shall have provisions to alter the acceleration and deceleration ramps 1-10 secs linear) .

3.4.7.1.4. POLE CHANGING AND DUAL WOUND MOTORS

Pole changing (for speed ratios of 2:1) and dual wound motors shall be three-phase. squirrel cage induction type, wound for the speeds required and shall comply with BS 4999. Motor characteristics shall be closely matched to the load characteristics at both speeds (e.g. for fans and pumps the motors shall be variable torque characteristics in which the power output is proportional to the square of the speed).

All motors shall be Class F Insulated. Design C Duty-type SI and Noise Grade N. Motors shall be totally enclosed to designation 1P54-IC 00 41. (Totally enclosed, frame cooled with internal fan, no external fan). If high starting torques are. required to run the load up to speed in a reasonable time then the squirrel cage

shall be deep bar or double cage type.

power factor correction capacitors shall be fitted to maintain a power factor of not less than 0.95 at full load.

3.4.7.1.5. ELECTRICAL CONNECTIONS

All coil ends and tapping connections shall be brought out to terminals in the terminal box. Terminal boxes shall be located in accordance with BS 5000 Part; 10, Clause 5, and shall be readily accessible on the side most convenient for cable entry. Separate terminal boxes or separate entry with insulated barrier shall be provided for non-power connections such as thermistors and BMS wiring Terminal boxes shall be generously sized to accommodate the appropriate number of terminations so that cable terminations can be easily made without constricting the cable. Earthing terminals shall be provided in each terminal box and all terminals, including the earth terminal, shall be complete with shell clamps, washers, lock washers and nuts.

Cable entry shall be by means of flexible conduit from an adjacent fixed terminal box or by direct termination of multi-core cables. Where flexible conduit is used a separate earth wire shall be run, preferably outside the conduit so that the integrity can be readily checked. The appropriate gland plates with glands and armour clamps shall be provided for cables.

Where cables are connected directly to motors or to any plant subject to vibration, suitable bends or loops shall be formed immediately prior to the termination in accordance with the cable manufacturer's recommendations. Sufficient slack shall be provided in cables and in flexible conduit to allow the full range of adjustment with an allowance for easy removal of the motor without straining the connections. Wiring and cable cores shall be colour coded and in addition clearly labeled in accordance with BS 4999. Rating plates corroding alloy shall be fitted to all

motors and shall require by BS 4999 plus blank space equal to one line, as plates shall be positioned where they are easily readable.

3.4.7.1.6. VIBRATION ISOLATORS

All vibration isolators shall be spring type of suitably treated and finished steel or steel alloys with rubber, neoprene or glass fiber acoustic pads to suit the application fixed to both the machine and support frame to prevent high frequency transmissions.

The ratio of lateral to vertical stiffness shall be at least 1.2 times the ratio of static deflection to working height.

Isolators with static deflection exceeding 50 mm or fitted to long units shall have dampers or snubbers to prevent excessive movement speed passes through the resonant frequency of the mounting system.

3.4.7.1.7. COWLS FOR ROOF MOUNTED FANS AND INTAKES AND OUTLETS

Each cowl shall be designed to handle the scheduled air quantity and directions and velocity of discharge or intake shall be those specified. The loss of total pressure through the cowl (including the discharge velocity pressure and any losses due to bird guards and back draught dampers) shall not exceed the value specified at the design air volume. This loss shall be added to the system resistance in the determination of the fan duty. Cowls shall be manufactured from stainless steel sheet. They shall be assembled with fittings, fixings, nuts, bolts, washers and other similar items manufactured from compatible and non-corroding materials, selected to allow for any contaminants handled.

'Roof mounted discharge cowls shall discharge vertically (upwards or downwards), or if mounted at roof slopes less than 30°C, in the corresponding directions perpendicular to the slope-Roof mounted intake cowls shall have inlets which face directly at the roof surface or a continuous inlet around the perimeter which faces the roof at an angle not exceeding 45° .

Cowls which discharge humidity or contaminated air from ducted system shall be so constructed that an airtight joint can be made between the throat of the cowl and tile duct. The throat and the discharge space under the weathering cap shall be separated from any internal voids in the cowl and the space between the weathering skirt and throat.

Backdraught dampers shall be fitted to all discharge cowls and shall be suitable for the type and conditions of the gases handled. Automatically controlled openings shall be provided where specified. The dampers shall be rigid, and substantially airtight when closed. Construction shall be in accordance with this Specification. Back draught dampers on vertical discharge cowls shall be protected from cross winds by an external weather-shield. The height of the weather-shield shall be at least 25 mm greater than the open height of the dampers. The dampers shall be a rain roof when closed. Damper hinges shall be positioned outside the perimeter of the discharge jet or shall be positioned over a gutter which drains to the outside of the cowl. The damper blades shall overlap their seating and have lipped edges.

Bird guards with 12-15 mm mesh shall be fitted at all intake cowls. Automatically controlled back draught dampers shall be fitted where specified.

Cowls for roof mounted centrifugal and mixed flow extract fans shall be designed to limit the change of direction of airflow between the impeller discharge and the cowl discharge to an angle not exceeding 105° in a radial plane.

The discharge (or intake) cap of cowls for axial flow roof mounted fan units shall be circular in plan of the distance between the fan impeller and the lower edge of the discharge (or intake)

cap is less than one impeller diameter, the cap shall be fitted with an internal core which gives a smooth 180° change in direction of airflow.

The throat and diaphragm plate of roof mounted propeller fan units shall be dimensioned to meet the requirements of the fan manufacturer, including the optimum relative positioning of diaphragm plate and impeller.

The exterior shape and fixing arrangements of cowls shall be suitable for the wind speed and type of roof.

Kerb mounted cowls shall have a weathering skirt at least 75mm deep which weathers the junctions between the cowl and the kerb seating, the skirt shall not be the fixing member. The cowls shall be suitable for a kerb and up stand with a total height above roof level not less than 150 mm. The fixing may be to the kerb or roof structure.

Purlin mounted cowls shall have a skirt at least 75 mm deep suitable for weathering the overlap of a soaker sheet up stand and the cowl throat. The cowls shall be fixed to purlins or purlin trimmers and the weight of the cowl shall be distributed over the upper surface of the purlin and/or trimmers by flanged inlet to the cowl throats. The length of a cowl's throat shall be suitable to the depth of roof structure including at least 75 mm clearance between the skirt and any part of the roof surface.

Soaker sheets shall match the form and colour of the roof surface. Soaker sheet shall have an end lap not less than 150 mm and side laps equivalent to 1 1/2 corrugation or the corresponding standard laps for the roofing surface which the cowl penetrates.

3.5. CONTROL DAMPERS

3.5.1. ISOLATION, DAMPERS

Plain blade isolating dampers shall have position indicator, and spindle ends slotted position a quadrant with a locking device and parallel with the blade to indicate blade.

3.5.2. DAMPER INSTALLATION

Multiple frames shall be used for damper requirements in excess of 300 mm width and /over 200 mm height

Automatic controls and regulating dampers in ductwork systems shall be provided,

Automatic controls dampers shall be fitted with a galvanized mild steel mounting plate rigidly fixed to the casing to support the actuator

Multileaf dampers shall be double skin bladed of stainless steel sheet 0.7mm minimum thickness and be arranged for opposed blade operation unless otherwise Bearings requiring lubrication shall be accessible.

Linkages shall be sufficiently robust to transmit motion to the blades simultaneously leakage from spindles penetrations shall be prevented by side seals.

Damper casings shall be of stainless steel or galvanized mild steel sheet 2.0 mm minimum thickness of length to extend beyond the blade swing, and formed into a channel section to provide a rigid assembly. Formed flanges shall be drilled to match adjacent connecting flanges and extend to

protect the external blade linkage system. Drilled holes shall be edge-painted with zinc-rich paint immediately after cutting.

Balancing dampers shall be fitted in each branch from a main or sub-main duct, and elsewhere as specified. The required distance from the branch-piece shall be maintained.

3.5.3. CONTROLLING DAMPERS FOR BLOWERS ROOM

When it is cold outside the damper 02 is open. Damper 01 and Damper 03 are closed.

When the temperature in the blower room will increase above 24° C the damper 02 start to close and the dampers 01 and damper 03 starts to open in order to increase the ventilation in the room and keep the temperature on 24° C.

When the damper 02 is totally closed and the damper 01 and damper 03 are quite open and the temperature still wants to increase over 33° C. The Extract Fan starts and damper 04 close. When the temperature will decrease below 24° C the dampers starts to regulate temperature.

3.5.4. MIXING SECTION AND DAMPERS

Dumper framework shall be constructed from 6mm thick rigid PVC extrusions suitably welded together to form a rigid assembly without deflection under all operating conditions. Damper section sizes shall be a maximum of 1500 in x 1500mm to prevent blade and frame deflection. One side of the frame shall be secured

with nylon bolts to allow easy removal for access and maintenance, and easy withdrawal of damper blades.

Mixing box dampers shall be constructed using a number of small dampers suitably connected together to form a composite damper of suitable size for the volume specified.

Damper shall operate with opposed blade action. Blades shall be 25 micrometer anodized aluminum suitable sealed and internally (filled) insulated. Spindles shall be carried in nylon bushes.

Damper blade motion transmission shall be achieved by ABS gear wheels having purpose-made protection shields at both ends. All mounting plates, fixings and actuators shall be supplied and fixed by the back aged unit manufacturer. Wherever possible, damper actuators shall be fitted externally to the unit. Where this is not possible, totally enclosed actuators shall be used.

3.6. AIR FILTRATION

Written Certification of filter efficiency in accordance with the appropriate requirements of BS 6540 shall be provided.

Provision shall be made for full access to all filters for media changing, inspection and general maintenance.

Filter installations shall be complete with an external differential pressure indicating manometer mounted adjacent to the filter bank. Clean and Change Filter indicators shall be fitted.

Filter media and frames shall meet the Local Authority and the appropriate fire Authority's fire and smoke requirements and the requirements of BS 5588:part9,BS 476: part 4 for non-combustibility and BS 8313. Each filter bank shall be housed in a metal frame-All filters shall be provided with metal fixing frames, which shall be treated to prevent corrosion

The following materials are excluded from filter composition:

(1) Material which are generally composed of mineral fibers, either man-made or naturally occurring, which have, a diameter of three microns or less or which contain any fibers not sealed or otherwise stabilized for prevention of migration

(2) Any substances generally know to be deleterious at the time of use.

3.6.1. PANEL FILTERS

Filter banks shall be made up from a number of individual cells of panels of uniform size, retained in a purpose-made steel or aluminum framework by positive action spring clips. Joints in tile frame sections shall be welded or riveted, and individual frames shall be bolted together to form the complete filter bank assembly in a manner or prevent by pass of air. Filter frames shall be suitable for connection to builders work frames, fixing in sheet steel cased air handling plats or suitable ductwork sections.

Filter panels shall be suitably reinforced to prevent rupture, and be securely held in cells or frames by spring clips and clamps.

3.6.2. POCKET/BAG TYPE FILTERS

Pockets/flags shall be formed from woven glass fiber cloths, in multiple layers and grades, properly Stitched and sealed or shall be formed from synthetic non-fibrous) material Pockets/bags shall be reinforced as necessary to prevent rupture, and securely held in cells or frames by spring clips and clamps.

The opening of each pocket/bag shall be bonded to a rigid metal frame to fit into the filter bank-retaining framework.

Each ceil shall be provided with an effective perimeter gasket to prevent air bypass. Pocket/Bags shall remain fully inflated to expose maximum filter surfaces at air

velocities related to system design duty. Filter cells formrig a multiple unit bank shall fit into a framework, of some supply, suitable for fixing into a ductwork system . Filter cells shall be completely accessible for inspection and replacement.

3.6.3. SAND TRAP LOUVRES (GRILLS)

Sand trap louvres shall be provided to units as specified to remove heavy particulate contamination from air, acting as a gravity filler.

Louvre blades shall be fabricated from 1 .6 mm mild steel sheets treated to resist corrosion and erosion. Cases shall be of 2.0 mm mild steel, protected as for louver blades.

Louvre blades shall be formed into channel sections and mounted vertically in the case.

Each louvre shall have two rows of blades in offset formation to induce airflow to change direction.

The bottom of the case shall be provided with sand drain holes.

Multiple height cells shall be arranged with a sand chute at transoms to discharge particulate matter from upper cells clear of lower cells.

Louvres shall be arranged for bolting into a structural opening, to intermediate transoms or connecting to an air handling unit.

3.6.4. INSTALLATION OF DUCTWORK

The installation of ductwork shall follow the details set out in the accompanying Tender Drawings and be in accordance with the best accepted English or American practices.

The Drawings are diagramatic and all contractors shop drawings shall be submitted to the Engineer for approval prior to manufacturing taking place.

All ductwork shall be adequately supported on hangers and / or brackets, according to position, to permit free movement of the ducts due to expansion or contraction and to permit application of insulation .

Ducts shall be positioned and spaced in relation to one another, in the building structure so as not to interfere with any other services and to allow for the required thickness of insulation as specified elsewhere .

All ductwork, silencers, dampers, louvers, grilles, diffusers and all other duct mounted equipment and components shall be erected and connected to all equipment as shown on the Air Ventilation Drawings .

All ducting systems shall be installed to a high standard and when complete shall be rigid and free from any sway, true-to-size, accurately lined up and completely sealed to limit air leakage rates to an acceptable minimum as detailed within SMACNA and ASHRAE standards.

All ducts emerging from the building shall be completely draught proof and watertight with suitable purpose made weathering .

All open ends of ducting left during erection shall be covered, to prevent entry of dust and debris, by means of hessian or stout bitumen backed paper, securely tied into position .

All ductwork shall be blown through by running the fan prior to finally fitting the grilles, and filters and the interior thoroughly wiped out with damp cloths by reaching as far possible into available openings .

All ducts passing through non-fire rated floors, walls or partitions shall have the space around the duct packed and sealed with mineral wool or other material acceptable to the Engineer. The space between the duct and the buildings element shall not exceed 20mm. maximum.

Sealing around fire dampers shall be made with materials approved by the relevant department of the local authorities .

Sleeves in walls and partitions through which ducts pass shall not be used as duct supports .

Duct runs shall be erected on the supports provided and aligned, prior to connection to items of equipment to present a neat and workmanlike appearance with allowance made for all clearances for insulation, etc., and other adjacent services .

Ducts shall be installed parallel to the building structure, plumb where vertical and arranged to present a coordinated and acceptable appearance .

Ducts supports shall be securely anchored to the building structure in an approved manner and installed completely free from vibration under all conditions of operation . Vertical ducts shall be supported at each floor and at intermediate positions as required .

Particular regard must be paid to the prevention of duct movement, preventing consequent noise, potential leakage and strain upon flexible connections. To this end, separation of metallic surfaces shall be provided by flexible packing material and particular attention shall be paid to the interposition of auxiliary flexible joints and anchoring supports, along duct runs.

3.6.5. STAINLESS STEEL DUCTWORK

The duct work shall be constructed from Stainless steel sheet accordance to B.S. accordance, 'Low and High Velocity / Pressure Air Systems , for Rectangular Circular and Spiral Wound

PART 3 – TECHNICAL SPECIFICATIONS

Ductwork, as published by the Heating and Ventilating Contractors Association, with the following exceptions :

The nominal sheet thickness of the ductwork shall increased to the thickness shown below. No ductwork shall be constructed from sheets less than 0.8mm (22.b.g.) .

a. TABLE A : Rectangular Ducts – Low Pressure

DUCT SIZE (Longer Side)	NOMINAL SHEET THICKNESS mm
UP to 400mm.	0.7
401 mm. to 600mm.	0.8
601 mm. to 800mm.	1.0
801 mm. to 1000mm.	1.0
1001 mm. to 1500mm.	1.0
1501 mm. to 2500mm.	1.2
2501 mm. to 3000mm.	1.6

All ducts over 400 mm. longer side shall be stiffened by beading at 300mm centers or cross breaking at not more than 1220mm spacing. Ducts above 800mm longer side to have transverse joints flanged, with maximum spacing of 2000mm.

b. TABLE B : Rectangular Ducts – High Velocity

Max. (Nominal Diameter)-mm	Min. Sheet Thickness- mm
205	0.8
762	1.0
914	1.0
1020	1.2
1525	1.2

c. TABLE C : Plant Connections – All Plant

Duct Size (Longer Side)	NOMINAL SHEET THICKNESS mm
UP to 800mm.	1.6
801mm.to 1000mm.	1.6
1001mm.to 2250mm	1.6
2251mm.to 3000mm	2.0

All low velocity ductwork shall generally be rectangular section, expect where indicated .

PART 3 – TECHNICAL SPECIFICATIONS

Longitudinal joints are to be either lock-seamed (and in all cases the edge of the seam is to be dressed down flush with duct to ensure an airtight joint) or snap lock joints. A suitable thinner, be foreland. Seams should not be visible from below. Transverse joints shall be flanged throughout, or jointed .

Stainless steel angle flanges shall be not less 25× 25mm. section, to be solid welded at four corners, with sheered hexagon head bolts and nuts .

The overall length of the Stainless steel duct should exceed by 13mm. or 19mm. the dimension over the angles, thereby allowing the material to be edged over the angle iron flange on each of its four sides by 12mm or 6mm. respectively.

All ducts through walls shall have an angle iron masking flange attached to each inside of wall. Where ducts terminate in a building duct in wall, the 'lead in' to terminate shall be a swept branch or bend with wall spigot and angle iron masking flanges shall be screwed to the wall, ceiling or floor, depending on the position of these, with sufficient clearance to allow slight movement of ductwork .

Slip joints shall not be less than 50mm. long with corners tapered, cutting or notching to achieve this taper shall be made good by welding , All slip joints should be made to lap in the direction of air flow and suitable sealing compound shall be applied in making these joints to prevent air leakage .

Where 'pop' rivets are used (which must always occur if the joint is under tension), these shall be of the 'Imex' sealed type .

Solid rivets shall be of the type suitably treated to resist corrosion and shall be inserted so that the rivet head is on the inside of the duct . Sharp edges or corners on ductwork and angles will not be permitted. After fabrication, all cut edges and bare metal shall be painted with approved zinc rich paint before being transported to site. Any adjustments or modifications made on Site shall also be similarly treated .

Each length of ducting shall be in one piece i.e. no riveted joints to occur between angle flanges. Ducts to be in 1830mm. minimum lengths, except where bends or branches occur.

All ductwork throughout shall be adequately stiffened to prevent drumming.

Internal stiffening will not be permitted. Stainless steel angles used as flanges or stiffeners shall be fixed to the duct by one of the following:-

- Mechanical closed rivets or bolts at 150mm. pitch.
- Spot welds at 75mm. pitch.

Angle flanges or joints shall be bolted together at 100mm. maximum pitch and fixing bolts shall be provided at each corner, angle size . Bolt sizes shall be as follows:-

25	×	25	mm.	angle	8	mm.	bolts
30	×	30	mm.	angle	8	mm.	bolts
40	×	40	mm.	angle	10	mm.	bolts
50	×	50	mm.	angle	10	mm.	bolts

The joints shall be made using suitable cord sealing compound inserted between flanges to ensure air tightness of joint.

High velocity ductwork shall be jointed by using proprietary heat shrink bands.

Provision shall be made in the main and branch ducts and adjacent all items of plant for testing air flow by means of flow meter.

Such provision shall include the forming of a series of holes in the ductwork to suit the test instrument and arranged as shown in B.S.848, 1980, Part 1. The series of holes in each case shall be suitably covered with Stainless steel cover plates, having rubber gaskets, and fixed to the ductwork with 6mm set screws and wing nuts. The screws shall be fixed permanently to the ductwork and removal of the cover plate shall be effected by removal of the wing nuts only.

Before any plant is put into commission, the ductwork shall be thoroughly cleaned to the satisfaction of the Engineer.

3.6.6. DUCTWORK FITTINGS

Fittings on ductwork shall be installed as follows:-

1) Supports :

Ductwork supports for insulated ducts shall be as detailed in shop drawings, incorporation a rigid insulator between the – support and ductwork. With the insulation vapour seal being continuums through the insulator support and not over the bracketing.

2) Access Doors :

Access doors shall be of double skin construction incorporating 40mm thick isocyanurate foam insulation, secured into a frame in the duct by hand – operated cam latches seated on a rubber gasket. The doors shall be installed proud from the ductwork with the insulation abutted and secured with 0.8 mm thick aluminum angles with mitered corners.

3) Specialized Fittings :-

Where test holes, damper arms, thermostats, etc., are installed in the ductwork, the insulation shall be trimmed to give access and edges shall be vapour sealed and protected from mechanical damage.

4) Flexible Connections :

Ductwork flexible connections to, all fans, Fan Coil Units etc., where a continuation of a vapour seal is required shall be insulated with glass fiber flexible duct insulation, free from short and coarse fibers, bounded with resin and faced with glass fiber reinforced aluminum foil/Kraft paper laminate. The insulation material shall have a thickness of 40 mm. in plant rooms and 40 mm. in ceiling voids etc., The insulation shall be arranged to be easily removable and joints shall be sealed with 100 mm. wide glass reinforced self-adhesive aluminum foil tape to form a vapour seal.

3.6.7. DUCTWORK BRACKETS

Other than specific details being indicated on the shop Drawing, the bracketing shall be of galvanized steel sections and shall be as follows:-

3.6.8. HORIZONTAL DUCTWORK

All ductwork shall be adequately supported by flat mild, steel band strips or mild steel angle bearers and rods. The rods shall terminate to the structure in one of the following manners.

On a solid structure, channel iron rawbolted to same, including holes to accept threaded rods, which will be attached to the structure by nuts and hemispherical washers .

On steelwork, angle iron clips to be fitted across the whole flange and extended beyond the flange. A hole in the extension piece will allow the threaded rod to pass and be attached as above.

On open type steelwork, 2 angle iron sectors placed back to back securely bolted, complete with nuts and washers at maximum spacing of 0.5m with minimum of 2 fixings.

To prevent vibration and drumming, an incompressible insulator shall be sandwiched between the bracket and duct contact face.

3.6.9. VERTICAL DUCTWORK

This shall be supported by cantilever brackets at shop drawing.

Where they are fixed to walls, not less than 150mm. washer plates on the back of the wall and rods shall be fitted. The plates shall be not less than 250mm. in length and shall be of equal width and thickness to the cantilever bracket material .

3.6.10. TESTING THE DUCTWORK

In the course of erection, where the ductwork is being insulated, sealed in roof spaces, or where close to walls, etc. and on completion, this shall be tested with smoke pellets to ensure the air tightness of all joints or any other method being currently used or as directed by the Engineer. All ductwork shall be tested as detailed in HVAC systems.

The Contractor shall include for balancing all control dampers, grilles, volume dampers, etc. to ensure that the circuit plant or equipment is operating with the correct performance temperature, pressure and flow rates in accordance with the performance schedules and system design .

The Contractor shall include for providing a schedule setting out the design pressures and flow rates and actual final commissioning pressure and flow rates, together with all damper and grille settings.

In addition, on ductwork systems, smoke pellets shall be used to demonstrate the air flow pattern in all rooms and pressure and flow shall be recorded and all dampers shall be locked securely in their positions and a wire and lead seal affixed.

Care must be taken in selecting smoke pellets to see that are used in accordance with the manufactures – instructions and that they are suitable for the environment to which the ductwork is supplying or extracting air.

4. AIR CONDITIONING UNITS

4.1. GENERAL

This section should be read in conjunction with all the other relevant sections of the specification and in particular those relating to electrical and mechanical works.

The following equipment shall be provided:

N°	Type	Service	Capacity / Dimensions
402-AC-001	Air conditioning unit	ambient air	100 m3/h, 10oC cooling
400-AC-001	Air conditioning unit Room 1	ambient air	100 m3/h, 10oC cooling
400-AC-002	Air conditioning unit Room 2	ambient air	100 m3/h, 10oC cooling
200-AC-001	Air conditioning unit for electrical room	ambient air	100 m3/h, 10oC cooling

4.2. MINI-SPLIT UNITS

Each split unit shall consist of two parts assembled, tested and ready for operation:

- An outdoor condensing unit
- A decorative type indoor fan - coil unit

The two parts shall be connected together with quick connections recharged and reinsulated refrigerant piping.

All split units to be used shall be used for cooling and heating.

4.2.1. OUTDOORS UNIT

The outdoor condensing unit shall be located as per drawings and shall contain sufficient refrigerant (R-22) for the complete system and shall be equipped with refrigerant line fittings. Brass service valves shall be located at the exterior of the unit. The compressor shall be of the welded hermetic type rotary/reciprocating with internal vibration isolations and shall be located in an isolated compartment of the unit to reduce the noise level. The compressor shall be equipped with safety devices like crankcase heater, thermal and current sensitive overload devices and low-pressure cutout switch. The condenser coil shall be constructed of aluminium fins mechanically bonded to copper tubing. Condenser fan shall be direct driven propeller type and arranged for either horizontal or vertical discharge. Fan hub shall be designed to protect motor shaft, bearing and winding. Fan motor shall be factory lubricated and inherently protected. The whole unit shall be housed in a weatherproof cabinet.

4.2.2. INDOOR UNIT

The indoor unit shall be exposed decorative type calling suspended/wall/floor mounted according to the drawings and Consultant's approval. The unit shall be fabricated from galvanised steel sheet and shall be internally insulated. The cabinet shall be pre-printed with baked enamel paint and provided with adjustable plastic grilles. The fan shall be centrifugal, direct driven, double inlet type with two impellers. The impellers and scrolls shall be made in shockproof material to guarantee maximum stability during transport and installation. The impeller shall be having airfoil blades.

The motor shall be permanent split capacitor type single phase and shall be totally enclosed. The unit shall be complete with remote control kit consisting mainly of three speeds and off switch and a thermostat.

5. COMPRESSED AIR SUPPLY SYSTEM

The supplier/manufacturer will supply pneumatic air supply system complete with all necessary items to ensure that it is fully functional and meets the principal needs. In addition the Contractor shall provide all supporting documentation and installation manuals.

The compressors shall be equipped with the following

- Air storage vessel (accordance to BS 487, Part 1 Class III or equal.)
- Air filters (accordance to BS 2831, or equal.)
- Air dryers (Minimum capacity 10 L/s.)
- Pressure regulators (inlet pressure up to 10 bar at 24° C) , Standard downstream set pressure range (0.35 to 9 bar).
- Pressure gauges (accordance to BS 1780, or equal.)
 - Pressure switches (Ratings : 2HP @ 240 VAC / 1HP @ 120 VAC / 21 AMPS @ 250 VAC).
 - Isolation valves (accordance to BS 3643 or equal.)
 - Safety valves (accordance to BS 1123, or equal.)
- Non return valves (Spring type stainless steel body, designed to withstand pressure up to 140 bar hydrostatic pressure, 10 bar working pressure ,Temperature use range from sub -2 to 120 °C)

All pipings connected to the compressors shall be equipped with the following :-

- Isolation valve
- Open/closed and pneumatic valves at each branch for or maintenance units.
- Condensate traps.
- Automatic oil adding units.
- Quick release coupling.
- Blower guns with plastic hose for cleaning purpose.
- Pressure regulating valve
- Pressure gauge

5.1. AIR COMPRESSORS

Equipment ID	102-BL-001
Manufacture & type:	Oil free compressor type, reciprocating compressor.
Quantity:	1 nos.
Location:	Screenings area (outdoors)
Capacity:	Pressure 8 bar, tank volume 50 L. capacity 3 L/S free emitted air quantity.
Media:	Air.
Purpose	Air purge of solids accumulated in screening channel
Cooling Dryers:	Minimum capacity 3 L/s.
Electrical Power	400 V, 3-phase, 50 Hz electrical motor.

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Accessories:	bottom plate with silencing cover
	Liquid removing filter
Maximum noise:	70 dBA, measured 1 m from equipment

Equipment ID	105-BL-501
Manufacture & type:	Oil free compressor type, manufacture Atlas Copco LF 75-10 UV2250S or any other equivalent product reciprocating compressor.
Quantity:	1 nos.
Location:	Sedimentation Tank gallery (indoors)
Capacity:	Pressure 10 bar, tank volume 250 L. capacity 14.4 L/S free emitted air quantity.
Media:	Air.
Purpose	Air actuation of automatic sludge withdrawal valve
Cooling Dryers:	Minimum capacity 10 L/s.
Electrical Power	400 V, 3-phase, 50 Hz electrical motor.
Accessories:	bottom plate with silencing cover
	Liquid removing filter
Maximum noise:	70 dBA, measured 1 m from equipment

5.2. AIR DRYER

Compressed air dryer shall remove moisture, water, oil, solid air particles and other contaminants for compressed air.

It shall have the following features :-

- Cooling Dryers Minimum capacity 3 L/s.
- Max. working pressure : 10 bar
- Pressure drop: 0.2 bar
- Made of Heavy duty aluminum casting
- Two polypropylene coalescer elements at inlet and outlet ports to absorb oil and all solid air particles
- Replaceable self-contained desiccant cartridges to absorb water and condensation from compressed air system.
- Air pressure gauges, safety relief valve and ball valve .
- Automatic timer drain
- Temperature and moisture indicator.

5.3. COMPRESSED AIR FILTER :-

- Efficiency rate 99.99 % for 0.01 µm particles and droplets, oil, water and solids from compressed air
- Flow range : Minimum capacity 10 L/s
- Made of anodized aluminum and stainless steel

5.4. PRESSURE GAUGE

Manufacture/type:	ABB or any other equivalent
Media:	Air
Signal:	4-20 mA
Measuring range:	0- 10 Bar
Limit of error:	Maximum +1%

5.5. PRESSURE SWITCH

Manufacture/type:	IFM electronic or any other equivalent
Media:	Air
Measuring range:	0- 10 Bar
Limit of error:	Maximum +1%

SECTION 15 570

BIOLOGICAL NATURAL SUBSTRATUM ODOUR TREATMENT

1. GENERAL

1.1. WORK INCLUDED

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of odour control system, namely biological odour treatment system.

To reduce odor on the site, a biological treatment of foul air shall be installed. These devices shall treat the air from the dewatering units, liming room, foul water sumps and sludge storage tanks.

2 polypropylene tanks filled with porous surface substrate set (mineral substrate, peat or shredded wood are generally used) shall be installed:

- one in the solids building to treat the foul air coming from the sludge handling (dewatering units, liming room, foul water sumps),
- one installed outside on a concrete slab, treating the air from the sludge storage and foul water sump in the Areas 103 and 105.

One ventilator per tank and a set of air regulating valves shall ensure the air is extracted from each zone. The ventilators shall be installed indoors in the vicinity of the biofilter tank.

For the unit installed outdoors (area 103-105), proper operation during freezing periods shall be ensured by installing an air heater downstream of the fan to maintain the air temperature at 25° C during winter operation, as the treatment loses its efficiency below 15 ° C. During these freezing periods, the extraction fan shall have the capacity to operate at a reduced speed at 4 air changes per hour instead of 6.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection;
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;
- E. Section 14100 – Pipes and fittings;

1.2.2. WORK UNDER THIS SECTION SHALL BE-COORDINATE WITH:

- A.** Concrete work
- B.** Section 15550 – HVAC
- C.** Electrical works

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Identification number	206-TK-001
Type	Filter in polypropylene for indoor installation
Number	1
Dimensions:	
- Length	6 m
- Width	2,6 m
- Depth of filter bed	2 m
Biological substrate bed	
Type:	Granular peat or lignocellulose medium OR Mineral porous granular substrate
Media volume :	16 m3
Foul Air flow :	8600 m3/h
Spray water flow :	4 m3/h (part time)
Accessories	
2 inlet pipes per filter with valve	
1 decanted water pulverization line per filter with solenoid valve	

Identification number	300-TK-001
Type	Filter in polypropylene for outdoor installation
Number	1
Dimensions:	
- Length	2,9 m
- Width	2 m
- Depth of filter bed	2 m
Foul Air flow :	3100 m3/h Reduced to 2 100 m3/h when freezing conditions
Spray water flow :	4 m3/h (part time)
Biological substrate bed	
Type:	Granular peat or lignocellulose medium OR Mineral porous granular substrate
Media volume :	6 m3
Accessories	
2 inlet pipes per filter with valve	
1 decanted water pulverization line per filter with solenoid valve	

The installation is designed to handle problems of odours for both operating staff inside the works and for the public outside.

The installation shall be connected electrically and electronically to all other structures and shall operate in local/remote and manual/automatic modes. In normal operation, the entire installation (apart from nutrient injection) is controlled automatically.

Air extracted from the premises shall pass in succession through one or more:

- supply flues,
- biological substrate boxes,
- outlets to the atmosphere, adapted to the structure.

The equipment to be installed shall include, amongst other things:

- spray boom with supply pumps and fibreglass-reinforced polyester pipes,
- a grating system to support the biological substrate,
- .a system for spraying the biological filter, consisting of sprinklers, pumps and HDPE pipes,
- a drainage system.

The assembly is designed to make operation easy. In particular, the humidifiers and spray booms shall be easy to dismantle, sprinkler nozzles shall be made of metal and removable, sprinklers shall be accessible without having to empty the substrate. Easy-to-open, watertight manholes provide easy access to the humidifying towers and flues.

For the unit installed outdoors, the decanted water pipes for spraying the filter shall be heat traced where exposed to ambient air.

1.4. QUALITY ASSURANCE

1.4.1. DESIGN CRITERIA

The following criteria shall be respected regarding the choice of medium material:

- Maximum speed on the biological filter of 550 m/h,
- Maximum split time of 7s.
- Head loss of the bed less than 100mm of water column.
- Maximum air volume not more than 120 Nm³/h per cubic meter of medium material
- Minimum lifetime of the medium: 5 years

1.4.2. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.

2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.

3. Workshop inspections and tests:

c) The seals and the embedded parts shall be presented separately and unpainted for checking.

d) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

e) Welds:

Refer to Section 01020 – Basic mechanical requirements

1.5. SUBMITTALS

The supplier should submit the following documents (non-exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts

4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

1.6. DIMENSION TOLERANCES

The requirements of Section 01020 – Basic mechanical requirements – will apply.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

2.1.1. BIOLOGICAL SUBSTRATE BEDS

Type of substrate: granular peat and fibrous lignocellulose medium.

Supports: self-supporting beams and cleats made of 316L stainless steel grating.

2.1.2. FILTER SPRAYING

The spraying system shall include the following in particular:

- A flow rate meter/accumulating meter
- Fine droplet sprinklers with stainless steel nozzles
- HDPE pipes complying with the specifications of Section 14100 – Pipes and fittings
- Locks, bolts and attachments: 314 L stainless steel or inert materials

The spraying system is triggered automatically when the relative humidity falls below a set value and by a timer.

2.1.3. INSTRUMENTATION

NH₃ and H₂S sensor shall be provided in each filter upstream of the surge shaft.

A head loss sensor shall be provided in each filter.

2.1.4. DRAINAGE

A pit will collect all the water coming from the humidifier and from the medium material. Collecting pipes and pit will have an easy access. A pump will be fitted in the pit for exhausting water up to the inlet of the secondary treatment basins; the pump will manually and automatically be controlled.

2.2. SPARE PARTS AND SPECIAL TOOLS

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2. GENERAL

The filter substrate shall be placed for the first time in normal operating conditions. An acceptance report shall be drawn up.

The filter medium is installed in such a way that it can be renewed regularly and easily. It shall be renewed from (or to) a machine by means of watertight devices (trap doors, chutes, etc.) to be provided by the Contractor and installed in the civil works if necessary. Substrate shall be transferred from the machine to the filter bed (and vice versa) automatically.

The Contractor shall provide a detailed description of the filter medium renewal method in his bid.

3.3. FIELD QUALITY CONTROL

3.3.1. INSPECTIONS BEFORE AND AFTER CONCRETING

1. The following inspections shall be carried out before and after concreting:

f) Equipment position

g) Flatness, verticality, horizontality of the embedded parts,

2. Erection tolerances:

Refer to Section 01020.

3.3.2. DRY TESTS

All no-load tests are recorded and an acceptance report drawn up.

During these tests, vibrations, temperature increasing and noise shall particularly be checked.

3.3.3. COMMISSIONING TESTS

Treatment quality shall be checked in accordance with applicable regulations.

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SECTION 15 800

WASTE SKIPS

1. GENERAL

1.1. WORK INCLUDED

1.1.1. SCOPE OF SUPPLY

The Contractor shall supply identical waste skips at all locations where waste skips are required.

1.2. RELATED WORK

1.2.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A.** Section 01000 - General requirements;
- B.** Section 01010 - Corrosion protection;
- C.** Section 01020 - Basic mechanical requirements;

1.2.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A.** Section 11 301 Coarse Screening
- B.** Section 11 305 Fine Screening
- C.** Section 14 410 Screw conveyors

1.3. SYSTEM DESCRIPTION, CHARACTERISTICS AND OPERATING CONDITIONS

1.3.1. DESCRIPTION

Skips for Screenings

Equipment numbers:	101-SK-001/002, 102-SK-001/002
Type:	Skip with mobile cover
Model & Manufacturer::	TL 25 m3 from Eurobenne or equivalent
Number:	4
Location:	Outdoors– Screening
Capacity:	25 m3

PART 3 – TECHNICAL SPECIFICATIONS

Materials:	Steel with epoxy painting
Accessories:	
Watertight hinged back flap for discharging	
Drapery in plastic tarpaulin for skip covering	
2 rails for guidance of the skip, integrated in the bottom floor	
Thrust block (stop) for skip	

Skips for Dewatered Sludge

Equipment numbers:	204-SK-001/002/003/004/005/006
Type:	Skip with mobile cover
Model & Manufacturer::	TL 25 m3 from Eurobenne or equivalent
Number:	6
Location:	Outdoors– Sludge disposal
Capacity:	25 m3
Materials:	Steel with epoxy painting
Accessories:	
Watertight hinged back flap for discharging	
Drapery in plastic tarpaulin for skip covering	
2 rails for guidance of the skip, integrated in the bottom floor	
Thrust block (stop) for skip	

Skips for Grit

Identification numbers:	103-SK-511/512/513
Type:	Skip with mobile cover
Model & Manufacturer::	TL 25 m3 from Eurobenne or equivalent
Number:	3
Location:	Outdoors– Grit Removal
Capacity:	25 m3
Materials:	Steel with epoxy painting
Accessories:	
Watertight hinged back flap for discharging	
Drapery in plastic tarpaulin for skip covering	
2 rails for guidance of the skip, integrated in the bottom floor	
Thrust block (stop) for skip	

Skips for Grease removal

PART 3 – TECHNICAL SPECIFICATIONS

Equipment numbers:	103-SK/501-502
Type:	Skip with mobile cover
Model & Manufacturer::	TL 25 m3 from Eurobenne or equivalent
Number:	2
Location:	Outdoors– Grease Removal
Capacity:	25 m3
Materials:	Steel with epoxy painting
Accessories:	
No back flap (discharge by suction truck)	
Siphoid separation for grease concentration to be welded in place	
Drapery in plastic tarpaulin for skip covering	
2 rails for guidance of the skip, integrated in the bottom floor	
Thrust block (stop) for skip	

1.3.2. OPERATING CONDITIONS

The skips shall be design to be lifted on a transport truck for transport to the landfill. The transport truck shall be provided by the Operator.

The contractor shall provide the Operator with the data sheet of the skips provided to ensure compatibility with the truck prior to purchase by the Operator.

1.3.3. CONTROL AND MONITORING

Not applicable

1.4. QUALITY ASSURANCE

1.4.1. SHOP TESTS AND INSPECTION

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
 - a) Welds: Refer to Section 01020.

1.5. SUBMITTALS

The supplier should submit the following documents (non exhaustive list):

1. Shop drawing of the grease concentration skips showing the siphoid separation for onsite welding.

2. Manufacturer datasheet of the skip, including exterior dimensions, weight and material.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. FABRICATION

The minimum thickness of the walls and bottom shall be 4 mm.

Backfold of 300 mm in front and 800 mm in the back.

The hinged door on the back of the skip shall include the following options:

- Integrated lubrication device on the hinges
- Neoprene watertight seal 30 x 30
- Lateral closing with tensioning ratchet

The following accessories shall be included:

- Ladder on the side
- Ringed back rollers
- Front Lifting ring for hydraulic arm lifting by transport truck
- Lateral rolling cover for closing during transport or when full, with small platform for operator access to the crankset and tensioning ratchet

The following coating requirements shall be met in addition to any other requirements under Section 01010-Corrosion Protection:

- Anti-rust treatment inside and outside
- Inside coating for corrosion protection to lime, ammoniac and other aggressive chemicals.
- Glazed finish painting inside and outside.

2.2. DIMENSION TOLERANCES

Not applicable

2.3. SPARE PARTS AND SPECIAL TOOLS

Not applicable

3. EXECUTION

3.1. INSPECTION BEFORE ERECTION

The two rails installed on the concrete slab to guide the back rollers of the skip shall be parallel.

3.2. FIELD QUALITY CONTROL

The water tightness of the seal around the hinged back flap shall be tested with clean water held during 24h in the skip.

SECTION 16000

HANDLING EQUIPMENT

1. GENERAL

1.1. WORK INCLUDED

The present specification shall apply to the Handling equipment to be installed in the various areas of the plant, including but not limited to:

1.2. WORK INCLUDED

The present specification shall apply to the conveying systems to be installed in the various plants and buildings, including but not limited to:

a. Area 101-102:

1. 2 Single beam monorail installed above screen stop logs, each 10 m long and 4 m above the top of wall.
2. Hand operated chain hoists with monorail truck for coarse screens stop log removal. Lifting weight 850 kg.
3. Hand operated chain hoists with monorail truck for fine screens stop log removal. Lifting weight 850 kg.
4. 1 mobile jib crane with hand operated chain hoist for other stop logs removal to be installed on each of the fixing plates adjacent to the stop logs location. Lifting weight 850 kg.

b. Area 103 and 105:

1. 1 mobile Jib cranes with hand operated chain hoists to lift the stop log at the entrance of the grit tanks or the stop logs at the entrance of the sedimentation tanks. A fixing plate for the mobile jib crane shall be installed at all locations adjacent to a stop log. Lifting weight 500 kg.
2. 4 Jib cranes with hand operated chain hoists installed on the scraper travelling bridge for air turbine removal (two on each bridge). Lifting weight 500 kg.
3. 3 Single beam monorail in the sedimentation tank gallery:
 - One 35 m long
 - Two 9.75 m long

PART 3 – TECHNICAL SPECIFICATIONS

4. 3 Hand operated chain hoists on monorail truck for each of the monorails. Lifting weight 500 kg.

1.3. RELATED WORKS

1.3.1. SUPPLIES AND WORKS INCLUDED UNDER THIS SECTION SHALL COMPLY WITH:

- A. Section 01000 - General requirements;
- B. Section 01010 - Corrosion protection
- C. Section 01020 - Basic mechanical requirements;
- D. Section 01030 - Basic electrical requirements;

1.3.2. WORKS UNDER THIS SECTION SHALL BE CO-ORDINATED WITH:

- A. Civil Engineering works and Building works;
- B. Section 09910 – Painting;

1.4. QUALITY ASSURANCE

1.4.1. DESIGN CRITERIA

According to the FEM rules:

- Mechanisms: Group 1 am
- Structures: Group 1

1.4.2. WORKSHOP TEST

- A. Inspection and tests of raw materials: mechanical tests and chemical analysis certificates shall be delivered by the Manufacturer.
- B. Inspection and tests of standard products and cables: routine tests.
- C. Workshop inspections and tests:
 1. Rails and embedded parts
The surface aspect of rails and embedded parts shall be examined and their dimensions checked. Rolling and sliding surfaces shall be perfectly flat and smooth;
 2. All dimensions of systems members shall be checked;
 3. The operation of the various motors and mechanisms shall be checked;
 4. Welds:
Refer to Section 01020 - Basic mechanical requirements.
- D. Shop test shall be carried out in particular:
 - Load test of 125% rated load with operation of lifting up and down, cross travelling.

1.5. SUBMITTALS

Submit for approval complete shop drawings and descriptive literature showing details of fabrication and erection of all material and equipment furnished under this Section. The shop drawings shall include but not be limited to the following data where applicable:

1. Length of bridge crane span.
2. Overhang of bridge trucks relative to crane rail.
3. Bridge wheel tread diameter and wheel base.
4. Limits of hook travel in relation to walls of structure.
5. Speeds of bridge drive, trolley and hoist.
6. Horsepower, full load amperes and number of motors.
7. Hoist capacity and length of lift.
8. Number and type of hoist brakes.
9. Length of track.
10. Installation of runway beams and crane rails.
11. Electric power supply and wiring.
12. Others.

2. PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1. GENERAL REQUIREMENTS

a. Hoist drums

All drums shall be grooved. The drums shall be supplied with cable clamps. The cable attachment points on the drums shall be easily accessible. The cable lengths shall be such that when the load is in its lowest position, at least three turns of cable remain on the drum.

b. Pulleys

Cable pulleys shall have machined grooves of a depth at least equal to one and a half times the cable diameter. The grooves must be designed to prevent any damage to the cables. The pulleys shall be made of steel (cast iron is not acceptable). The pulleys, lifting hooks and pulleys assemblies shall be designed with a safety factor greater than that used for the cables.

c. Lifting hooks

Lifting hooks shall be of forged or cast steel, or of welded plate. There must be no sharp angles nor curvatures of small radius, which could damage the cables. The hooks shall be supplied with hook safety catches to prevent any rope from becoming unhooked.

d. Chains and cables

The threads of cables strands shall be made of galvanised steel. The cables shall have a metallic central core and shall be grease-impregnated inside and outside so as to resist corrosion and wear. The cables shall be rolled up to a diameter conforming with their characteristics for shipment and storage purpose.

If, during any particular manoeuvre, several lengths are used, the tension on each cable shall be equally distributed by means of pulleys or balancing beams. The only exception to this rule will be the case where such a procedure could cause the lifted item to jam. In such

PART 3 – TECHNICAL SPECIFICATIONS

a case, the possible overload due to lack of balance shall be taken into account at the cable design stage. Eyes, endsocket and other attachments for fastening the cables shall be galvanised and capable of with standing 90% of the guaranteed breaking stress of the cables to which they are fixed.

The cable manufacturers shall supply test cables of sufficient length so that samples may be cut off for destructive tensile test. Cost of these tests shall be borne by the supplier. The minimum cable breaking load shall be equal to at least six times the maximum design load of the cable. The minimum breaking load shall be equal to at least four time the maximum design load of the chain.

e. Breaks

All breaking mechanisms, whether of the clamp or disc type shall exert a braking torque of at least 1.5 times the nominal driving torque. The brakes shall also be capable of operating 600 times/hour.

f. Operating speed and loads

The operating speeds shall be guaranteed under normal operating conditions and at all loads within a 5% tolerance band. The maximum operating loads specified by the Contractor shall be considered as guaranteed.

g. Nameplates

All equipment shall have a permanent nameplate clearly showing all pertinent information regarding the equipment, in the English language, following:

- Manufacturer's name and address.
- Name, type, serial number and other equipment identification data.
- Rating and other design data.
- Date of manufacture.
- Lifting capacity.

The lifting capacity shall be indicated on the frame of bridge crane and on the hoist casing.

2.2. HAND-OPERATED CHAIN HOISTS

a. General

Hand-operated chain hoist shall be plain or geared trolley with chain hoist. Design load and lifts shall be as required. Chain hoist shall be designed and manufactured in accordance with FEM Rules.

b. Construction and Materials

Chain hoist shall consist of frame, casing reduction gear and flanged load sheave with precision roller bearings, load and operation chain, overload limiter, mechanical brake safety latch hook. The reduction gears shall be ample proportioned and provided a positive drive between the driving shaft and the load. Pinions and spur wheels shall be made from high grade heat-treated alloy steel, and have precision machine cut-teeth.

The brake shall be of the screw and disc type where the brake pressure and the sustaining power increases in proportion to the load on the hook. Screwed brake sleeve shall be high grade steel and mounted on a splined driving shaft.

PART 3 – TECHNICAL SPECIFICATIONS

All chain shall be electrically welded steel, heat treated, polished and accurate to pitch. The geared trolley shall be the gear drive type with 4 ball-bearing pressed steel wheels, equipped with lifetime lubrication and hardened threads with a geared travel mechanism.

The push and plain trolley shall be of the hung-in travelling type with a forged steel bar held between the side plates of the trolley. The push and plain trolley shall have 4 ball bearings pressed steel wheels equipped with lifetime lubrication. Monorail truck shall conform to the requirements specified in previous Art. 2.3 - Motorized Wire Hoist.

2.3. JIB CRANE

a. General

Jib crane shall be 180° or 360° revolving type crane equipped with fixed motorized wire hoist.

b. Construction and materials

Jib crane shall preferably made up of fixed vertical support rigidly anchored in the concrete base and rotating arm.

The arm shall easily and smoothly rotate with minimum friction using lubricated sleeves or bearings. A locking device shall be provided to maintain the arm in any rotating position.

The controls shall be push-button pendant with a weather tight case and a pilot circuit to reduce the voltage at the push-button to 24 volts. The pendant shall be easily accessible in every rotating position.

2.4. SPECIAL TOOLS AND SPARE PARTS

Refer to General Requirements

3. EXECUTION

3.1. INSTALLATION

The conveying systems shall be installed-in strict conformity with the Manufacturer's instructions and as required by the Engineer.

Main switch for motorized equipment shall be wall-mounted in accessible location.

3.2. FIELD QUALITY CONTROL

The equipment shall be tested in accordance with BS 466 or equivalent international standard.

a. Rail-track

Rail-track position shall be checked before and after its definitive setting and clamping.

b. No-load test

During the testing manoeuvres, the following items shall be checked:

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- Correct operation and efficiency of brakes and limit switches.
- Vertical and horizontal travelling distances and approach measurement.
- Synchronisation of pulley operation when several hoists are used.
- Operating speeds.
- Operation and characteristics of manual and emergency control.
- Examination of paintwork.

c. Commissioning and acceptance tests

1. As far as possible, the load tests shall be carried out under the worst operating conditions in which the hoisting equipment shall be operated under its rated load. In the event of these conditions not being possible, the Contractor shall make provision for the additional loads necessary, in order to be able to simulate the required test conditions:

- Under the rated load, the same items shall be checked as in the no-load test. In addition, the brakes shall be checked, so as to ensure that they stop the hoisting equipment operating at its rated speed, with a maximum slip of 10 mm and that the load is held in a stationary position without sliding. The bearings and other mechanical parts shall also be checked for temperature rise. The temperature of such mechanisms shall not exceed the value specified.
- Under overload conditions, the overload safety system shall be checked.

After completion of the load tests, all suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication. Defective components shall be replaced at the Contractor's expense.

2. Testing of complete handling mechanism:

- Static test:

With the handling mechanism in a fixed position, the hoisting equipment shall be tested under an overload 50% greater than its rated load. This load shall be maintained for one hour. The load shall then be relieved gradually. No defect or permanent deformation shall remain after complete removal of the load.

- Dynamic test:

After satisfactory completion of the static test, the testing load shall be decreased to a value 20% greater than that of the rated load of the hoisting equipment. Under these conditions, all the lifting and lowering operations shall be carried out successively for a period of fifteen minutes of effective operation, without vibration, deformation or detrimental temperature rise. Translational movements of the handling mechanism shall be tested under the same conditions as above.

During these manoeuvres, the following shall be checked:

- correct behaviour of the handling mechanism along its rolling track: the framework shall remain perpendicular to the track and shall under no circumstances give evidence of any defect or deformation,
- correct operation and efficiency of the brakes and limit switches,
- adjustment of the starting equipment, adherence of rollers on starting and braking.

After the dynamic tests, the hoist shall be loaded to its rated load and the following shall be checked:

- The deflection.
- The horizontal and vertical travel distances.
- Correct general operation of the safety mechanisms and accessories.
- Synchronization of pulley operation when several hoists are used.

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- The operating speed.
- The lifting and lowering movements, which shall be made in a continuous smooth manner so that all manoeuvres shall be possible with the desired accuracy.
- Brakes and stopping distance: the hoist brakes shall be capable of stopping the rated load operating at a normal speed with a maximum slip of 10 mm and maintaining this load in a stationary position without slipping.

The bearings and other mechanical parts shall also be checked for temperature rise.

After the dynamic test, suspect components shall be removed and cleaned in order to inspect the bearing surfaces for wear and lack of lubrication; defective components shall be replaced at the Contractor's expense.

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SECTION 17050

FUNCTIONAL DESCRIPTION

1 GENERAL

This section presents the functional description of the WWTP area by area.

2 AREA 101, 102 - SCREENING

2.1 STONE PIT

The following instrumentation and controls will be implemented:

- The float level sensor (101-FL-001) will indicate a high level alarm in the stone pit
- The ultrasonic level sensor upstream of the coarse screen (101-UF-001) will indicate if the emergency bypass weir is used, based on the water level transmitted.
- Stop logs will be positioned manually by the operators for planned bypasses.

2.2 SCREENS

The automatic screens will be operated continuously. However, in order to avoid sedimentation of solids in the channel during the low flow events, the sluice gates (or Penstocks) to each channel will be closed or opened according to the following control philosophy:

- Coarse screen channel 1 (or 2) shall be closed by the motorized sluice gate (101-SG-101 or 201) from 9 pm to 6 am (operator adjustable), alternating which channel is closed every night.
- Fine screen channel 1 (or 2 or 3) shall be closed by the motorized sluice gate (102-SG-101 or 201 or 301) from 9 pm to 6 am (operator adjustable), alternating which channel is closed every night.
- If the level upstream of the coarse screens (101-UF-001) reaches the level “HIGH” then the gate to coarse channel 1 (or 2) and the gate to Fine screen channel 1 (or 2 or 3) will open even if the timer control indicates it should be closed.
- The screens will work automatically with the conveyors and will be controlled by the manufacturer’s control box. The following information will be transmitted to the SCADA:
 - ON/OFF status of each equipment
 - Alarms

- The SCADA will indicate to the manufacturer control box which screen should be in standby.
- Alarms shall be reported when the water levels exceeds the set points upstream of the fine screen or upstream of the coarse screen indicating excessive blockage.

An optional air compressor shall be turned ON by the Operator from the SCADA. When turned ON, the air flow shall be automatically directed to one of the four discharge areas by opening one of the following solenoid valve at a time: 101-SV-001 ; 101-SV-002; 102-SV-001 OR 102-SV-002. The time cycle for the opening of each valve shall be fully adjustable by the Operator from the SCADA System.

2.3 FLOW METER

In case of maintenance on a flow meter 103-MF-001 (or -002), the Sluice gate 102-SG-001 (or -002) shall be closed and the wastewater contained in the pipe and grit tanks entrance area shall be pumped to the grit tank remaining in service. The Flow meter can then be dismantled and maintained as necessary.

3 AREA 103 – GRIT AND GREASE REMOVAL

3.1 GRIT TANKS

Each bridge will travel at a constant speed and will be equipped with a ON/OFF/ AUTO switch. When the bridge is traveling then:

- The air compressor for the airlift grit removal is turned ON.
- The grease scraper on each bridge is lifted when the bridge is travelling upflow and lowered when the bridge is traveling in the flow direction.

When a bridge is OFF:

- The air compressor for the airlift grit removal is turned OFF.
- The grease scraper on each bridge is OFF.

The motorized sluice gates at the entrance of each ND 1400 pipe (102-SG-001 (or -002)) will be equipped with an OPEN/CLOSE/ AUTO switch. In AUTO Mode, the following controls will be available

- Both sluice gates are normally open (open in case of power outage)
- One sluice gate will be closed from 9 pm to 6 am (operator adjustable) to allow for energy savings. The two closed tanks will alternate. Under this condition:
 - the corresponding bridge will be turned OFF.
 - the submerged air turbines will be turned OFF

The air turbines in the tanks will be equipped with one ON/OFF/ AUTO switch controlling all turbines of one tank, located in the pump room. A total of four switched shall be provided, one for each Tank. The air turbines will normally be in Auto mode, so that they can be automatically turned off when a tank is closed.

If a single tank is isolated for maintenance (with a stoplog) then

- the corresponding bridge will continue to run, but the air lift to the isolated tank will be manually closed
- the air turbines in the isolated tank can be manually turned OFF

3.2 GRIT PUMPS AND CLASSIFIERS:

The grit chamber is filled by the airlift continuously except when the bridge reaches the end of the tank, where it rests for 1 or 2 minutes.

Grit Pump 103-PP-501 is normally dedicated to grit classifier 103-GC-511 and Grit Pump 103-PV-502 is normally dedicated to grit classifier 103-GC-513. Both pumps can pump the grit water to classifier 103-CG-512, by manually opening and closing valves orientation. One grit classifier is a standby. The operator will ensure that the standby unit alternates so that the run times on each classifier remain similar.

For each Grit transfer Chamber:

- If the capacitive level sensor 103-LS-501 (or 502) indicates Level High, then the Pump 103-PP-501 (or -502) is turned ON.
- If the capacitive Level sensor indicates Level Low 103-LS-501 (or 502), then the Pump 103-PP-501 (or -502) is turned OFF.
- If capacitive Level sensor 103-LS-501 (or 502) indicates Level High High, then the Airlift 103-BL-501 (or -502) on the corresponding bridge shall be turned OFF and an ALARM is triggered.

3.3 FOUL WATER SUMP

Pump 103-SP-002 and -002 shall be operated alternatively at every Pump ON-OFF cycle, so that the run times on each pump remains similar.

- If the capacitive level sensor indicates Level High, then the duty Pump for the chamber is turned ON.
- If the capacitive Level sensor indicates Level Low, then the operating Pump is turned OFF.
- If the capacitive Level sensor indicates Level High High, then turn both pumps ON and ALARM.

The discharge pipe from the sump pumps shall be directed to the entrance of the grit tanks. Normally the flow will be directed to the Tanks 1 and 2 entrance. However, in case on maintenance on these tanks, a valve may be manually closed on the Tank1&2 discharge and the valve to Tanks 3&4 manually opened.

4 AREA 104 – FUTURE COAGULATION - FLOCCULATION

No specific equipment is planned at this stage. The future extension is planned at the North and South side of the lamellar Tanks.

5 AREA 105 – LAMELLAR SEDIMENTATION

5.1 SCRAPER THICKENER MECHANISM

The scrapers/thickener mechanisms in each Tank shall operate continuously, at constant speed. There shall be an ON/OFF/Auto switch for each scrapers/thickener mechanism installed in the pump gallery between the tanks. In Auto Mode, the scrapers/thickener mechanism shall be turned ON or OFF by the SCADA system.

5.2 OVERFLOW AND LAMELLAR TANK BYPASS

The distribution channel on each side of the tanks shall be equipped with a motorized downward opening overflow gate. If the incoming flow, as measured by the flow meters 103-FM-001 and -002, is higher than 4,9 m³/s, the downward opening gates shall be lowered on each side so that the flow in excess of 4,9 m³/s is directed to the lamellar tanks outlet chamber via the bypass pipes (one on each side), each equipped with a flow meter (105-FM-001 and -002). The level of opening of the downward opening gate shall be adjusted to divert only the flow in excess of 4,9 m³/s, via an Iterative Control Loop using the flow meter signals.

5.3 SLUDGE WITHDRAWAL

The sludge extraction is controlled by the opening of the pinch valve on the sludge piping. The sludge flows by gravity to the sludge holding tank, which water surface level is 4 m lower than the sedimentation tank water surface. The opening of the pinch Valves (105-PV-501,-502,-601,-602) can be controlled by three control modes, as selected by the operator at the Scada:

1. A time cycle set by the SCADA and adjustable by the operator.
2. The sludge layer level in the lamellar settling tank,
3. The volume extracted, as measured by the magnetic flow meters (105-FM-501,-502,-601,-602)

If the level in the storage tank is too high, the SCADA will not authorize the extraction from the sedimentation tank. An alarm will appear.

Under all control modes, the operator shall visualize on the Scada interface screen:

- The level of the sludge layer in each tank
- The volume of sludge extracted from each tank
- The extrapolated wastewater flow coming into each tank

5.4 SLUDGE STORAGE AND BUFFER TANKS

One Mixer in each Tank shall be operating based on a time cycle determined by the operator (continuous operation or intermittent operation for several minutes an hour).

A capacitive level sensor, shall switch off the mixer if the sludge level is too low.

The sludge extraction to dewatering shall be controlled by the pumps (105-PC-701, -702, -703) turning ON and OFF. Pumps turning ON or OFF shall be enslaved to the operation of the dewatering facilities and will be controlled as follows:

- Each pump is dedicated to a dewatering line.
- The dewatering line operation will be automated from 5 am to 9 pm. When started, the SCADA control program will call for the feed pumps to start operation with several minutes delay between each dewatering line start up time, the delay shall be set by the operator on the SCADA.
- According the level in sludge storage tank, two or three units will be turned on at 5 am.

Then the operator will check the extraction cycle from the primary settling tanks and adapt the sludge extraction from the sedimentation tanks in order to store a minimum volume at the end of the day.

The sludge flow rate treated by each dewatering unit shall occasionally be manually adjusted by the operator by changing the gear on the pumps (105-PC-701, -702, -703). The sludge flow rate treated by each dewatering unit shall be measured by the flowmeters (105-FM-701, -702, -703).

If the capacitive level sensor in the tank indicates Level Low (this value shall be adjustable by the operator) or level high an alarm will be sent. The operator may then choose

- to reduce or increase the extraction from the primary settling tanks or
- turn off a dewatering unit line or
- manually change the speed of one or more of the pumps (105-PC-701, -702, -703).

If the capacitive level sensors in the tanks indicates Level low low the pumps (105-PC-701, -702, -703) will be switch off.

If the capacitive level sensor in the tank indicates Level high high extraction from primary settling tanks won't be allowed. The operator may decide to increase the speed on the dewatering feed pumps (105-PC-701, -702, -703).

Dry running protection devices and overpressure pressure protection devices shall protect the pumps.

6 AREA 200 – SLUDGE DEWATERING

6.1 AREA 201 – POLYMER PREPARATION

The arch breaker and screw feeder shall operate automatically in association with the automatic polymer preparation. A level sensor, shall switch the equipment off if the polymer level in the big bag is too low, or if

the polymer level in the hopper is too high. Specific protection devices shall turn off the archbreaker and the screw if a jam is detected.

Four levels sensors shall regulate the equipment.

An electric enclosure supplies and controls every piece of equipment and centralizes default information.

The automatic preparation unit shall be turned off in case of:

- Low level in the hopper,
- No water provided,
- High level in storage compartment,
- Mixer defaults,
- All dewatering lines turn off.

Turning ON and OFF shall be enslaved to the operation of the dewatering facilities. Flow rate shall be set by the operator with the mechanical variable geared motor. To facilitate flow control, magnetic flowmeters shall be installed on outlet pipes.

The polymer flow rate shall be adjustable by the Operator based on the primary sludge flow rate coming to each of the dewatering units. Note that the sludge and polymer flow may be different from one dewatering unit to the other. The Polymer unit control panel shall display the polymer and sludge flow rate for each dewatering unit.

Dry running protection devices shall protect the pumps.

The level sensor in the polymer preparation unit shall switch off the polymer pumps if the level is too low.

6.2 AREA 202 – THICKENING AND DEWATERING

The combined thickening and dewatering units are equipped with their own electrical and control panel. This panel shall display the polymer and sludge flow rate for each dewatering unit.

Turning ON and OFF shall be enslaved to the operation of:

- wash water pumps,
- air compressors,
- liming and limed sludge transport facilities,
- the polymer pumps
- the liquid sludge feed pumps

Several level sensors in dewatering units will inform in case of dysfunction of the Equipment and trigger appropriate alarms.

6.3 AREA 203 – LIMING AND SLUDGE STORAGE

Units are equipped with their own electrical and control panel, including the control of the silos, lime dosing screws, lime conveyor screws, and lime sludge mixers. The dosing of the lime in the dewatered sludge shall be automatically adjusted based on the liquid sludge flow rate to each dewatering unit (105-FM-701, -702, -703). The system shall provide for the future addition of a fourth lime sludge mixer.

Turning ON and OFF of the Lime mixers shall be enslaved to the operation of:

- The dewatering units,
- Limed sludge conveyors,
- Lime dosing system (lime silo and dosing screw)

Each lime mixer (203-SM-101, -201, -301) is dedicated to each dewatering unit (202-BT-101, -201, -301 and 202-FP-101, -201, -301), respectively.

Lime mixers 203-SM-101, -201 shall normally operate with the skip feeding screw conveyor 203-SW-001, and Lime mixers 203-SM-301 (and future -401) shall normally operate with the skip feeding screw conveyor 203-SW-002.

In case of failure of 203-SW-001 or -002, the belt conveyor (203-BC-001) between the two screw conveyors shall be manually turned on to allow diverting all the sludge to one single skip feeding screw conveyor.

Several level sensors and anti-block devices on the lime dosing system shall inform the SCADA and shall stop the unit in case of dysfunction.

The limed sludge screw conveyors (203-SW-001, -002) shall each discharge to two sludge storage skips via a waste distribution device with manual rotation.

Two storage skips shall be in standby, so that the operator can remove the full skip and place the empty skip as necessary.

7 AREA 110 – SERVICE WATER

7.1 WELL WATER

The well water pump (existing, 110-SP-001) shall be turned ON or OFF based on the Float sensor information in the well water tanks (110-TK-001, -002):

- Turn ON when level is Low
- Turn OFF when Level is High
- Trigger and Alarm when Level is High High

If Well water level is low in the Tank and the well water pump (existing, 110-SP-001) does not turn ON, an Alarm shall be triggered. The operator may decide to manually switch the washwater supply of the dewatering unit to the decanted water supply.

7.2 EMERGENCY DECANTED WATER SUPPLY FOR DEWATERING UNITS

If the operator switches the “Emergency Decanted Water Supply for dewatering units” mode ON, the pump 105-PP-801, shall be enabled to be turn ON from the SCADA and the valve to the washwater supply line shall be manually switched to the decanted water tank by the Operator.

The operator shall then clean the particulate filters (105-FT-801 and 802) several times a day by manually switching the flow from one filter to the other.

7.3 DECANTED WATER SUPPLY FOR ODOUR TREATMENT UNITS

The pump 105-PP-802, shall be always be turned ON in Auto mode. The solenoid valves (105-SV-811; -812) shall alternately be switched ON or OFF in order to direct the flow to the Sludge area odour treatment or to the area 300 odour treatment. The time cycle for each valve to be opened shall be fully adjustable by the Operator from the SCADA system. One of the two valves shall always be opened, unless the pump 105-PP-802 is turned off.

The particulate filters installed on the discharge of pump 105-PP-802 shall be manually cleaned twice a day by the operator.

8 HVAC

Room Ventilation shall continuously operate in automatic mode at the low fan speed. When operators are present in the room, they shall switch the fan speed to “High” with a switch on the wall indicating the speed change to the SCADA.

The heating or cooling in each room shall be triggered by a local thermostat. The SCADA shall receive the indication from Heaters and AC units when they turn ON.

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SECTION 17100

SCADA SYSTEM REQUIREMENTS

1. GENERAL

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all SCADA equipment, and shall be applicable to these works.

1.1. WORK INCLUDED

This contract includes for the provision of a SCADA (Supervisory Control And Data Acquisition) system for the monitoring and control of Aeratsia Wastewater Treatment Plant.

The SCADA system shall be implemented as an operational management tool, i.e. shall provide with facilities to undertake the day to day monitoring and control of the Wastewater Treatment Plant and the production of general management information.

A Supervision and Control system will be installed to manage the new installation.

The SCADA system database will be configured to include:

- a) 1000 database points.
- b) 50 mimic displays.
- c) 30 trend displays.
- d) 15 reports.

The SCADA will consist of the following:

- a) One supervision operator Control station installed in one of the offices of the existing administration building.
- b) One local control station in the Electrical Room (Area 402).
- c) One local control station in the Grit Pump Room (Area 103).
- d) One local control station in the Transformer Building (Area 400).
- e) One local control station in the Electrical Room of the Sludge Building (Area 200).

All these control stations will be connected through an optical fiber ring network. (See Control System Block Diagram)

1.1.1. CONTROL STATIONS

1.1.1.1. FIELD CONTROL STATION

Field control stations are installed in the vicinity of each equipment drive.

The field control stations have the highest priority. The station shall be equipped with a selector switch “Local/Off/Remote” and an adequate number of push buttons to operate a drive.

In “Local” mode the drives can be operated locally via push buttons. All other control levels shall be disabled. Protection interlocks shall be hard-wired.

Each drive shall be equipped with a separate emergency lock stop push button, which is hard-wired directly into the drive contactor control circuit.

1.1.1.2. SUPERVISION OPERATOR CONTROL STATION

The supervision operator Control Station installed in one of the offices of the existing administrative building will consist of the following:

- a) One Ethernet/Fiber optic switch.
- b) One Remote Terminal Unit (RTU).
- c) One industrial PC, with Armenian Keyboard and optical mouse.
- d) One Screen 23 inches.
- e) One colour printer.
- f) One Uninterruptible Power Supply (UPS) Unit.

If the selector switch at the field control station is set to “REMOTE” and the selector switch at the Low Voltage Power Distribution (LVPD) is set in “AUTO”, the operation from the corresponding RTU in automatic or in manual mode by SCADA will be possible.

By switching from automatic to manual the drives will hold the actual state of operation, i.e. an operating drive keeps on running, a switched off drive is not started.

1.1.1.3. LOCAL CONTROL INTERFACE

Each local control Interface installed in the electrical room will consist of the following:

- a) One Ethernet/Fiber optic switch.
- b) One Remote Terminal Unit (RTU) with modules of I/O. (Analogic and Digital).
- c) One Human Machine Interface (HMI).
- d) One Uninterruptible Power Supply (UPS) Unit.
- e) The instrumentation converters.

The Remote Terminal Units (RTU) will ensure the redundancy of the system.

The Remote Terminal Units (RTU) are located at the following places:

- a) RTU 1 – In the Electrical Room (Area 402)
- b) RTU 2 – In the Grit Pump Room (Area 103).
- c) RTU 3 – In the Transformer Building (Area 400).
- d) RTU 4 – In the Electrical Room of the Sludge Building (Area 200).

1.1.1.4. INPUTS / OUTPUTS REQUIREMENTS

1.1.1.4.1. Screening Areas (101 & 102), Well Water (110) & Electrical Room (402)

RTU 1 – Screening Areas (101 & 102), Well Water (110) & Electrical Room (402)							
Item	Description	Source	Number	Digital Input	Digital Output	Analogue Input	Analogue Out put
101	Inlet / By-pass / Coarse Screening						
FL001	High Level	Switch	1	1			
TI001	Temperature Meter	Transducer	1			1	
UF001	Level Meter	Transducer	1			1	
SG101	Sluice Gate	Motor	1	3	1		
SG201	Sluice Gate	Motor	1	3	1		
BS101	Automatic Coarse Screen 40mm	Motor	1	3	1		
BS201	Automatic Coarse Screen 40mm	Motor	1	3	1		
BC001	Belt Conveyors	Motor	1	3	1		
HTR901	Heat Tracing	Switch	1	1			
SV001	Solenoid Valve	Switch	1	1			
SV002	Solenoid Valve	Switch	1	1			
102	Fine Screening						
UF001	Level Meter	Transducer	1			1	
SG101	Sluice Gate	Motor	1	3	1		
SG201	Sluice Gate	Motor	1	3	1		
SG301	Sluice Gate	Motor	1	3	1		
SG001	Sluice Gate	Motor	1	3	1		
SG002	Sluice Gate	Motor	1	3	1		
BS101	Automatic Coarse Screen 10mm	Motor	1	3	1		
BS201	Automatic Coarse Screen 10mm	Motor	1	3	1		
BS301	Automatic Coarse Screen 10mm	Motor	1	3	1		
SW001	Screw Conveyor and Compactor	Motor	1	3	1		
BL001	Air Compressor	Motor	1	3	1		
UF002	Level Meter	Transducer	1			1	
SV001	Solenoid Valve	Switch	1	1			
SV901	Solenoid Valve	Switch	1	1			
SV902	Solenoid Valve	Switch	1	1			
SP801	Submersible Pump Drainage Sump	Motor	1	3	1		
110	Well Water						
SP001	Existing Artesian Well Pump	Motor	1	3	1		
402	Electrical Room						
AC001	Air Conditioning Unit	Motor	1	3	1		
	Control Panel Board		1	4	2		
	Power Measurement		1			1	
	Allocated I/O Count			65	20	5	
	Spare (Mimimum 20%)			13	4	1	

	Total I/O Count			78	24	11	

1.1.1.4.2. Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300)

RTU 2 – Grit and Grease Removal Tank (103), Primary Settling Tank (105) & Odor Control (300)							
Item	Description	Source	Number	Digital Input	Digital Output	Analogue Input	Analogue Out put
103	GG Removal Tank						
BL100	Submerged Air Turbine	Motor	8	24	8		
BL200	Submerged Air Turbine	Motor	8	24	8		
BL300	Submerged Air Turbine	Motor	8	24	8		
BL400	Submerged Air Turbine	Motor	8	24	8		
SR102	Surface Scraper	Motor	1	3	1		
SR202	Surface Scraper	Motor	1	3	1		
SR302	Surface Scraper	Motor	1	3	1		
SR402	Surface Scraper	Motor	1	3	1		
BL501	Air Lift Compressor	Motor	1	3	1		
BL502	Air Lift Compressor	Motor	1	3	1		
TB101	Traveling Bridge	Motor	1	3	1		
TB401	Traveling Bridge	Motor	1	3	1		
HTR901	Heat Tracing	Switch	1	1			
HTR902	Heat Tracing	Switch	1	1			
HTR101	Heat Tracing	Switch	1	1			
HTR102	Heat Tracing	Switch	1	1			
HTR103	Heat Tracing	Switch	1	1			
HTR104	Heat Tracing	Switch	1	1			
FL001	High Level	Switch	1	1			
FL002	Low Low Level	Switch	1	1			
LS001	Level Meter	Transducer	1			1	
SP001	Pump Submersible	Motor	1	3	1		
SP002	Pump Submersible	Motor	1	3	1		
LS501	Level Meter	Transducer	1			1	
LS502	Level Meter	Transducer	1			1	
PP501	Grit Pump	Motor	1	3	1		
PP502	Grit Pump	Motor	1	3	1		
PI501	Pressure Sensor	Transducer	1			1	
PI502	Pressure Sensor	Transducer	1			1	
PI503	Pressure Sensor	Transducer	1			1	
PI504	Pressure Sensor	Transducer	1			1	
GC511	Grit Classifier	Motor	1	3	1		
GC512	Grit Classifier	Motor	1	3	1		
GC513	Grit Classifier	Motor	1	3	1		
HT001	Electro Heating	Switch	1	1			
FN001	Exhaust Ventilation	Motor	1	3	1		
SG001	Sluice Gate	Motor	1	3	1		
SG002	Sluice Gate	Motor	1	3	1		
MF001	Flowmeter	Transducer	1			1	
MF002	Flowmeter	Transducer	1			1	
105	GG Removal Tank						
SG001	Sluice Gate	Motor	1	3	1		
SG002	Sluice Gate	Motor	1	3	1		
MF001	Flowmeter	Transducer	1			1	
MF002	Flowmeter	Transducer	1			1	

PF101	Primary Settling Tank PF	Motor	1	3	1		
PF201	Primary Settling Tank PF	Motor	1	3	1		
PF301	Primary Settling Tank PF	Motor	1	3	1		
PF401	Primary Settling Tank PF	Motor	1	3	1		
FL101	High Level	Switch	1	1			
FL201	High Level	Switch	1	1			
FL301	High Level	Switch	1	1			
FL401	High Level	Switch	1	1			
HTR901	Heat Tracing	Switch	1	1			
HTR902	Heat Tracing	Switch	1	1			
HTR903	Heat Tracing	Switch	1	1			
HTR904	Heat Tracing	Switch	1	1			
SV501	Solenoid Valve	Switch	1	1			
SV502	Solenoid Valve	Switch	1	1			
SV601	Solenoid Valve	Switch	1	1			
SV602	Solenoid Valve	Switch	1	1			
MF501	Flowmeter	Transducer	1			1	
MF502	Flowmeter	Transducer	1			1	
MF601	Flowmeter	Transducer	1			1	
MF602	Flowmeter	Transducer	1			1	
IM501	Immersed Mixer	Motor	1	3	1		
IM601	Immersed Mixer	Motor	1	3	1		
LS501	Level Meter	Transducer	1			1	
LS601	Level Meter	Transducer	1			1	
MF701	Flowmeter	Transducer	1			1	
MF702	Flowmeter	Transducer	1			1	
MF703	Flowmeter	Transducer	1			1	
PC701	Progressing Cavity Pump	Motor	1	3	1		
PC702	Progressing Cavity Pump	Motor	1	3	1		
PC703	Progressing Cavity Pump	Motor	1	3	1		
LS701	Level Meter	Transducer	1			1	
SP801	Submersible Pump	Motor	1	3	1		
HT001	Electro Heating	Switch	1	1			
HT002	Electro Heating	Switch	1	1			
PP801	Decanted Water Pump	Motor	1	3	1		
PP811	Decanted Water Pump	Motor	1	3	1		
PI801	Pressure Sensor	Transducer	1			1	
PI811	Pressure Sensor	Transducer	1			1	
SV811	Solenoid Valve	Switch	1	1			
SV812	Solenoid Valve	Switch	1	1			
BL501	Air Compressor	Motor	1	3	1		
SBL101	Sludge Banket Level	Transducer	1			1	
SBL201	Sludge Banket Level	Transducer	1			1	
SBL301	Sludge Banket Level	Transducer	1			1	
SBL401	Sludge Banket Level	Transducer	1			1	
FN001	Exhaust Ventilation	Motor	1	3	1		
300	Odor Control						
FN001	Speed Fan	Motor	1	3	1		
HT001	Heater	Motor	1	3	1		
PI001	Pressure Sensor	Transducer	1			1	
HTR901	Heat Tracing	Switch	1	1			
SV001	Solenoid Valve	Switch	1	1			
	Control Panel Board		1	4	2		

	Power Measurement		1			1	
	Allocated I/O Count			235	70	29	
	Spare (Minimum 20%)			47	14	6	
	Total I/O Count			282	84	35	

1.1.1.4.3. Decanted Water Area (110) & Transformer Building (400)

RTU 3 – Decanted Water Area (110) & Transformer Building (400)							
Item	Description	Source	Number	Digital Input	Digital Output	Analogue Input	Analogue Out put
110	Well Water						
FL101	Low Level	Switch	1	1			
FL102	High Level	Switch	1	1			
FL103	Alarme HH	Switch	1	1			
FL201	Low Level	Switch	1	1			
FL202	High Level	Switch	1	1			
FL203	Alarme HH	Switch	1	1			
PP011	Surpression Pump	Motor	1	3	1		
PP021	Surpression Pump	Motor	1	3	1		
FL111	Low Level	Switch	1	1			
FL112	High Level	Switch	1	1			
FL113	Alarme HH	Switch	1	1			
400	Transformer Building						
AC001	Air Conditionning Unit	Motor	1	3	1		
AC002	Air Conditionning Unit	Motor	1	3	1		
	Control Panel Board		1	4	2		
	Power Measurement		1			1	
	Allocated I/O Count			25	6	1	
	Spare (Minimum 20%)			5	2	1	
	Total I/O Count			30	8	2	

1.1.1.4.4. Sludge Building (200) & Outlet Chamber (107)

RTU 4 - Sludge Building (200) & Outlet Chamber (107)							
Item	Description	Source	Number	Digital Input	Digital Output	Analogue Input	Analogue Out put
107	Outlet Chamber						
SP801	Submersible Pump	Motor	1	3	1		
200	Sludge Building						
AC001	Air Conditionning Unit	Motor	1	3	1		
FN001	Exhaust Ventilation	Motor	1	3	1		
FN002	Exhaust Ventilation	Motor	1	3	1		
HT001	Electroheating	Motor	1	3	1		
HT002	Electroheating	Motor	1	3	1		
HT003	Electroheating	Motor	1	3	1		
HT004	Electroheating	Motor	1	3	1		

HT005	Electroheating	Motor	1	3	1		
201	Sludge Conditioning						
BF001	Polymer Vibrator	Motor	1	3	1		
SW001	Screw Conveyor	Motor	1	3	1		
DS001	Dosing Screw	Motor	1	3	1		
FL005	Stemming	Switch	1	1			
MX001	Vertical Slow Mixer	Motor	1	3	1		
MX002	Vertical Slow Mixer	Motor	1	3	1		
FL001	Alarme HH	Switch	1	1			
FL002	High Level	Switch	1	1			
FL003	Low Level	Switch	1	1			
FL004	Alarme LL	Switch	1	1			
PC101	Progressing Cavity Pump	Motor	1	3	1		
PC201	Progressing Cavity Pump	Motor	1	3	1		
PC301	Progressing Cavity Pump	Motor	1	3	1		
MF101	Flowmeter	Transducer	1			1	
MF201	Flowmeter	Transducer	1			1	
MF301	Flowmeter	Transducer	1			1	
MF102	Flowmeter	Transducer	1			1	
MF202	Flowmeter	Transducer	1			1	
MF302	Flowmeter	Transducer	1			1	
MV101	Motorized Valve	Actuator	1			1	1
MV201	Motorized Valve	Actuator	1			1	1
MV301	Motorized Valve	Actuator	1			1	1
SV101	Solenoid Valve	Switch	1	1			
SV201	Solenoid Valve	Switch	1	1			
SV301	Solenoid Valve	Switch	1	1			
SUR001	Surpression Pump	Motor	1	3	1		
202	Sludge Dewatering						
BT101	Gravity Belt Thickener	Motor	1	3	1		
BT201	Gravity Belt Thickener	Motor	1	3	1		
BT301	Gravity Belt Thickener	Motor	1	3	1		
FP101	Belt Filter Press	Motor	1	3	1		
FP201	Belt Filter Press	Motor	1	3	1		
FP301	Belt Filter Press	Motor	1	3	1		
SW101	Screw Conveyor	Motor	1	3	1		
SW201	Screw Conveyor	Motor	1	3	1		
SW301	Screw Conveyor	Motor	1	3	1		
PP101	Wash Water Pump	Motor	1	3	1		
PP102	Wash Water Pump	Motor	1	3	1		
PP103	Wash Water Pump	Motor	1	3	1		
CP101	Air Compressor	Motor	1	3	1		
CP201	Air Compressor	Motor	1	3	1		
CP301	Air Compressor	Motor	1	3	1		
FL101	Stemming	Switch	1	1			
FL201	Stemming	Switch	1	1			
FL301	Stemming	Switch	1	1			
203	Sludge Liming						
DF101	Lime Storage Dust Filter	Motor	1	3	1		
DF201	Lime Storage Dust Filter	Motor	1	3	1		
DF301	Lime Storage Dust Filter	Motor	1	3	1		
AB101	Lime Archbreaker	Motor	1	3	1		
AB201	Lime Archbreaker	Motor	1	3	1		
AB301	Lime Archbreaker	Motor	1	3	1		

DS101	Screw Dosing	Motor	1	3	1		
DS201	Screw Dosing	Motor	1	3	1		
DS301	Screw Dosing	Motor	1	3	1		
SW101	Lime Screw Conveyor	Motor	1	3	1		
SW201	Lime Screw Conveyor	Motor	1	3	1		
SW301	Lime Screw Conveyor	Motor	1	3	1		
SW102	Screw Injector	Motor	1	3	1		
SW202	Screw Injector	Motor	1	3	1		
SW302	Screw Injector	Motor	1	3	1		
FL101	Stemming	Switch	1	1			
FL201	Stemming	Switch	1	1			
FL301	Stemming	Switch	1	1			
SM101	Sludge Lime Mixer	Motor	1	3	1		
SM201	Sludge Lime Mixer	Motor	1	3	1		
SM301	Sludge Lime Mixer	Motor	1	3	1		
SW001	Skip Feeding Screw Conveyor	Motor	1	3	1		
SW002	Skip Feeding Screw Conveyor	Motor	1	3	1		
BC001	Stand-by Belt Conveyor	Motor	1	3	1		
HT001	Electroheating	Motor	1	3	1		
HT002	Electroheating	Motor	1	3	1		
204	Sludge Storage						
HTR901	Heat Tracing	Switch	1	1			
205	Sludge Building Foul Water Pit						
LS001	Level Meter	Transducer	1			1	
FL001	High Level	Switch	1	1			
FL002	Low Level	Switch	1	1			
SP001	Submerged Sump Pump	Motor	1	3	1		
SP002	Submerged Sump Pump	Motor	1	3	1		
206	Odor Control – Sludge Building						
FN001	Speed Fan	Motor	1	3	1		
PI001	Pressure Sensor	Transducer	1			1	
SV001	Solenoid Valve	Switch	1	1			
207	Electrical Room						
	Control Panel Board		1	4	2		
	Power Measurement		1			1	
	Allocated I/O Count			199	58	12	3
	Spare (Minimum)			40	12	3	1
	Total I/O Count			239	70	15	4

1.1.2. SCADA SYSTEM FEATURES

1.1.2.1. SCADA MIMICS

The following mimics are anticipated for Aeratsia control screens:

Tabl. 1 - List of SCADA Mimics

MIMICS	Quantity
SCADA Network Status Schematic	1

MIMICS	Quantity
WWTP Geographical Overview	1
WWTP Process Schematic Overview	1
Inlet Structure	1
Coarse Screening	1
Fine Screening	1
Grit and Grease Removal (General)	1
Grit and Grease Removal (Individual)	2
Grease Pit	1
Foulwater PS	1
Lamellar Tanks (General)	1
Lamellar Tanks (Individual)	2
Sludge storage	1
Polymer preparation and dosing	1
Dewatering (General)	1
Dewatering (Individual)	3
Liming (General)	1
Dewatered sludge conveyors and storage skips	1
Foul water Pumping Station	1
Odor Treatment	1
Incoming MV supply	2
LV Distribution System	2
A contingency for the following number of additional mimics shall be included	20%

1.1.2.2. ALARM FACILITIES

The facility shall be fitted to enunciate user definable alarms that have been accepted within a user definable period via the klaxon and lights associated with each control panel. The klaxon and light at each panel shall be reset on acceptance of the alarm.

1.1.2.3. HISTORIC INFORMATION

The SCADA system will automatically save the current day's historic data and delete any data greater than 365 days old at midnight. The facilities shall be provided to recover data greater than 365 days old from the archive device.

1.1.2.4. REPORT GENERATION

The SCADA will allow for simple reports generation summarizing statistical information relating to the operation and performance of the WWTP station.

1.1.2.5. SCADA SYSTEM DATABASE CONFIGURATION

The SCADA database will be configured to include all input/output requirements. This shall include, but not be limited to:

- a) Descriptions.

- b) High, High-High, Low-Low and Low alarm levels.
- c) Alarm text.
- d) Alarm priorities.
- e) Dead-bands.
- f) Persistency (How long the signal must be in alarm condition before alarm is raised).
- g) Historic data for trending of inputs etc.
- h) Scanning intervals.

The following shall be saved to disc, for display on the SCADA system:

- a) Hours run for each item of plant, including pumps, screens, washers, compactors, conveyors, scrapers, mixers, blowers, presses and transporters, etc.
- b) Flowmeter readings for incoming flow to treatment, return sludge and excess sludge, etc.
- c) Total outlet flows to treatment (per hour, day, month and year).
- d) Ditto for the return sludge.
- e) The total daily sludge capacity shall be calculated using the measured excess flow, the amount of dry substance returned and the amount of dry substance de-watered for each day, month and year.
- f) The instantaneous and integrated power consumption for the WWTP.

In addition the following elements dependent upon the Consumption of Power:

- a) The instantaneous and integrated power consumption for the Hydraulic Load.
- b) The instantaneous and integrated power consumption for the “Time dependent” power consumers.

1.1.3. DETAILED FUNCTIONAL DESCRIPTION

The functional description and control logic for each process area is described in Section 17050.

2. FUNCTIONAL DESIGN SPECIFICATION

The Contractor shall submit a Functional Design Specification (FDS) to be approved by The Engineer prior to manufacture and purchasing of equipment.

The FDS shall be submitted in English and the national language of the Employer on A4 size sheets numbered within each section and page within section, to include, but not limited to, the following for each Treatment Area and item of packaged plant:

- a) Content List.
- b) Reference to supporting standards, manuals and specifications.

- c) Description of the design and design criteria.
- d) Relevant details of associated mechanical, electrical and instrumentation equipments.
- e) Control philosophy (functional description).
- f) Complete set of supporting drawings.
- g) Design documentation, including:
 - ☐ A description of each major element of the control scheme.
 - ☐ A flow-chart or pseudo-code description of each sequential element of the control scheme.
 - ☐ Analysis of failure modes and shutdown procedures.
- h) Calculations.
- i) Quality control procedures and approvals.
- j) Outline of test procedures.
- k) Manufacturer's literature for each item of equipment supplied.

All drawing shall be on A4 or A3 sized paper as appropriate to ensure legibility include a title block detailing:

- a) Employer's Name.
- b) Contract Title.
- c) Contractors Name.
- d) Drawing Title.
- e) Drawing Number.
- f) Date.
- g) Author.
- h) Verification and approval by the Contractor prior submission.

3. SYSTEM OVERVIEW

A control centre should be established inside the existing Operations Building in which a location shall be agreed to with the Engineer to accommodate the Dispatcher equipment and operator workstations.

The system implemented should be able to operate within the control strategy described but shall be flexible enough to be easily changed should the control philosophy change.

The proposed system shall provide:

- a) A centralised Dispatcher processing function, complete with standby facilities and local workstations.
- b) Distributed intelligence using microprocessor based Programmable Logic Controllers (RTU's) for monitoring and data logging. Under normal operating conditions, the RTUs shall monitor and control plant to given schedules and record the installation's operational/performance data e.g. pump start/stop, inlet flow, storm tank level etc.
- c) The RTUs shall have programmable alarm limits for discrete and rate of change settings. This shall apply to both real and derived values. There shall be a facility for high and low priority alarms, e.g. low, very low, high and very high.

In order to cater for communications failures, the RTU shall be capable of holding 8 days worth of data as follows:

- a) Analogue, totalised and derived signals - on significant change/15 minute intervals.
- b) Digital signals on change of state.
- c) The data gathered from the RTUs shall be incorporated into the Dispatcher database and shall also be made available to applications programs written by the client.
- d) Where RTUs are programmed to perform local control of plant it shall be possible for the programmes, schedules, set-points etc. to be downloaded from the Dispatcher. Subject to being assigned suitable privileges, system users shall have the facility to make short term alterations to RTU control schedules via the control centre, e.g. to implement remedial action when an alarm occurs.

SCADA Control shall be effected at two levels, these being:

- a) RTU local control via programs stored locally at the RTU, e.g. pump start, fallback control.
- b) Supervisory control from the control centre. An authorised user, at the control centre shall be able to modify the control routines at any RTU by downloading new control (start/stop) schedules, new performance criteria e.g. increase/decrease flow/pressure or operating individual items of plant e.g. open/close valve, start/stop pump.

There shall be a requirement to download control programs and schedules to the RTUs from the dispatcher via the communications network.

The preferred method of communication with site based RTU's is cable with low power UHF radio for remote sites. As future developments may require different forms of communication at specific sites, the equipment shall be capable of operating in all modes with minimal software changes.

The system shall operate using 'management by exception' techniques. The RTU shall monitor and control the site and record operational data. When an alarm condition is detected the RTU will dial into the master station immediately to announce the alarm and forward any data collected. Where alarm conditions arise, individual alarm presentation with alarm lists, mimic and tabular diagrams, and help pages shall be available to assist the operator.

4. DISPATCHER SYSTEM HARDWARE

4.1. GENERAL

A centralised SCADA Dispatcher shall be provided for the SCADA system unless otherwise specified.

All equipment required to fulfil the requirements shall be industry standard proven computing equipment with a demonstrable long-term life cycle and support.

To permit other manufacturer's equipment, e.g. RTUs, to be added to the SCADA system, all equipment shall, wherever possible, interface using open-system communications protocols.

4.2. SYSTEM AVAILABILITY

4.2.1. GENERAL

The strategic importance of the SCADA system requires a high level of system availability, i.e. not less than 99.9% availability for each calendar year. The SCADA system shall therefore be provided with the following.

4.2.2. HOT STANDBY

The system shall be provided with a master and standby Dispatchers where the standby Dispatcher shall be continually updated and automatically assume responsibility within 30 seconds following failure of the master Dispatcher.

Synchronisation of the databases following system recovery shall be automatic i.e. shall not require manual intervention.

4.2.3. UNINTERRUPTIBLE POWER SUPPLY (UPS)

The system shall be provided with a UPS capable of supporting all the main computer equipment (central processing units, discs, communications processors etc.), operating consoles and the alarm/event printer for a period of not less than 4 hours. The UPS shall be provided to cater for a 50% increase in load without the need for additional hardware.

Note: Essential services, e.g. UPS, generator and security etc. shall be monitored by the SCADA system.

4.2.4. MAINTENANCE

The Dispatcher equipment shall be subject to a maintenance contract where a competent engineer shall attend site within 8 hours from the time the failure was reported, twenty four hours a day, 365 days a year.

4.2.5. COMMUNICATIONS EQUIPMENT

The Dispatcher equipment shall be provided with all necessary communications equipment to support:

- a) All operator workstations.

- b) All printing devices.
- c) The communications network comprising:
 - ☐ Communications to all on-site RTUs.
 - ☐ All remote equipment.

4.2.6. DATA STORAGE

Each master station shall be provided with the following storage media:

- a) Random Access Memory – to store the “real-time”/instantaneous database.
- b) Hard discs – to store the system configuration, mimics and local short-term (70 days) historical database etc.:
 - ☐ Digital points on change of state.
 - ☐ Analogue points at 15 minute intervals.
 - ☐ Derived points.
- c) Optical disc - to store off-line (greater than 70 days old) historical database, system backups, data transfer etc.
- d) DVD burner- to transfer data to off-line PC equipment.

4.2.7. OPERATOR WORKSTATION

The operator workstations shall be the main Man-Machine Interface (MMI) and shall consist of 23 inch (minimum) Visual Display Units (VDUs) capable of displaying graphical and alphanumeric characters in at least sixty-four colours in all foreground/background combinations.

The VDU shall have an associated keyboard consisting of a standard typewriter QWERTY alphanumeric set, with additional numeric and special function keys, augmented by a mouse or tracker-ball.

4.2.8. PRINTING DEVICES

The system shall be provided with two types of printing device:

- a) Alarm/Event Printer:
 - ☐ To provide a hard copy log of all alarms and significant events, e.g. operator sign-on or control override issued a medium speed dot matrix printer shall be provided. The printer shall be capable of 300 characters per second, 132 characters per line, multiple colours (to differentiate alarms and level of alarms from events) and operating on continuous fan fold stationery.
- b) Colour Printer:
 - ☐ To provide high quality printed output for report summaries, programme development, copies of mimic displays, historical trends etc., issued a high speed colour ink-jet printer shall be provided.

4.3. REMOTE DATA TRANSFER

The SCADA system shall be capable of processing the data received from operational sites e.g. into daily minimum, maximum and means, and forwarding the raw and processed data to off-line packages e.g. Microsoft Excel.

5. SYSTEM FEATURES

5.1. GENERAL

The Employer requires a low risk system supplied with proven software.

5.2. SYSTEM ACCES

Users of the system shall be allocated individual passwords allowing each user an appropriate level of access commensurate with their requirements, responsibilities and areas of knowledge and interest.

Three general categories of access have been identified:

- a) Data only.
- b) Data and Control.
- c) Data and System Management.

Data only shall be generally available to all system users. Data and control shall be limited to those personnel with the knowledge and responsibility to take control actions.

5.3. COLOUR GRAPHICS DISPLAYS

The following display types shall be available on all colour graphics terminals:

- a) Mimic diagrams.
- b) Help pages.
- c) Graphs.
- d) Bar charts.
- e) Alarm and event log listings.
- f) System configuration and maintenance displays.

5.3.1. MIMICS DIAGRAMS

Mimic diagrams are required to present a pictorial representation of the plant and its present status. Features required are as follows:

- a) Display of fixed (background) diagrammatic plant information and text.

- b) Display of variable information i.e. symbols or text displaying plant status.
- c) Easy picture creation, possibly using a CAD style package.

5.3.2. DISPLAY OF VARIABLES

Variables can be considered as digital on/off parameters, analogue or totalisers.

Digitals may be either status (e.g., running/stopped) or alarm points, and shall be displayed by:

- a) Text changing.
- b) Symbol colour changing.
- c) Symbol shape changing.
- d) Text or symbol flashing.

It must be possible to associate more than one digital point with a symbol, so that more than two colours/shapes can have operational meaning. For example, a pump may be shown in four colours indicating running/stopped/failed/non-operational.

In addition, it shall be possible to associate any number of symbols within different mimics with a particular digital point.

Analogues and totalisers shall be displayed by:

- a) Numeric value.
- b) Bar chart.
- c) Graph.

It shall be possible to display all these three types of indication in mimic diagrams. Colour changes shall be used to indicate further information about a point, e.g. if an alarm limit has been exceeded.

5.3.3. DISPLAY ATTRIBUTES

Using the display facilities described above, the mimic diagrams shall indicate the following attributes for analogue, digital and totaliser points:

<u>Attribute</u>	<u>Point Type</u>
Status On/Off	Digital Status
Alarm/Normal	Digital Alarms
1 st Stage Alarm (High, Low)	Analogues
2 nd Stage Alarm (High-High, Low-Low)	Analogues
Communications Failure	All
Alarm Manually Suppressed (out of service)	All
Alarm Automatically Suppressed	All
Out of Range	Analogues

5.3.4. PICTURES CREATION

It is essential that picture creation is a straightforward procedure, a CAD type package would be suitable. It must be possible to create symbols which may then be used in any orientation, size and colour and to create a symbol library, i.e. a part of a diagram which may then be used many times. It must be possible to display, on any single mimic diagram, information from anywhere within the system.

5.4. HELP PAGES

Help pages shall be available within the system, to assist the operators in dealing with received alarm conditions. These pages will be compiled by the plant managers and will provide advice as to which staff shall be notified of which alarms.

Help pages may be presented as individual pages accessed from a mimic, or as a window superimposed on a mimic.

5.5. GRAPHS

Graphical representation of historical data is required, with a selectable time base and the ability to put up to four graphs on display at once on the same axes, using different colours.

The system must be easy to use, with automatic default facilities so that only a minimum of instructions need be given to the system to obtain each plot.

Features that will be required are:

- a) Pre-configured and ad-hoc trend displays.
- b) Ability to compare graphs over different time spans, e.g. today's flow compared against yesterday's flow.
- c) Read-out of the actual value of a graph at a given time point.
- d) Ability to roll a graph forward and backwards in time.
- e) Ability to set the scale for each graph.
- f) Trend graphs giving a plot of the selected variable up to the last scan, updating when a new value is received.
- g) Ability to incorporate a trend graph as a feature on a mimic diagram.
- h) Graphical output of both analogue and digital signals (real and derived). Digital signals will produce a square wave type plot indicating for instance when a pump started and stopped.
- i) Auto ranging scale unless manually overridden.
- j) Ability to display data from different sites within the same trend display.

5.6. BAR CHARTS

A bar chart type representation of analogue variables is required. This is required on mimic diagrams, and must be capable of horizontal or vertical orientation, with selectable scaling. Width of bars must be selectable so that the feature can also be used for such items as tank level pictorial representations.

5.7. ALARM AND EVENT LOG LISTINGS

All alarms and changes of status (i.e. digital events) in the system shall be logged to disc. It shall be possible to recall this information to the screen via a select and sort programme. This programme shall sort and display information on at least the following bases:

- a) Process Area.
- b) Site type.
- c) Site name.
- d) Time period.
- e) Signal identification numbers.
- f) Signal state (on/off).
- g) Alarm status i.e. cleared, accepted and unaccepted.
- h) Alarms or status occurrences required.

Any sort parameters not entered shall default to "all".

5.8. SYSTEM SET-UP AND MAINTENANCE DISPLAYS

Suitable displays of information shall be provided to display all set-up features of the system. These displays will be closely associated with the SCADA system set-up facilities.

6. LOGGING ON/OFF

Every user of the SCADA system shall be required to log on (i.e. activate) his terminal when he wishes to operate on it. The system will be aware of which terminals are logged on and the access rights of the user and will therefore be aware of where to send certain information.

6.1. ALARM FACILITIES

6.1.1. GENERAL

Digital points within the system shall be capable of operating as either status (e.g. running/stopped) or alarm points (e.g. normal/failed). A digital alarm point shall enter the Alarm State when it is either a logical '1' or logical '0' as designated in the system set-up for each point, the opposite state being the normal condition.

Analogue points shall be provided with two high alarm limits (high and high-high), and two low alarm limits (low and low-low). Should an analogue value either rise or fall from a value considered to be normal, a first stage high or low alarm limit will be encountered resulting in a new alarm condition. Should the value continue to rise (or fall) it will then encounter the second stage high-high or low-low alarm limit again resulting in a new alarm condition.

6.1.2. ALARM PRIORITIES

Every alarm generated within the system shall be allocated an alarm priority to indicate the importance of the alarm. Whereas a digital point will have only one alarm priority, an analogue point will have three. This will allow the relative importance of the first and second stage high and high-high (low and low-low) alarms to be set. The alarm priority is used in conjunction with the 'area of interest' of the users logged onto the system to determine where and when a new alarm is enunciated. The priority of an alarm shall change if required depending on the time and date.

6.1.3. ALARM ANNUNCIATION

Alarms are to be enunciated on the operator workstation both visually and audibly, and have clear and unambiguous acceptance procedures. High priority alarms shall be presented for acceptance before low priority ones.

6.1.4. ALARMS FILTERING

The SCADA system shall have a "tool-kit" of facilities that may be applied to individual points in the system in order to prevent unnecessary annunciation of alarms. These shall typically include:

- a) Analogues:
 - ☐ Dead Band.
 - ☐ Delay before initial alarm.
 - ☐ Minimum alarm repeat interval.
 - ☐ Logical suppression of new alarm if other conditions are presents.
 - ☐ Averaging values in RTU.
- b) Digitals:
 - ☐ Delay before initial alarm.
 - ☐ Minimum alarm repeat interval.
 - ☐ Logical suppression of new alarm if other conditions are presents.

Users, subject to authorisation (i.e. correct level of access), shall be able to manually suppress an alarm, e.g., if a transducer is faulty and is being particularly troublesome. The suppression of alarms shall be logged to the event list.

6.1.5. DERIVED ALARMS

A combinational and sequential logic package is required within the SCADA system, allowing signals to be combined to form derived alarms. These may be combinations of analogue and digital information obtained from different sites (e.g., a pump may be running at a pumping station but no flow entering the associated inlet works resulting in a derived alarm indicating a potential burst).

6.2. HISTORIC INFORMATION

6.2.1. RTU

RTUs will sample and store values of analogue parameters at predetermined intervals to cater for loss of communications. These will normally be 15 minutes but shall be user configurable between 1 minute and 24 hour intervals.

6.2.2. MASTER STATION

In addition to the raw operational data, a long-term archive of analogue max/min/mean values, pump hours run etc. will be maintained. Values stored shall be , at a minimum:

- Wastewater Flow integrated as m3/h with 1 value recorded every hour
- Wastewater Flow temperature integrated as average temperature per day with 1 value recorded every day
- Liquid Sludge flow to dewatering, integrated as m3/day with 1 value recorded every day
- Power usage for each area, separating HVAC power usage, as kWh per day with 1 value recorded every day for each area.

6.3. CONTROLS

6.3.1. MANUAL CONTROL

It shall be possible to perform control operations (e.g. remote start/stop of pump) from any of the operator consoles. Access to controls will be limited by the access rights assigned to the individual passwords for various operatives (see System Access).

The issuing of control instructions shall take precedence over the scanning for alarms.

A well organised select check and execute system is required.

6.3.2. AUTOMATIC CONTROLS

Automatic control features shall be available within the SCADA system, and fall into two categories:

- a) Profile type controls where a working pattern (e.g. of reservoir level) is downloaded to a RTU for use by a local control system. New profiles may be sent for each day or week etc., as required.
- b) Combinational and sequential control:

There are circumstances where the only practicable way of closing a control loop is via the SCADA system, although this should be avoided whenever possible. The package used for alarm derivation will also fulfil the automatic control requirements. The following facilities shall be provided as a minimum:

- ☐ Logical AND/OR/NOT/EXOR/EQUALS.
- ☐ IF-THEN-ELSE Constructions.
- ☐ Arithmetic operations including >, \$, >, #, =, +, -, H,), /.

- Logical constructions including time and data.
- Look-up tables, with interpolating facilities.
- Input to functions from any system point including digital, analogues, totalisers, controls from a keyboard, set-point input from a keyboard.
- Output from functions to be available as digital, analogue or totaliser points, or transmitted to any RTU as a control or set point.
- Access to point attributes in addition to present value, including:
Suppressed, telemetry failed, in alarm (and for analogues, which alarm level).

6.4. TERMINAL TIME OUT

When a terminal is used for control purposes, it shall have to be logged on specifically for that function. If it is not used for a user configurable period of time (e.g. 5 minutes) in this mode, it shall automatically revert to a display only mode. A warning should be provided one minute prior to the auto log off.

6.5. SYSTEM RECORD

A record shall be kept on disc within the system of all operator actions, such as alarm acceptance or control actions performed on the system. The record shall include:

- a) Time and date.
- b) Action.
- c) Operator.

This record shall be retrievable from the system using a similar select and sort routine to that specified for status and alarm logs.

6.6. REPORT GENERATION

The system shall be capable of generating both regular and individual reports. Reports must be easily configured and altered in order to maintain their relevance.

An example of a regular report which may be produced from the system is the following, designed to be made available to the works manager each morning:

- a) Treatment works: previous day's output.
- b) Alarms that have occurred during the night.

6.7. SYSTEM TIME

The system shall support:

- a) Greenwich Mean Time (GMT/UCT).
- b) Daylight Saving Time (DST).
- c) Leap Years.

All data shall be logged at GMT/UCT + 2 hours, but automatically displayed in the appropriate local time adjusted for daylight saving.

6.8. SYSTEM DATA CONFIGURATION

The system shall be provided with privileged and secure on-line database building utilities i.e. it shall not be necessary to stop the scanning and alarm presentation facilities. Any configuration shall not be installed into the active database until completed, verified and authorised by the user. A reliable verification procedure shall be required to prevent the creation on invalid files and the deletion of in-use files.

It shall be possible to define process point files, calculated/derived point files, remote RTU files, to include:

- a) Meaningful point identification and description.
- b) Allocation of points to groups/locations.
- c) Range of analogue values in Engineering Units.
- d) Alarm limits/categories.
- e) Scan control/frequency.
- f) Report control (whether change of state is to be logged to the alarm/event printer).
- g) Save control (whether values are to be archived).
- h) MIS control (whether values may be transferred to other systems).

6.9. SYSTEM RESPONSE TIMES

The Dispatcher provided under this contract shall meet the following performance criteria:

Item	Description	Response (seconds)
1	From change of state of plant being detected by RTU	0.5
2	From change of state being detected by the Dispatcher to updating the SCADA database	0.5
3	From change of state in the SCADA database to updating the alarm list	0.5
4	From change of state in the SCADA database to updating the active mimic	0.5
5	All requests for mimic displays, alarm lists and help pages from the completion of the operator request.	3
6	All requests for trend displays and event lists shall from the completion of the operator request.	10
7	Time to perform screen dump from completion of the operator request	30

7. EQUIPEMENT

7.1. REMOTE TERMINAL UNIT (RTU)

7.1.1. QUALITY CRITERIA

Equipments installed within the framework of this project of remote processing will have to answer particularly the following criteria:

- a) A very big reliability to guarantee a maximal availability of the remote processing, even on very exposed sites.
- b) An important sustainability of the solutions proposed for allow to realize easily a future extensions with the best cost.

A big simplicity of implementation and use to minimize the times of putting into service and assure the control of this tool by the staff concerned without specific training.

7.1.2. ASSEMBLY IN CUPBOARD

The RTU can have risen in face before of an electric cupboard to reach the data of the RTU on the graphic screen without having to open the cupboard.

7.1.3. MATERIAL

7.1.3.1. RELIABILITY AND MODULARITY

To guarantee the reliability of equipments, the proposed RTU must be conceived with components allowing a high protection EMC (Electromagnetic Compatibility); that is the level 4 for the following standards:

- a) **IEC EN 61000-4-4:** Testing and measurement techniques - Electrical fast transient/burst immunity test.
- b) **IEC EN 61000-4-5:** Testing and measurement techniques - Surge immunity test.

Every RTU will have to have modular architecture:

- a) On one hand, to fit at best the configuration of the post to the need for the installation.
- b) On the other hand, to allow extensions a lesser cost.

Finally the modularity will allow to facilitate the maintenance: the cards being independents, the one compared with the others, the diagnosis will be faster and the replacement of a defective card will be made very easily.

7.1.3.2. ELECTRONIC CARDS

The not exhaustive list of cards below can constitute a RTU following the needs for the site to be equipped:

- a) Inputs/Outputs Cards.
 - ☐ Digital Input Card.
 - ☐ Analogic Input Card.
 - ☐ Digital Output Card + Guard dog.
 - ☐ Analogic Output Card (If later need).
- b) Cards of Communication.

- ☐ GSM Modem.
- ☐ RTC Modem.
- ☐ Card for connections LS / LP.
- ☐ Card for connections Ethernet.
- ☐ Card for connections Radio.
- ☐ Serial Interfaces RS232 / RS485.
- ☐ Card for badge reader (Access control).

To facilitate the cabling, all the cards must be equipped with disconnectable terminal blocks.

Cards for the acquisition of the Analogic Inputs will have to be capable of feeding directly the sensors 4-20 mA, without requiring the appeal to an external power supply. This power supply must be protected from the short circuits.

Cards for the acquisition of the Digital Inputs will have to be of the type " in dry contact ": they will have to supply an opto-insulation and the power supply of the contacts via an isolated power supply besides with the equipment.

7.1.3.3. POWER SUPPLY OF THE RTU

The power supply of the RTU is a sensitive part. The group constituted by the power supply card and the safety power supply (battery / UPS) will have to answer the following characteristics:

- a) A battery charger (plan a battery offering a minimal autonomy of 12 hours).
- b) A device against the deep discharges to protect the life expectancy of the battery during prolonged power break.
- c) A protection against the inversions of polarity.
- d) A presence detection battery.
- e) A periodic test of capacity of the battery.

This last function guarantees the efficiency of the battery while optimizing maintenance costs (the battery will be only replaced on detection of insufficient capacity).

7.1.3.4. GSM MODEM

The modem GSM of the PLT is also an essential element because he assures the link with the control centre and the distant users. He will thus have to be of a big reliability and have a guarantee of sustainability.

The modem GSM will thus have to be integrated into the RTU. He cannot involve an office automation modem or an external modem of the business the characteristics of which are not adapted at the applications of remote processing.

7.1.4. FEATURES

The RTU proposed will have to assure the following functions:

- a) Acquisition of inputs - outputs.
 - ☐ Digital status (on/off, defaults, ...).
 - ☐ Measures (level, pressure, ...).

- ☐ Countings (Flow, time of functioning, ...).
- ☐ Command (opening/closing, ...).
- ☐ Regulations (Instruction of Flow, ...).

The acquisition of inputs-output will be made or by means of cards of integrated or external inputs-output in the RTU.

b) Treatment of the acquired information

- ☐ Measures (level, pressure, ...).
- ☐ Warning levels.
- ☐ Temporizations of the alarms.
- ☐ Calculation of balance sheets.
- ☐ Complete module for the archiving of the information and the events:
 - For the measures : periodic archiving of the value and on variation if the measure evolves in a significant way between 2 archivings.
 - For the Digital inputs - output: archiving in every change of state.
 - For the countings : periodic archiving or in the form of balance sheets.

All these treatments will have to be configurable by the user, via an interface operator. This interface operator, schedules no requiring IT programming.

c) Transfert of alarms

The alarms will have to be able to be transmitted by GSM in the form of vocal messages, of SMS or of Emails towards on-call agents, or towards control centre.

The authorized people will have to be able to at any time consult at a distance the information of the installation via the voice server or by SMS, so authorizing a big freedom of movement.

d) Communication with other equipments

For the future evolutions, the RTU will have to be capable of communicating with other equipments by using a standard protocol as the MODBUS or MODBUS-TCP.

e) Interface Operator of exploitation

For the local exploitation, the RTU will have to integrate a graphic screen allowing the consultation of states, alarms, values archived in the form of curve, and the positioning of the instructions (according to the seizure of a password).

For the remote exploitation, the RTU or GSM will have to have a voice server allowing the management of the alarms, the consultation of states and the activation of commands.

Finally the RTU will have to be totally accessible, in local and remote, via a simple Internet browser, on PC.

f) Interface Operator of configuration

To assure its control by the concerned users, the tool of configuration will have to be particularly intuitive and call on to simple notions of "questions-answers" using the usual terms of the job (no specific language of programming). This tool of configuration will have to work on a standard PC and call on to graphical interfaces easy to treat.

g) Automatism

The RTU will have to have a function allowing to realize simply combinations between digital inputs, or to make an elementary automatism. On the other hand, to answer needs for more elaborate automatisms (regulation, permutation / management of pumps, the RTU will have to have a language of standard automatism (according to the standard IEC1131-1) and libraries of functions ready for the use.

8. COMMUNICATIONS

8.1. GENERAL

The Contractor shall supply install and commission all necessary communications equipment and software to provide a complete integrated communications network for the SCADA system.

8.2. EMPLOYER LIAISON

The Employer will be responsible for the processing the licences required from the national licensing agencies.

The Contractor shall, however, provide all detail design calculations, equipment characteristics, equipment approval certificates and completed application forms for the Employer to enable the Employer to process all applications for communications circuits, frequencies etc. as an administrative task.

The Tenderer shall, within his bid, allow for all necessary tests to prove compatibility of the offered equipment with the national licensing agencies and communications standards.

8.3. SCAN TIMES

The Contractor shall prepare a detailed assessment of the RTU scan times for his system and submit this to the Engineer for approval. The assessment shall assume the use of UHF polling to gather operational data from RTUs located at remote sites.

The longest scan time for RTUs with radio communications shall not exceed two minutes under full system utilisation.

8.4. DATA RATES

The Contractor shall ensure that the data rates are not less than the following:

- a) Public Switched Telephone Network (PSTN) Direct Exchange Lines (DEL) connection: 2400 Baud.
- b) UHF Radio network: 1200 Baud.

8.5. TRANSMISSION AND PROTOCOL

The Contractor shall wherever possible use an industry standard transmission protocol. The Contractor shall provide details of the proposed protocol to be used at the time of Tender.

8.6. ELECTRONIC EQUIPMENT

All communications equipment used in the communications system shall be of high reliability and shall comply with the most recent edition of appropriate National and International Standards Specifications and recommendations at the time of Tender.

8.7. LIGHTNING PROTECTION

8.7.1. LIGHTNING PROTECTION DEVICES

The Contractor shall provide lightening and surge protection devices at each RTU on each communications circuit, base station and at all other parts of the radio network to ensure isolation and automatic resetting of the system being subject to high surge currents. Devices shall be unfused.

Lightning protection shall conform to the appropriate sections of BS6651, code of practice for protection of structures against lightning.

Lightning protection shall be selected to provide the highest degree of protection possible for the circuit being protected i.e. the clamp voltage shall be the lowest possible commensurate with normal operation of the circuit.

The type and manufacturer of the Lightning Protection Unit (LPU) shall be subject to the approval of the Engineer.

LPUs shall be earthed to the nearest earth reference bar, as direct as possible without inductive loops by a single unjointed cable.

Individual LPUs shall bolt directly onto a lightning earth bus bar. Cables and cores containing the circuits to be protected shall not be loomed or grouped together until the circuits subject to induced lightning energy have passed through the protection units.

Where two or more LPUs are mounted on the same Din rail mounted earth bar, the cable shall be sized as follows:

- a) Cables less than 6 metres: 10 sq. mm.
- b) Cables greater than 6 metres: 16 sq. mm.

The whole assembly shall be mounted inside an insulated box, if not already mounted separately from other equipment, close to the chosen earth termination in order to achieve a short, straight connection.

LPUs that are mounted in an enclosure supplied with an a.c. electrical power supply that utilise Din rail mounted earth bars shall have either:

- a) The earth bars insulated by means of proprietary stand-offs or.
- b) The Din rail insulated in an approved manner from the electrical power earth or any earthed conducting surface.

The route for the earth conductor shall be as far away as possible from the vicinity of the signal cables.

The earth conductor shall be copper, no greater than 16 sq. mm in section, it's route shall be as short and direct as possible and, in any case, no longer than 10 metres.

Ideally the cable route should be straight, but any necessary bends shall have a long radius.

The earth termination and the method of connection shall be subject to the approval of the Engineer.

8.7.2. EARTH ELECTRODES

The Contractor shall provide an earth electrode system in cases where the contract provides for the facility of lightning surge diversion equipment. The system shall be cabled to the main protective conductor system at the common point of connection of the distribution system that it serves.

Earth electrode systems shall be provided where specified in the **particular Specification** ??.

Where the provision of lightning protection is specified, the Contractor shall provide an earth electrode system in accordance with the relevant code of practice.

8.7.3. EARTH ELECTRODE INSTALLATION

Earth electrode installation shall connect earthing conductors to the general mass of the earth. The installation shall comprise one or more earth rods, mesh or combination thereof to obtain the required earth electrode resistance.

Earth rods shall be of proprietary manufacture, 16 mm outer diameter, made up of sections of 1.2 metres long with internal screw and socket joints and fitted with hardened steel tip and driving cap. They shall be driven into the ground to a minimum of 2.4 metres.

A minimum of two earth rods or other electrode shall be provided for each main earthing system and the conductor brought back to the main earth bus bar for each.

Connections to the electrodes are to be readily accessible for periodic inspection and shall be protected against mechanical damage and corrosion. The actual connection to the rod shall be by means of a purpose made non ferrous clamp and shall be made below ground level in a concrete inspection pit having a removable cover.

When the installation is complete, soil resistivity or other tests shall be performed and witnessed by the Engineer, to ensure that the required earth loop impedance figure of less than 5 ohms is attained.

8.8. TESTING

The Contractor shall allow for the following tests with regard to communications equipment:

- a) Factory testing of sub-assemblies.
- b) Factory testing of complete units.
- c) Factory simulated system tests to prove the performance of all elements of the integrated communications network.
- d) Commissioning tests of all installed radio equipment to record the characteristics for future maintenance of the network.

Test certificates shall be provided at each stage and for each complete unit and sub-system. The Contractor shall supply all test equipment and shall provide seven days notice prior to testing to the Engineer.

8.9. RADIO EQUIPEMENT

8.9.1. STANDARDS REQUIREMENTS AND APPROVAL

All equipment shall comply with the appropriate CCIR recommendations and shall be approved by the national licensing agency. The equipment shall comply with the most recent editions of the appropriate National and International Standards Specifications and Recommendations.

Type approval numbers issued by the National Frequency Allocation Committee in the country of manufacture shall be supplied, together with appropriate CCIR recommendations, appropriate National and International Standards Specification met by the equipment at the time of Tender.

8.9.2. RADIO SYSTEM

The radio system shall conform to the latest regulations and requirements current at the time of delivery. The radio system shall be of the following type:

- a) Frequency: UHF as allocated by the Frequency Committee.
- b) Modulation : FM.
- c) Base Mode: Full Duplex.
- d) RTU Mode: Two-Frequency Simplex.
- e) Channel Spacing: 12.5 Khz.

8.9.3. RADIO PATH PROFILES

The Contractor shall provide path profiles and subsequent technical examinations prior to detailed design of the radio system.

8.9.4. PCL RADIO TRANSMITTERS/RECEIVERS

RTU transmitter/receiver radio units shall be units with standby facilities. These units shall have sufficient battery backup for the system to function for 4 hours in the event of mains failure. The units may either be wall mounted or installed in the RTU enclosure (the preferred option).

The alarm signal shall be transmitted to the SCADA system when a changeover occurs due to a radio failure.

The R.F. output of the radio units shall be variable from maximum down to 0.5 watt. Attenuation pads shall be provided in the transmit leg only, and the radio output set to maximum in the final system configuration.

8.9.5. BASE STATION RADIO TRANSMITTERS/RECEIVERS

Base station transmitter/receiver radio units shall be located adjacent to the Works Control Centre (WCC) and shall be of a dual main/standby type with auto-changeover of the duty units.

The Contractor shall supply within the tender document an explanation of how this is to be accomplished. An alarm signal shall be transmitted to the SCADA system when a changeover occurs. The base station shall be provided with power supply equipment, including: nickel cadmium battery and 230 volts 50 Hz a.c. mains fed battery charger and have sufficient battery backup to allow the system to operate for eight hours on the event of mains failure. The charger shall be capable of recharging the battery to full capacity within 8 hours while the radio equipment continues to operate at full duty.

The alarm signal shall be transmitted to the SCADA system when a changeover occurs due to a radio failure.

The R.F. output of the radio units shall be variable from maximum down to 0.5 watt. Attenuation pads shall be provided in the transmit leg only, and the radio output set to maximum in the final system configuration.

The base station radio shall be forced to change the duty radio at a user definable interval (normally every 24 hours).

8.9.6. AERIAL AND AERIAL STRUCTURES

The Contractor shall supply and install all aerials and aerial support structures and shall provide typical drawings to show how each type of aerial mast is to be mounted (including free standing, guyed stub etc.) with the tender document. The base station shall have omni-directional aerials plus any associated duplexers.

RTUs shall have a single 12 element, yagi aerial with a gain of 12dB with respect to a half wave dipole on the corresponding base station.

The aerial and support structure shall be capable of withstanding winds gusting to 160 km/hour without damage. The Contractor shall provide all supporting calculations.

The Contractor shall supply to the Engineer all necessary calculations and information to demonstrate the aerial wind performance and structural integrity of it's support and all necessary documentation and calculations to enable the appropriate planning approvals to be obtained for the aerial and it's support structure.

The Contractor shall supply and install all necessary low loss coaxial down leads for connection to the radio unit and lightning protection for the aerial system. The aerial masts shall be earthed in accordance with BS CP 326. The lightning protection system shall include use of aerial elements at earth potential, the aerial support structure, the test link and the earth rods/spikes.

8.9.7. MAST STRUCTURES

The Contractor may use the following mast types, however the Contractor shall assess the requirements for the mast structure and suitable alternatives for approval may be provided:

- a) 3m or 5m Pole
 - A 50mm diameter aluminium pole with a 300mm stand-off bracket kit for building mounting, aerial clamps and 15 metres of low loss coaxial cable.
- b) 6m pole
 - A free standing circular or octagonal column aluminium finish with bottom flush fitting door opening, tamper proof lock and stainless steel earth stud. Poles may be flange mounted or cast in a concrete foundation. A 35mm diameter PVC duct shall be installed between the pole and the RTU building. 25 metres of low loss coaxial cable shall be allowed at each 6m pole.

c) Guyed pole

- A 50mm diameter aluminium pole secured by stainless steel guyed lines mounted on a concrete base. A 35mm diameter PVC duct shall be installed between the pole and the RTU building. 25 metres of low loss coaxial cable shall be allowed at each guyed pole.

d) Lattice

- Lattice structures shall be constructed of steel and shall be hot dip galvanised to BS 791/71 to provide a maintenance free finish. The coaxial down-lead shall be enclosed within a galvanised steel conduit to a height of 2m above ground level. A 35mm diameter PVC duct shall be installed between the pole and the RTU building. 25 metres of low loss coaxial cable shall be allowed at each lattice structure.

8.10. PSTN COMMUNICATIONS

8.10.1. GENERAL

All equipment for connection to the PSTN lines shall be offered:

- a) To comply in all respects to the National and Local regulations and approvals.
- b) To comply with the most recent editions of appropriate CCITT Recommendations, National and International Standards Specifications and Recommendations.
- c) Such that any line sending and receiving sensitivity controls shall be capable of alteration by removal of the unit by authorised maintenance personnel.
- d) With evidence of prior use by major national telecommunications networks, together with type approval numbers and full details of CCITT Recommendations, National and International Standards Specifications and Recommendations met.

8.10.2. MODEMS

The Contractor shall supply and install all modems and interconnecting wiring to the SCADA system and telephone equipment as appropriate.

RTU equipment modems shall form part of the RTU unit and shall be compatible with the associated 'line connection' modules.

All modems shall be approved by the national and local service provider and shall comply with V21, V23, V26, and V29 (III-1) as appropriate.

8.10.3. ON SITE COMMUNICATIONS CABLES

On-site communications networks shall be Optical Fiber Cable.

9. TESTING

The Contractor shall provide for system testing as detailed. The tests shall conform to BS 5887 (code of practice for testing of computer based systems) and BS 6238 (code of practice for performance monitoring of computer based systems).

The Engineer shall approve all acceptance procedures for inclusion within the system specification.

9.1. FACTORY ACCEPTANCE TEST

9.1.1. GENERAL

The Tenderer shall provide for full Factory Acceptance Test of the fully configured system, to include:

- a) The complete system network.
 - ☐ Support for all RTUs with all points over an integrated network, simulated to include all types of communications units and interfaces.
- b) Mimic display pages on the system as defined within this specification.
- c) Test 1 - Simultaneous occurrence of:
 - ☐ The control centre polling outstations in normal (i.e. daytime) operational mode receiving 50% of data from each RTU with 10% of points in alarm conditions.
 - ☐ Operator workstations performing:
 - Simultaneous access.
 - Access staggered by 2 seconds.
- d) Test 2:
 - ☐ As test 1.
 - ☐ Performing daily system archive.
- e) Test 3:
 - ☐ As test 1.
 - ☐ Performing archive data recovery.
 - Full daily archive recovery.
 - Four data points for one week (15 minute intervals).
- f) Test 4:
 - ☐ As test 1.
 - ☐ Performing screen dump.
 - ☐ Printing daily report.

The simulation package shall use the SCADA system to demonstrate proper performance under full utilisation conditions.

The Contractor shall record the following:

- a) DISPLAY RESPONSE: This shall be no greater than as specified.
- b) PERCENTAGE CPU UTILISATION.
- c) SCAN TIME: This shall be no greater than 1 minute for full system scanning.
- d) TIME TO CLEAR BACKLOG: The Contractor shall also record any adverse conditions that become apparent.

The Contractor shall substantiate the validity of the simulation to the Engineer and shall confirm, at the time of Tender, by what means such simulation will be carried out.

e) The RTU to demonstrate:

- All control and failure recovery sequences, simulating all digital and analogue inputs and outputs on each system.

f) The communications system to demonstrate:

- Full simulation utilising all interface nodes, with RTUs connected, in order to prove the performance over the network. Communications failures shall be simulated in order to prove the automatic re-routing of communications to SCADA system.

9.1.2. FACTORY ACCEPTANCE TEST - WITNESSING

The Factory Acceptance Test shall be conducted in the presence of witnesses, who shall be nominated, in writing, by the Employer and the Contractor respectively. The witnesses shall be empowered to act during the Factory Acceptance Test, on behalf of the parties they represent, to judge the success or failure of a particular test. Either party as necessary, in writing may appoint nominated Deputies.

The Contractor shall provide evidence that the tests (FAT/SAT) have been successfully performed prior to the witnessing by the Engineer.

9.1.3. FACTORY ACCEPTANCE TEST - PROCEDURES

The testing procedures shall be designed such that each separate testable entity (e.g. hardware configuration, picture building) consists of a well-defined series of tests.

Each test shall be documented to include:

- a) The purpose of the test.
- b) Any pre-requisites required allowing the test to be completed successfully.
- c) Any hardware required allowing the test to be performed successfully.
- d) A detailed schedule of activities to be performed within the test.

9.1.4. FACTORY ACCEPTANCE TEST - RECORD

A log shall be maintained during the Factory Acceptance Test. This log shall record for each test performed:

- a) The test results.
- b) Any faults which occur.
- c) Any remedial action taken.
- d) Re-test results.
- e) Decisions taken by the witnesses which may affect the test results.

The witnesses of both parties shall initial all entries within the log.

Copies of the log shall be provided to the Employer on completion of the Factory Acceptance Test.

9.1.5. FAILURE AND RE-TEST

The success or failure shall be determined as follows:

- a) If the system performs as laid down in the Functional Design Specification the test shall be deemed successful.
- b) The tests shall not be failed due to external conditions, e.g. power fail, provided the system fulfils the resilience criteria detailed within this tender document and any subsequent project specification.
- c) The tests shall not be failed through incorrect operation provided the fault can be corrected by normal operating procedures and provided the test performed satisfactorily in all other aspects (e.g. printer ribbon failure).

Any test that is deemed unsuccessful may be retried following any remedial action that may be necessary.

If the system should fail any test and it is apparent that the fault may have affected the result of tests previously regarded as successful any or all of the tests affected may be re-tested.

To allow all participants to fully understand all aspects of the Factory Acceptance Test, the Factory Acceptance Test Specification as agreed between all parties shall be issued with the Contractor's Project Specification (CPS).

9.1.6. SYSTEM MANAGEMENT

The Factory Acceptance Test shall include, but not be limited to, the following as defined within Contractor's Project Specification.

- a) Hardware
 - The hardware configuration being tested shall be fully detailed and cross-referenced against the Tender Return Document.
- b) System Start-up and Shut-down Procedures
 - These tests shall exercise the system start-up and shut-down commands including:
 - System start-up commands.
 - Operator log-in and log-out commands.
 - Password verification.
 - Any special function command keys.
 - Orderly system shut-down.
- c) System Back-up and Recovery
 - These tests shall exercise the system back-up and recovery procedures, including:
 - System back-up to archive media.
 - Orderly system shut-down.
 - Synchronisation of the Master Station and outstations.

9.1.7. SCADA DATA BASE CONFIGURATION

These tests shall exercise the database commands including:

- a) Password and level of access maintenance.
- b) The creation and amendment of RTUs.
- c) The maintenance of RTU communications parameters, e.g. telephone numbers, radio characteristics, change of media, scanning intervals, on/off telemetry scan.
- d) Regions of interest.
- e) Creation and amendment of SCADA points:
 - ☐ Name.
 - ☐ Type, e.g. status, analogue, derived.
 - ☐ Alarm limits.
 - ☐ Historic data recording and characteristics.
 - ☐ Re-transmission of value to associated points.
 - ☐ Scaling factors.
 - ☐ Calculation formulae maintenance.
 - ☐ Set output control parameters for digital, analogue and derived controls.

9.1.8. PICTURE CONFIGURATION

The tests shall exercise the picture configuration commands available to the privileged operators, including:

- a) The creation of picture pages, to include foreground/dynamic and background/static picture elements.
- b) The modification of picture pages, to include foreground/dynamic and background/static picture elements.
- c) The deletion, copying and renaming of pictures.
- d) Any function control key usage.
- e) Examples of all picture types, e.g.:
 - ☐ Static information pages (e.g. indices).
 - ☐ Mimic pictures for information display and control monitoring.
 - ☐ Alarm list pages.
 - ☐ Statistical pictures (e.g. trends, histograms).
 - ☐ Help/text pages.
- f) The display and printing of pictures.

9.1.9. DATA COLLECTION

These tests shall exercise the data collection commands available to the privileged operators, including:

- a) The collection of digital, analogue and derived parameters.
- b) The collection of all data from outstations at frequencies defined by the privileged operator.
- c) The manual entry of data.
- d) The inhibition of data collection from a RTU.
- e) The inhibition of data collection from an individual point.
- f) The editing of stored data (subject to correct level of access).

9.1.10. SUPERVISORY CONTROL

These tests shall exercise the supervisory control commands, including:

- a) The creation and downline loading of control sequences.
- b) Digital, e.g. open/close, and analogue, e.g. set point, controls of individual control points.
- c) Revertive checks to ensure the correct control point is addressed.

9.1.11. ALARM/EVENT HANDLING

These tests shall exercise the alarm and event reporting procedures, including:

- a) Digital and analogue alarms:
 - ☐ Reported on the alarm/event printer.
 - ☐ Logged to disc.
 - ☐ Reported to the appropriate operator consoles.
- b) Events, e.g. issue remedial control command:
 - ☐ Are only issued from appropriate operator consoles.
 - ☐ Logged to the alarm/event printer.
 - ☐ Logged to disc.
 - ☐ Are subject to correct level of access and regions of interest.
- c) Alarm acceptance/acknowledgement procedures.
- d) Alarm list interrogation procedures.
- e) Alarm list printing.
- f) Alarm inhibit for an individual point.

9.1.12. DATA LOGGING

These tests shall exercise the data logging and archiving procedures including:

- a) Tests to ensure all data/alarms collected are logged to the on-line archive storage.
- b) Tests to ensure data can be archived to and recalled from long term archive media.

9.1.13. RTU PROGRAMMING

These tests shall exercise the RTU sequence programming procedures, including:

- a) Sequence program editing, compilation and loading.
- b) The ability to load new sequences on demand by a privileged operator.

9.1.14. MANAGEMENT INFORMATION SYSTEM DEVELOPMENT

These tests shall demonstrate the use of the enquiry package and the applications programs development tool kit, including:

- a) The editing and compilation of programs.
- b) The abstracting of data from the SCADA database.
- c) The automatic scheduling of programs as a result of time of day queues and as a result of a SCADA event/alarm.

9.2. SITE ACCEPTANCE TESTS

The Contractor shall provide for full site acceptance tests for each item of plant to be provided under the Contract. This shall include the interface to the marshalling unit, the communication system, the earthing system and full functionality as demonstrated at the Factory Acceptance Test.

9.3. SYSTEMS ACCEPTANCE TEST

The Contractor shall provide for full system test on completion to include tests as stated above.

All special test equipment relevant to the Contractor supplied equipment shall become the property of the Employer on completion.

10. TRAINING

The Contractor shall at time of tender state any minimum levels of training/experience required for participants, prior to attending the appropriate course.

The Contractor shall provide training for the Operator's staff as detailed. The Tenderer may offer training courses structured to meet his technical offering. These courses shall be subject to the approval of the Engineer and shall be detailed at the time of Tender.

In general training courses shall be provided at the WWTP as detailed within the General Conditions. However some courses may be held at the manufacturer's works as agreed to by the Employer.

The Contractor shall provide all course materials and equipment needed.

The training shall be organised such that the Employer's Operator shall be able to operate and maintain the SCADA scheme following completion of all training courses.

10.1. SYSTEM OPERATORS

The Contractor shall provide for 10 attendees selected by the Employer in accordance with the General Conditions.

This purpose-designed course is to be held at the Works Control Centre. Training must be provided in advance of commissioning to enable the Operator's staff to participate in the full process commissioning of the system and safely operate the plant and maintain the SCADA system.

System take-over shall not take place until satisfactory training has been provided.

This course shall be designed to familiarise the participants with the general running of the standard operating system and the SCADA package to include but not limited to:

- a) Loading and starting up the Operating System.
- b) System Operators interface.
- c) Operator control of program/task execution.
- d) Operator control of disc files.
- e) File transfer tasks - archiving, retrieval.
- f) Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database.
- g) SCADA system interrogation facilities - alarm lists, log printouts select mimic and trend displays etc..
- h) Alarm acknowledge accept/delete.
- i) Control actions, e.g. start pump, close valve.
- j) All functions associated with each access level of the SCADA system.

10.2. SYSTEM SUPERVISOR PERSONNEL

The Contractor shall provide a five-day course for 4 attendees selected by the Employer in accordance with the General Conditions Specification.

To be held at the Works Control Centre prior to the systems hand-over and shall consist of all of the above tasks plus:

- a) Basic systems design overview.

- b) The use of computers to perform diagnostics and to tune other parts of the system.
- c) Changing passwords and access control.
- d) Sequence verification.
- e) Preventative maintenance.

10.3. SYSTEMS DEVELOPERS/PROGRAMMERS/ENGINEERS

The Contractor shall provide 1 no. five day course for 2 attendees selected by the Employer in accordance with the General Conditions Specification.

This course shall be designed to cover all configuration and advanced facilities of the SCADA package. To include, but not be limited to:

- a) The system database structure.
- b) System database building/configuration.
- c) Mimic building.
- d) Applications program interface to the system database.
- e) Management information system interface.
- f) Downtime loading of control programs/sequences to RTUs.
- g) Advanced operating features.

10.4. SITE TRAINING

The Contractor shall liaise with the Engineer and the Employer on site as new areas of plant are to be changed over to the new system, to establish the following:

- a) What training is required for operating and maintenance staff?
- b) Who is to be trained?
- c) Who will provide the training and when?

The Contractor shall supply O & M documentation prior to training. A section of the plant shall not be handed to the Employer for operation until training on the control systems has been completed. Should defects occur prior to Take-over of the whole scheme the Contractor shall be responsible for rectifying the fault prior to any other phased hand-over of the scheme.

This training course/workshop shall be designed as a "reference" course rather than a formal educational course, i.e. the Contractor's personnel shall be present to assist the Operator's personnel, as necessary, with any technical difficulties.

11. OPERATIONS & MAINTENANCE DOCUMENTATION

11.1. GENERAL

This contract shall include full documentation for all equipment and software provided under this contract. The documentation shall be written in a clear and concise manner which is fully formatted and indexed to provide documentation that is easy to understand and friendly to use. It shall be capable of incorporating upgrades and amendments to information in an efficient and effective manner. Generally the documentation shall be compiled in A4 ring binders. Liaison will be required with the Engineer regarding the contents of the individual manuals.

All documentation shall also be provided on disk in the Employer standard format current at the letting of the contract. The Employer shall hold the copyright for these documents.

All drawings, unless within word-processing documents, shall also be provided in AutoCAD format on disk, or other media agreed to with the Employer. All documentation shall conform to ISO 6592 Code of Practice for Documentation of Computer Based Systems. The Tenderer may offer manuals structured to meet his technical offering. These manuals shall be subject to the approval of the Engineer and shall be detailed at the time of Tender. The documentation shall be submitted to the Engineer for approval.

11.2. FULL SYSTEM OPERATING PROCEDURES (6 NO. COPIES)

The Contractor shall provide full operating procedures detailing how to use the SCADA system, to include but not limited to:

- a) Loading and starting up the Operating System.
- b) System Operators interface, including:
 - ☐ System mimic navigation.
 - ☐ SCADA system interrogation facilities - alarm lists, event log printouts and trend displays etc.
 - ☐ Alarm acknowledge accept/delete.
 - ☐ Control actions, e.g. start pump, close valve.
 - ☐ All functions associated with each access level of the SCADA system.
- c) Operator control of program/task execution.
- d) Operator control of disc files.
- e) File transfer tasks - archiving, retrieval.
- f) Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronisation of the system database.

11.3. FULL SOFTWARE DOCUMENTATION (6 NO. COPIES)

The complete software specification shall be provided and shall include the system design specification, flowcharts, logic diagrams, system software definitions, program index, system build definition, and system data for each system and module. The information shall not be disclosed to any third party without the author's consent.

11.4. HARDWARE MANUALS (2 NO. COPIES)

The Contractor shall provide documentation for all equipment supplied within the Contract.

11.5. RTU PROGRAMMING DOCUMENTATION (1 NO. COPIE)

The Contractor shall provide a copy of all necessary RTU programming documentation as supplied by the RTU manufacturer.

12. QUALITY ASSURANCE

12.1. GENERAL

The SCADA Contractor shall be registered to ISO9001.

12.2. QUALITY PLAN

The Contractor shall provide a quality plan within 4 weeks of award of the contract.

12.3. SOFTWARE DEVELOPMENT

All software development shall be carried out under an EU-recognised quality system compatible with ISO 9001 that is defined in the quality plan.

12.4. PRODUCT AUDIT

The Engineer shall have the right to audit the product at any time during the contract period.

12.5. QUALITY RECORDS

The Contractor shall maintain quality records in line with the quality plan throughout the period of the contract. These will provide an audit trail for the design and implementation of the technical solutions adopted for the project.

12.6. ACCESS FOR THE ENGINEER'S REPRESENTATIVE

The Employer shall have the right to audit the project at any time during the contract period.

12.7. SUB-CONTRACTORS

The Contractor shall be responsible for the quality of any sub-contracted work and the quality plan shall incorporate all the work undertaken by sub-Contractors.

The Tenderer shall nominate his sub-Contractors in his tender return. The Contractor shall be required to obtain the Engineers approval (which will not be unreasonably withheld) to change any nominated sub-Contractor.

12.8. DELIVERY AND INSTALLATION

12.8.1. SCOPE

The Contractor shall be responsible for all costs involved with the delivery and installation of the equipment for the system.

12.8.2. DELIVERY

The Contractor shall provide all personnel and equipment necessary to unload the equipment and transport the equipment to its' final location.

12.8.3. INSTALLATION

The Contractor should be aware that there may be periods such as flood events or for operational reasons, that the Contractor will not be allowed to work on the system or some particular part of the system or RTU, for some specified period.

The Contractor shall make due allowances for this in his costing and programming of his installation and commissioning works.

12.9. SYSTEM RECOVERY

The Contractor shall supply a full backup set of the supplied software, on suitable archival media (e.g., CD-ROM, magnetic tape, optical disk, etc.). The Contractor shall also himself keep a full backup of the supplied software for the life cycle of the supplied equipment.

12.10. CONSUMABLES

The Contractor shall supply all consumables for the SCADA equipment for the duration of the contract, including, but not limited to:

- a) Printer paper.
- b) Printer ribbons/ink cartridges.
- c) Storage media.
- d) Cleaning materials.

12.11. SPARES AND TEST EQUIPMENT

The Contractor shall provide a list of recommended list of spares and test equipment required to the SCADA system.

oOo

SECTION 17200

INSTRUMENTATION, MONITORING AND CONTROL REQUIREMENTS

1. GENERAL

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all instrumentation, monitoring and control equipments, and shall be applicable to these works.

1.1. WORK INCLUDED

Various types of detectors and measuring instrument must be installed in the various areas of the process.

They are listed below :

1. Electromagnetic flow meter.
2. Capacitive Level Sensor.
3. Level Switch.
4. Ultra Sonic Level Sensor.
5. Temperature Sensor.
6. Sludge Blanket Level Detector.
7. H₂S Detector.
8. NH₃ Detector.

1.2. ELECTROMAGNETIC FLOW METER

The electromagnetic flow meters are located according to the table below:

Tabl. 1 - List of electromagnetic flow meters

Area	Description	Quantity
Primary Settling Tanks	Electromagnetic Flow meter for pipe DN 150	4
	Electromagnetic Flow meter for pipe DN 350	4
Sludge Building	Electromagnetic Flow meter for pipe DN 50	1

1.3. CAPACITIVE LEVEL SENSOR

The capacitive level sensors are located according to the table below:

Tabl. 2 - List of capacitive level sensors

Area	Description	Quantity
Inlet / By-pass / Screening	Capacitive level sensor	1
Grit and grease removal tanks	Capacitive level sensor in grease tank	1
	Capacitive level sensor in grit chamber	1
	Capacitive level sensor in foul water sump	1
	Capacitive level sensor in decanted water sump	1
Primary Settling Tanks	Capacitive level sensor for storage tanks	2
	Capacitive level sensor for lamellar tanks	4
Sludge Building	Capacitive level sensor for foul water tank	1

1.4. LEVEL SWITCH

The level switches are located according to the table below:

Tabl. 3 - List of level switches

Area	Description	Quantity
Primary Settling Tanks	Level Switch Alarm High High for storage tanks	2
	Level Switch Alarm Low Low for storage tanks	2
Sludge Building	Level Switch Alarm High High for foul water tank	1
	Level Switch Alarm Low Low for foul water tank	1

1.5. ULTRA SONIC LEVEL SENSOR

The ultra-sonic level sensors are located according to the table below:

Tabl. 4 - List of ultra-sonic level sensors

Area	Description	Quantity
Inlet / By-pass / Screening	Ultra sonic level sensor	3
Grit and grease removal tanks	Ultra sonic level sensor in well water storage	1

1.6. TEMPERATURE SENSOR

One temperature sensor is located according to the table below:

Tabl. 5 - List of temperature sensors

Area	Description	Quantity
Inlet / By-pass / Screening	Temperature sensor	1

1.7. SLUDGE BLANKET LEVEL DETECTOR

Sludge blanket level detectors are located according to the table below:

Tabl. 6 - List of sludge blanket level detectors

Area	Description	Quantity
Primary Settling Tanks	Sludge blanket level detector in lamellar tanks	4

1.8. GAS DETECTOR

The H₂S and NH₃ detectors are located according to the table below:

Tabl. 7 - List of gas detectors

Area	Description	Quantity
Primary Settling Tanks	H ₂ S detector	1
Sludge Building	H ₂ S detector	1
Sludge Building	NH ₃ detector	1

2. GENERAL REQUIREMENTS

2.1. APPLICABILITY

The clauses in this section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all instrumentation, monitoring and control equipment (excluding distribution switchgear and motor starter units), and shall be applicable to these works.

2.2. CONTRACTOR'S RESPONSIBILITY

The Contractor shall be responsible for:

1. All aspects of design, application and subsequent operation of the equipment, monitoring facilities and control circuits in accordance with all the operational requirements of this specification.
2. Liaison between subcontractors to ensure complete compatibility of all equipment at both component and system interface levels.

3. Overall systems engineering to ensure that all equipment, components and systems together form a consistent, rational and fully integrated monitoring and control installation.
4. Ensuring that each system is handed over complete in all detail and in perfect working order.
5. The supply and installation of all components, such as signal amplifiers, isolators, interference suppressors, line protection devices etc. which may be necessary to achieve the correct and specified function or to provide a safe and reliable installation, whether or not such components are specifically called for in the specifications.
6. Compatibility with existing monitoring and control installation of Stage 2, Phase 1, to ensure that all new and existing equipments will form a rational and integrated installation.

The approval by the Engineer of any drawing shall not relieve the Contractor from his complete design responsibility.

2.3. GENERAL DESIGN REQUIREMENTS

The Equipment shall be designed:

1. Such that routine and occasional maintenance through its life shall be a practical minimum, compatible with the preservation of maximum reliability.
2. To withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure.
3. And constructed to the highest available standards of manufacture, reliability, accuracy and repeatability.

Where more than one component or item of equipment is supplied to perform a particular function, all such items shall be identical and interchangeable.

The degree of environmental protection for all equipment and enclosures shall be in accordance with BS 5490 or IEC 529 as follows:

1. IP54 for internal applications.
2. IP55 for equipment in pumping stations and similar locations.
3. IPW55 for external applications.
4. IP67 for transducers and equipment mounted within valve or meter chambers or similar locations.

All instrumentation, monitoring and control equipment shall be designed and guaranteed suitable for operation under the environmental conditions.

Equipment in air conditioned locations shall be rated for continuous operation in ambient temperatures up to 40°C. External equipment and internal equipment not in air conditioned locations shall be rated for continuous operation over the ambient temperature range 0°C to 45°C. The above temperatures make no allowance for local temperature rises due to operation of the equipment itself or by adjacent equipment.

External equipment shall be protected from direct sunlight by a well ventilated cabinet, canopy or other approved type of sunshade.

2.4. DRAWING APPROVAL

Where there is no detail in the Specification or associated drawings regarding the exact location or method of installation of measuring equipment, sensors or other site mounted equipment, the Contractor shall submit details of his proposed installation to the Engineer for approval and obtain this approval before starting any installation work.

Further to Clause in Volume 2 Part 1.4, the drawings, diagrams and schedules to be submitted for approval at an early stage in the contract shall include the following:

1. System block diagrams.
2. Fully detailed P & I diagrams.
3. Control schematic diagrams showing clearly the operation of each system.
4. Analogue loop diagrams showing all relevant detail including instrument reference and loop impedances.
5. Power distribution diagrams for all instrumentation and control supplies.
6. Certified drawings and technical data for all instruments.
7. Drawings showing the location and relevant installation details for all panels and enclosures.
8. Instrument installation and hook-up drawings.
9. General arrangement drawings (internal and front panel) showing finish and relevant construction details for all panels and enclosures.
10. Comprehensive instrument schedules covering all primary, secondary and panel instruments, giving all relevant data including reference (tag) No, input range and output ranges, input and output impedances, scale, supply voltage, manufacturer, type number and the like.
11. Complete alarm schedules including legends, initiating contacts or equipment, and alarm grouping.
12. Cable specifications, cable route drawings and comprehensive cable schedules.
13. Interconnecting cable termination details.
14. Earthing details.

2.5. INSTRUMENTATION AND CONTROL SUPPLIES

2.5.1. SUPPLIES - GENERAL

All instrumentation, monitoring and control circuits and equipment shall be supplied at a voltage not exceeding 55 volts to earth. These shall be from:

1. A battery/charger unit, typically of 24 volt nominal output, but under no circumstances exceeding 48 volts nominal output.
2. A double wound transformer having a fused primary, a 55-0-55 volt secondary with the centre point earthed and each secondary line fused.
3. A transformer/rectifier system, comprising a double wound transformer with a fused primary and a secondary having one end earthed, together with full wave rectifier unit incorporating voltage stabilisation if necessary. The mean voltage of the rectified output shall not exceed the nominal output from the instrumentation battery/charger units.

Equipment such as battery/chargers, uninterrupted power supplies, inverters etc. shall be supplied as necessary to maintain the required electrical supplies to essential instrumentation, monitoring and control systems which are to be kept in operation during a main power failure. The essential equipment to be maintained during a power failure shall include workstations, mimic panels, control panels, alarm systems and flow measuring/indicating/recording/integrating equipment or as otherwise detailed in the application clauses.

2.5.2. REMOTE CONTROL SUPPLIES

On remote control/indication circuits (such as occur with valves, penstocks etc). d.c. voltages and relays shall be used in all cases where the cable capacitance could be of sufficient magnitude to maintain a.c. relays in an energised state. The Contractor shall be responsible for establishing where such d.c. operation of control/indication circuits is required and for providing a suitable supply at locations where an instrumentation battery/charger supply is not available.

2.6. CONSTRUCTION OF PANELS

2.6.1. GENERAL

All panels, cubicles, cabinets, consoles, and desks together with any other types of enclosure (excluding motor control centres and switchgear) which form part of the instrumentation, monitoring and control installation shall comply with the requirements of this Clause, and of Clauses 7 and 8 covering panel wiring, equipment and terminals.

Removable earthed metal gland plates shall be provided to accommodate all incoming/outgoing cables, and shall be fitted not less than 250 mm above the floor level.

All equipment, other than front of panel items, shall be mounted on racks or fixing bars and not directly onto the panels.

Each enclosure shall be vermin proof and dust proof with the necessary provisions made for natural or forced ventilation.

All panel construction and arrangement details shall be approved before manufacture, and panels shall be subject to inspection.

2.6.2. PANELS FOR INTERNAL USE

All instrumentation, monitoring and control panels, designed for use within buildings shall be constructed of prime quality, cold rolled and annealed mild steel or zinc coated sheet steel, of adequate thickness, welded and braced to form a rigid structure. The minimum sheet steel thickness shall be 1.6 mm, with panel fronts and desk tops being thicker (2.00 mm min) to provide the necessary strength to prevent bowing. Panel fronts shall be flat and free of bow and ripple. External corners and edges shall be rounded to give a smooth overall appearance. No

design involving the use of externally visible assembly bolts or screws will be accepted. All floor standing enclosures shall be constructed with a 60 mm deep plinth arranged to provide a recessed kicking strip at the front.

Equipment mounting panels shall be not less than 2 mm thick and shall be strengthened and/or braced to avoid any distortion or vibration. Equipment mounting plates and brackets shall, if necessary, be hinged to provide quick and easy access to equipment securing screws, terminals and wiring.

Doors and access panels shall be adequately braced or strengthened to avoid any buckling or twisting. Doors shall be of folded and welded construction mounted on lift-off hinges, with one hinge engaging before the other. Where necessary, removable access covers secured by quick release fasteners shall be provided. All doors and access panels shall close onto neoprene or soft rubber sealing strips which shall be held in place mechanically and not by adhesive. All doors shall be lockable. Where “Walk-in” panels or structure are provided, they shall be fitted with lockable car type handles operable from inside even when locked.

Surface preparation and finish shall be in accordance with the specification, with all internal surfaces finished in white. The external finish colour will be advised by the Engineer.

The design and construction shall be such as to provide an enclosure of superior quality which shall match all other panels in the same location in style, appearance and finish, and have environmental protection to IP54.

2.6.3. PANELS FOR EXTERNAL USE

All instrumentation and control cubicles, kiosks etc. designed for use outside shall be manufactured of double skinned, resin bonded fibreglass, with a totally encapsulated infill of rigid weather and “Boils” proof plywood or equivalent between the two skins.

The roof section shall have a totally encapsulated infill of end grain balsa instead of plywood.

Box section steel shall be encapsulated into door edges and door frames. Hinges shall be of high tensile, non-corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel reinforced surfaces.

The laminate material shall have flame retardant characteristics and shall retain stability, integrity and insulation for 30 mins when tested.

Colour impregnated gel coats backed by coloured resin shall be used to ensure maintenance free and “colour fast” finishes. The finish colour, both internal and external shall be white.

Door mounted meters and transparent windows shall be of glass. Cubicles and kiosks shall be provided with canopies to protect the top surface and any meter or window glass from direct sun light. There shall be an air gap of 100 mm between the top surface of the cubicle and the canopy.

All internal equipment shall be mounted on support built into the fibreglass structure. Fixing bolts through the skin will not be accepted.

Each cubicle shall be constructed to provide environmental protection to IP55.

2.7. PANEL WIRING AND EQUIPMENT

2.7.1. APPLICABILITY

The requirements of this Clause shall apply to all instrumentation and control cubicles, desks, cabinets, mimic panels etc., but not motor control centres or switchgear.

2.7.2. PANEL WIRING

Panel wiring shall be carried out using cable to the appropriate ISO or IEC Standards, installed in a neat, systematic manner, securely fixed and supported on insulated cleats or trunking, and arranged so as not to impede access to any internally mounted equipment.

Analogue signal cables and d.c. control cables at voltages not exceeding 48 volts (nominal) may be run together in the same cable bunch or trunking; but these cables shall be run separately from all other cables. In any cubicle, panel, or structure which is not fully enclosed (such as some mimic panel structures), all cabling which is or may be at a voltage in excess of 55 volts (nominal) to earth, shall be run in conduit.

For all cables, the sizing shall be fully adequate for the possible maximum loading, and derating shall be applied as appropriate for cable bunching and ambient temperature.

Identification ferrules shall be fitted to both ends of all wires, and shall be of the full circle type, threaded on to the cable such that all numerals are in line, and read outwards from the terminal.

Where stranded conductors are used, each end shall be fitted with a sleeved termination lug.

Terminations shall be restricted to one wire per terminal.

Cabling to door mounted equipment shall be bunched and cleated to form a loom with a loop of adequate length to allow easy door opening without causing strain to the components or cable.

Sharp edges of cubicles, trunking, components etc., which may be in contact with cables, shall be protected to avoid damage to cable insulation.

Requirements relating to terminals are covered in Chapter 2.8.

2.7.3. PANEL PROTECTION

All terminals and all live parts (on equipment) which are or may be at a voltage in excess of 55 volts (nominal) to earth, shall be enclosed by a protective cover, and carry a warning label stating the actual voltage.

For panels and enclosures covered under this section, the maximum potential between any two points within the panel or enclosure shall not exceed 250 volts.

Terminals and equipment which are supplied from other sources and which may remain live when the panel isolators are opened, shall be adequately protected and clearly labelled to this effect.

Adequate fuse protection for circuits and sub-circuits shall be provided and arranged such that any fuse failure causes the minimum disruption to controls and indications, and that any such fuse failure cannot create an unsafe operating condition. Fuses shall be of the HBC cartridge type with plastic moulded carriers and bases.

2.7.4. PANEL EARTHING

A copper earthing bar shall be provided and bonded electrically to the main frame. It shall be provided with suitable brass screw terminals for the connection of the metal cladding, instrument frames, gland plates, cable tray, the armouring of all incoming cables and the site earthing system.

2.7.5. PANEL/LIGHTING

Each enclosure shall be fitted with fluorescent lamp fittings to provide adequate and even illumination. Each lighting circuit shall be individually fused and switched.

2.7.6. PANEL HEATING

Each enclosure shall be fitted with one or more heaters to prevent condensation and assist ventilation. The heaters shall be so arranged and located that no deterioration can be caused to any equipment or wiring. The surface temperature of any part which may be accidentally contacted shall not exceed 65°C. The heating circuit shall be supplied via a fuse, an isolator and a Hand/Auto switch. In the "hand" position the heater shall run continuously and in the "auto" position the heater shall be controlled by a thermostat or humidistat. All switches and controls shall be mounted within the enclosure.

2.7.7. PANEL EQUIPMENT

A fuse and isolating switch shall be provided for each incoming a.c. and d.c. supply.

Where instrumentation, monitoring or control equipment is to be operated on ac. supplies derived from within the cubicle, a 110 volt (55-0-55) control transformer (or transformers) shall be provided for this duty. Each micro-processor and/or programmable logic controller shall have its own control supply transformer.

Each cubicle shall be complete with a distribution unit providing an adequate number of fused outlets at 110 volts (55-0-55) for possible future requirements.

For internal panels only, a minimum of two, three-pin switched socket outlets shall be provided. These shall be mounted within the enclosure, shall operate at the panel supply voltage and shall carry a label clearly stating the voltage and rating.

All items of equipment mounted within the enclosure such as relays, electrical transducers, indicators, recorders, switches fuses, terminals etc. shall be arranged so as to provide easy access, be securely fixed and clearly labelled as to their function, designation, and where applicable, the voltage.

Where meters and recorders are mounted on vertical fronted panels, the mounted height shall be based on the height of the centre line above finished floor level as follows:

- Indicating Meter: 1.35 m. min. to 1.90 m. max.
- Recorders: 1.45 m. min. to 1.85 m. max.

2.7.8. LABELS

All labels for panels and other items as specified shall be provided in accordance with corresponded Clause.

Panels with doors which are not interlocked with an isolator (or isolators) giving complete protection shall carry a warning label having white letters on a red background as follows:

“DANGER LIVE TERMINALS” both in English and Armenian.

The relevant voltage shall be stated.

2.8. TERMINALS AND TERMINATIONS

Terminals for the connection of all incoming/outgoing cables shall be provided and comprise anti-tracking mouldings of melamine, phenolic or comparable material fitted on a purpose built mounting rail. The conductors shall be secured by screw clamps or bars, but not pinch screws.

All terminals used on circuits not exceeding 55 volts (nominal) to earth, excluding power supplies and auxiliary drives, shall be of the disconnecting link type.

Every terminal shall carry a clear identity number. Terminals at different voltages shall be grouped separately, and each group shall be clearly labelled with its respective voltage and function.

Transparent protective covers complete with voltage warning label shall be provided on all terminals which are, or may be, at a voltage in excess of 55 volts (nominal) to earth.

Sufficient terminals shall be provided for terminating all cores of all cables (including spares) associated with the particular enclosure. The number of terminals shall be sufficient to cater for all anticipated requirements plus 20% spare terminals and 30% spare terminal rail.

Terminals for connecting to incoming/outgoing cables shall be mounted vertically wherever possible and arranged to provide easy access and to enable ferrule numbers to be read without difficulty. Direct termination onto such equipment as distribution boards, fuses or miniature circuit breakers is not acceptable.

2.9. 24VDC SUPPLY FOR CONTROL

2.9.1. GENERAL

This Clause covers the requirements for 24 VDC supply, specified in the application clauses for the Operation of Control, Instrumentation, Alarm and Monitoring equipment, but not for switchgear tripping/closing batteries or other special function batteries.

220 VAC uninterruptible power supplies (UPS) must be provided for the supply of the equipment through control cabinets and panels. These UPS 220 VAC must be sized to enable the supply of the control components through a 220 VAC / 24 VDC convertor installed in the relevant control cabinets and panels to be installed in control rooms.

Where alternative a.c. supplies are available, provision shall be made for taking the supply to the UPS from either source (e.g. from either side of the bus-section switch) with facilities for changeover from one source to the other in the event of failure of the supply source.

The UPS unit shall form a composite unit and be housed in a single, sheet steel, floor standing cubicle having adequate ventilation and separate compartments for the batteries, chargers and inverter.

2.9.2. BATTERIES

The batteries shall be of the nickel cadmium type with a normal cell output of 1.4 volts, and shall be of adequate capacity to maintain full operation of the specific load equipment plus a further

10% for a period of 4 hours during mains failure, unless specified otherwise in the application clauses, and assuming a normal charge condition at the start of the mains failure.

The battery cases shall be made of translucent, high impact polystyrene so that the electrolyte level can be seen through the battery casing.

All batteries shall be suitable for the intended service under the prevailing site conditions without excessive gassing or loss of electrolyte.

2.9.3. BATTERY CHARGERS

Duplicate chargers, one “duty” and one “standby” shall be provided and mounted on their own respective chassis in the upper cubicle compartment.

The controls for each charger shall be mounted on their own respective mounting plates, and these, together with all controls and indications projecting through the front of the upper compartment cabinet section shall be positioned at a height not exceeding 1 800 mm from floor level.

Each charger mounting plate shall contain:

- 1 “ON/OFF” Main switch.
- 1 Charger output Ammeter.
- 1 Charger output Voltmeter.
- 1 Lamp to indicate “Boost Charge” (Red).
- 1 Lamp to indicate “Float Charge” (Green).
- 1 Lamp to indicate “Charger Failed” (Red).
- 1 Lamp to indicate “High DL Voltage” (Red).
- 1 Lamp to indicate “Low DC Voltage” (Red).
- 1 Lamp “test button”.

Each charger unit shall also be provided with:

- 1 “Float/Boost” selector switch, mounted internally.
- 1 set of a.c. supply fuses for each charger unit.
- A volt-free contact for charger failed alarm.
- A volt-free contact for low d.c. output voltage alarm.
- A volt-free contact for loss of d.c. output voltage alarm.

The above volt-free contacts shall open under fault conditions and be wired to a terminal block.

The battery charger unit shall also be provided with one set of full capacity rated output/d.c. terminals and fuses.

In the event of failure of the duty selected charger, the standby charger shall be connected automatically, and contacts for the remote alarm indication shall be provided. The alarm indications of the failed charger unit shall remain on until the duty charger has been repaired and returned to operation.

Reversion from “Standby” to “Duty” charger shall be a manual operation.

The chargers shall be of the solid state constant potential type, and shall be designed to regulate the charger output voltage to within +1 % for a mains input voltage variation.

The d.c. terminal voltage shall be further regulated such that under “Float” or “Boost” charge condition the d.c. voltage does not rise more than 10% of nominal.

The charger unit shall also be provided with both short circuit and reverse polarity protection.

All internal and external components shall be labelled in accordance with the Specification.

The cabinet shall be manufactured in accordance with Clauses 6.1 and 6.2 but with additional treatment to the interior surfaces to prevent any corrosion by battery chemicals and with environmental protection to IP52.

Internal wiring shall be in accordance with Clause 7.

Terminals and their positions shall be in accordance with Clause 8.

For each battery/charger unit, the Contractor shall supply a set of maintenance tools, spares and hydrometer; all of which shall be contained and secured within the charger cabinet.

The Contractor shall fix inside the cubicle a wiring diagram indicating and identifying all out-going terminals, components and fuses.

Special precautions shall be taken in the sizing of the battery and charger for tropical use, and all equipment shall be adequately rated for the prevailing site conditions.

2.9.4. INVERTER

Inverters shall be solid state type and shall provide a single phase output at 220 VAC.

Inverter mounting plate shall contain:

- 1 “ON/OFF” Main switch.
- 1 AC output Ammeter.
- 1 AC output Voltmeter.
- 1 AC output Frequency.
- 1 Lamp to indicate “Load on inverter” (Green).
- 1 Lamp to indicate “Load on reserve” (Yellow).
- 1 Lamp to indicate “Maintenance” (Red).
- 1 Lamp to indicate “Reserve fault” (Red).
- 1 Lamp to indicate “Inverter unsynchronized” (Red).
- 1 Lamp to indicate “Overload inverter built” (Red).
- 1 Lamp to indicate “Inverter fault” (Red).
- 1 Lamp to indicate “Inverter over voltage” (Red).
- 1 Lamp to indicate “Inverter bridge fault” (Red).
- 1 Lamp to indicate “Inverter over temperature” (Red).
- 1 Lamp to indicate “DC high voltage” (Red).
- 1 Lamp to indicate “Imminent shutdown” (Red).
- 1 Lamp to indicate “End of discharge” (Red).
- 1 Lamp to indicate “AC earth fault” (Red).
- 1 Lamp to indicate “General fault” (Red).
- 1 Lamp “test button”.
- 1 Lamp “reset button”.

Inverters shall have the following characteristics:

- Maintain an output frequency constant within $\pm 1\%$ of nominal.
- An adjustable ac output voltage of $\pm 5\%$ at nominal dc input voltage.
- A maximum deviation of ac output voltage of $\pm 2\%$ over the entire ranges of load, dc voltage and power factor.
- Be capable of continuous operation under the ambient temperature specified.
- A limited overload capacity.
- An in-built current limiting circuit to provide short circuit protection.
- An ac output filter to limit the total harmonic voltage distortion across linear loads to 5%, over the entire range of load, voltage and power factor.
- A dc input filter to ensure that the r.m.s. value of ac voltage does not exceed 5% of the dc voltage.
- A totally enclosed floor mounting sheet steel enclosure with front access doors.
- The cabinet shall be manufactured in accordance with an environmental protection to IP52.

2.10. ALARM SYSTEMS

2.10.1. ALARM SYSTEMS - GENERAL

All alarm systems throughout the whole site shall be of the same type supplied in accordance with this Clause, and to the requirements of the specific application clauses.

Although it is intended that all alarms shall be initiated by contacts which open under fault conditions, each alarm channel shall be individually capable of accepting an input from contacts which open or close on occurrence of a fault.

The Contractor shall ensure that all necessary alarm initiating facilities are provided.

Each alarm system shall:

1. Be supplied complete with an annunciator having two lamps to each light box.
2. Include facilities for operating one local and two remote audible units. The local units shall be supplied and installed in the same panel as the annunciator. The remote units, if required, shall be supplied and installed in accordance with the specific application Clauses. All audible units shall be suitable as regards output and degree of environmental protection, for the particular application and location.
3. Have fully equipped alarm channels for all the alarms ultimately required, together with 10% (one for every ten or part thereof) plus two, spare channels.
4. Have alarm logic incorporating a short built-in delay (say 0.25 to 1.0 sec) to avoid initiation of an alarm from a fleeting contact.
5. Be supplied from the relevant UPS and AC/DC power supply.

A rapid flashing indication is acceptable as an alternative to the dim lamp facility specified in the following sub-clauses.

2.10.2. LOCAL ALARM SYSTEMS

Local Alarm Systems are defined as those systems which are installed at various locations round the site, as opposed to the Central Alarm System detailed in chapter 2.10.3.

Each local alarm system shall comply with the requirements of Clause 10.1 and shall:

1. have manual reset facilities and be complete with “Reset”, “Alarm Accept” and “Lamp test” push buttons.
2. have facilities for grouping alarm signals for display at the local annunciator and for grouping alarms for transmission to the Works Monitoring Centre. The alarms transmitted to the Works Monitoring Centre shall be maintained until “reset” at the local alarm system.
3. have the following alarm sequence:

Condition	Visual	Audible
Normal	Off Off	Off
Alarm Flash	Flash Flash	On
Accept (alarm still on)	Steady Steady	Off
Return to Normal after Accept	Steady Steady (dim)	Off
Reset	Off Off	Off
Return to Normal before Accept	Flash Flash (dim)	On
Accept (after return to Normal)	Steady Steady (dim)	Off
Reset	Off Off	Off

2.10.3. CENTRAL ALARM SYSTEM

The Central Alarm System is that system which is located in the works monitoring/control centre, and is normally located in the administration building.

The central alarm system shall comply with the requirements of chapter 2.10.1 and shall:

1. have automatic reset facilities and be complete with “Alarm Accept” and “Lamp Test” push buttons,
2. have an additional output for each alarm channel to provide signals to a possible future event recorder or data logger,
3. have the following alarm sequence:

Condition	Visual	Audible
Normal	Off Off	Off
Alarm	Flash Flash	On
Accept (alarm still on)	Steady Steady	Off
Return to Normal after Accept	Off Off	Off
Return to Normal before Accept	Flash Flash (dim)	On

2.10.4. BATTERY MAINTAINED ALARM SYSTEMS

At locations where the alarm system is to be maintained during a period of power failure, the UPS shall be sized to maintain full operation for: a period of 4 hours, assuming the UPS battery to be in a normal charge condition prior to the failure.

2.10.5. MAINS POWERED ALARM SYSTEMS

At locations having a mains powered alarm system, a power failure alarm shall be provided as detailed below. Where applicable, provision shall be made for taking the supply from a UPS unit with dual battery charger system and manual changeover from one battery charger to the other in the event of failure of supply. The alarm and annunciator system shall be operated from a 24 volt dc supply.

2.10.6. POWER FAILURE ALARMS

At all places where plant and/or switchgear are located, there shall be a power failure alarm incorporating a 5 second time delay. This alarm shall be initiated in the event of a total power failure, and at locations having dual feeders, both incomers shall be “dead” before the alarm is initiated.

For mains powered systems, this alarm shall be independent of the alarm system and shall be connected directly back to the Area Monitoring Centre alarm system. The alarm initiation shall be by a relay (or relays) which shall be energised under normal conditions, and de-energised under loss of supply so as to open the initiating contact (or contacts).

The alarm legends shall be of adequate size to ensure that they are easily readable from the normal operating or viewing location.

2.11. FLOW MEASUREMENT THROUGH PIPELINES

2.11.1. MAGNETIC FLOW METERS

Magnetic flow meters shall be provided in accordance with the following:

1. Meters shall be of the short form, having a modulated, direct current excitation and inherent total zero stability.
2. The power consumption shall not exceed 16 watts per 100 mm of diameter.
3. The output shall be 4-20 mA and the system accuracy shall be within $\pm 0.5\%$ of rate. Test certificates shall be provided.
4. The field coils shall be fully encapsulated.
5. The equipment shall be guaranteed suitable for the ambient and process liquid temperatures.
6. Each flow meter primary shall be supplied with a polyurethane or PFA liner and electrodes of the material best suited to the particular process fluid.
7. Primary units shall be suitable for accidental submergence to a depth of 3 metres.
8. The Contractor shall provide primary units having flanges in accordance with the relevant mechanical clauses relating to pipes, flanges, fittings, etc..
9. The Contractor shall ensure that all primary units are rated well in excess of the maximum possible process fluid pressure, including possible surge pressures.
10. Each primary unit shall be supplied and installed complete with a flange adaptor coupling or similar approved arrangement to permit removal for repair or inspection.

11. The Flow meter equipment shall be supplied complete with amplifier (converter), drive unit (if applicable) and all cable for connecting between the components.
12. The amplifier/converter shall be fully screened to prevent interference from adjacent equipment.
13. The amplifier/converter shall incorporate voltage stabilisation to ensure maintenance of system accuracy with a supply variation from 85 to 260 VAC.
14. The Contractor shall provide a length of pipe having the same length and being flanged as the flow meter primary, to replace the meter should this have to be removed for repair.
15. Each installation shall be provided with ultra-sonic electrode cleaning equipment. This equipment shall be installed complete with the necessary switches, push-buttons, timers etc.

Where a number of identical units are being provided, replacement flanged pipes detailed under item o) shall be provided on the basis of one for every four (or part thereof) primary units.

2.11.2. THERMAL MASS FLOW METERS

Thermal Mass flow meters shall be provided in accordance with the following:

1. Meters shall be of the probe type fitted on welded sleeve.
2. The power consumption shall not exceed 5 Watts for any pipe diameter.
3. The output shall be 4-20 mA and the system accuracy shall be within $\pm 2\%$ of rate. Test certificates shall be provided.
4. The probe shall be of draw-out type and shall be removable without interrupting the service.
5. The equipment shall be guaranteed suitable for the ambient and process liquid temperatures.
6. Each sleeve shall be supplied with a lining as specified for steel pipes and probe shall be of the material best suited to the particular process fluid.
7. Primary units shall be suitable for accidental submergence to a depth of 3 metres.
8. The Contractor shall provide carbon steel sleeves having flanges in accordance with the relevant mechanical clauses relating to pipes, flanges, fittings, etc.
9. The Contractor shall ensure that all primary units are rated well in excess of the maximum possible process fluid pressure, including possible surge pressures.
10. Each primary unit shall be supplied and installed complete with a flange adaptor coupling or similar approved arrangement to permit removal for repair or inspection.
11. The Flow meter equipment shall be supplied complete with amplifier (converter), drive unit (if applicable) and all cable for connecting between the components.
12. The amplifier/converter shall be fully screened to prevent interference from adjacent equipment.

13. The amplifier/converter shall incorporate voltage stabilisation to ensure maintenance of system accuracy with a supply variation from 20 to 30 VDC.
14. The Contractor shall provide a length of pipe having the same length and being flanged as the flow meter primary, to replace the meter should this have to be removed for repair.

Where a number of identical units are being provided, replacement flanged pipes detailed under item o) shall be provided on the basis of one for every four (or part thereof) primary units.

2.12. ULTRA-SONIC LEVEL

2.12.1. CONSTRUCTION

Where such equipment is specified in the relevant application Clause, level measurement shall be accomplished the use of non-contact, echo-time measuring equipment operating at ultra-sonic frequency. The equipment shall transmit pulses which are reflected back to the sensor from the surface of the liquid whose level is being measured.

The equipment shall consist of a sensor or transponder incorporating both transmitter and receiver, together with a separate control unit.

The equipment shall be provided with automatic temperature compensation shall be suitable for operation in the designated application under the climatic conditions.

The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall be totally enclosed and hoseproof with environmental protection to IP55 or IP67, as appropriate.

The control units shall incorporate facilities for adjusting independently both zero and span, and shall have an output of 4-20 mA proportional to level.

The overall accuracy of the level measurements shall be within $\pm 0.1\%$ of the instrument span.

The connection between the sensor and control unit shall be via commercially available screened cable, and the equipment shall operate with up to 150 metres of such cable.

The Contractor shall ensure that each equipment, particularly with regard to the transmitted beam angle or cone and the blocking distance, is suitable for the application.

2.12.2. INSTALLATION

The sensor shall be installed on a structure provided for the purpose. The structure shall have a square hole approx. 300 x 300 mm at the sensor mounting position.

Under this Contract, a stainless steel mounting plate of not less than 430 x 430 mm shall be provided. This plate shall be drilled to take the sensor and bolted securely to the civil structure. The Contractor shall ensure that, when bolted down, the mounting plate is exactly horizontal, so that the ultra-sonic beam will be perpendicular to the liquid surface.

The Contractor shall, where applicable, provide a canopy around and/or above the sensor and/or control unit to provide protection from direct sunlight.

2.13. ULTRA-SONIC OPEN CHANNEL FLOW MEASUREMENT

Where ultra-sonic equipment is specified in the application clauses for measuring flow in open channels, the equipment shall be supplied and installed in accordance with chapter 2.12, but shall, in addition, include a lineariser either as a separate matching unit or incorporated within the control unit.

The lineariser shall convert the level signal into a 4-20 mA signal proportional to flow in accordance with the type of flume or weir being used.

The overall accuracy of the level measuring and linearising equipment shall be within $\pm 0.2\%$ of the instrument span.

2.14. ELECTRODE LEVEL CONTROL EQUIPMENT

Electrode level control equipment shall consist of a control unit or units and a number of electrodes.

For all applications, sufficient electrodes and associated controls shall be provided to prevent "hunting" between the two states.

The Control Unit shall:

1. Be of modular style and totally enclosed except for the front panel mounted terminals, controls and indications.
2. Have all live parts at a voltage in excess of 55 volts to earth completely shrouded and complete with warning labels.
3. Have an output relay with double pole changeover contacts of suitable material for the application.
4. Have all internal equipment tropicalised, but without potting on the printed circuit boards.
5. Have a light emitting diode mounted on the front panel to indicate when the relay is energised.
6. Have a lockable sensitivity control potentiometer.
7. Be designed for operating from a 230 volt a.c. supply.
8. Be capable of operating at a distance of up to 100 m from the electrodes.
9. Have a voltage on the electrodes not exceeding 25 volts.

The electrodes and holder shall comply with the following:

1. The electrode holder shall be fully weatherproof, constructed from die-cast aluminium and provided with a mounting flange having a minimum of 4 No. fixing holes.
2. The electrode holder shall be designed to allow a minimum of 75 mm adjustment of the electrode length.
3. The electrode shall have glazed ceramic insulator cemented to the metal housing.

4. The electrodes shall be of 18/8 stainless steel grade 316L to BS 970 Part 4 or equivalent, having a minimum O.D. of 25 mm and a wall thickness not less than 2.6 mm. The lower end of the electrode shall be sealed, and the upper end shall be locked to the ceramic insulator by a brass clamp.
5. Cable entry shall be via a standard screwed gland entry.
6. Each electrode shall be firmly secured to avoid any movement due to turbulence or flow velocity. The securing brackets shall be of the same material as the electrode and shall be installed above top water-level.
7. Where electrodes pass through securing brackets, they shall be protected by heat shrunk sleeving extending from 300 mm above the bracket to 300 mm below the bracket.

All brackets and fixings as required for the complete installation shall be provided.

2.15. FLOAT SWITCHES

Float switches shall be the pendant type with the float suspended on a flexible cable, such that with the float free of the liquid, the float and cable hang vertically, but with a rising liquid level the float shall rise and tend to invert.

The float shall be of robust design and comprise a mercury switch having changeover contacts encapsulated in a hard plastic foam and connected to a 3 core cable. The whole assembly shall be covered and hermetically sealed in polypropylene or similar material.

With the tilting action which occurs on rising level, the contacts shall change over, but there shall be a dead band between opening one contact and closing the other, during which period the contacts shall be open. This dead band shall operate over an arc approximately 20° either side of the horizontal.

The contacts shall be rated for a minimum of 10 amps at 230 volts. The voltage on the contacts shall not exceed 55 volts nominal to earth.

In all applications, the installation shall be complete with approved means of preventing the float (and lead) from movement due to wind or liquid turbulence.

Where float switches are to be used in applications under which they may be submerged during normal operation (e.g. pump control and or low level alarm); they shall be attached to a weighted chain to minimise movement due to turbulence and also provide a means of raising the units for maintenance and repair.

All brackets, fixings etc. as necessary for the complete installation shall be provided. The chain/float assembly shall be installed such that the point of suspension is not less than 400 mm from any side wall.

2.16. TEMPERATURE MEASURING EQUIPMENT

2.16.1. TEMPERATURE METERS

Unless otherwise specified, platinum resistance elements shall be used for measuring spans of up to 200°C and chromel-alumel thermocouples for spans exceeding 200°C.

Each temperature sensor, unless otherwise specified, shall have a stainless steel thermowell, or pocket-and-extension assembly, non-corrodible metal sheath and waterproof terminal head.

Pockets for steam, oil and pressurised-water lines shall be welded; pockets for other duties shall be screwed.

The sensor assembly shall be designed to permit removal of the temperature element without twisting the leads.

2.16.2. PLATINUM RESISTANCE THERMOMETERS

Platinum resistance thermometers shall comply with BS 1041 Parts 2 and 3 and BS EN 60751.

Sensors shall have a resistance of 100 ohms at 0°C and shall conform to the European standard curve (DIN 43720), where $\alpha = 0.00385$. Each element shall be artificially aged during manufacture. Terminal heads and amplifiers shall be designed for four-wire connections between head and amplifier.

Platinum resistance elements shall be spring-loaded and fully encapsulated in ceramic material and the elements and high-temperature-resistant lead wires shall be hermetically sealed. The associated resistance-to-current converters shall have zero and span adjustments and input-output circuit isolation.

2.16.3. THERMOCOUPLES

Thermocouples shall be of the mineral-insulated type and unless otherwise specified shall be of the chromel-alumel (nickel-chromium v nickel-aluminium) type. Thermocouple junctions shall be welded. Ceramic-insulation material may be used for base-metal thermocouples but low-silicon insulation material shall be used for noble-metal thermocouples. Thermocouple systems shall have thermoelectric ice point reference chambers or receivers or amplifiers with automatic cold junction compensation.

Thermocouple receivers and amplifiers shall also have zero and span adjustment, common and series mode interference rejection circuits, radio-frequency filters, input-output circuit isolation and thermocouple break feature whereby the output is driven to zero or full-scale, as stipulated by the Engineer, when the receiver or amplifier input circuit is broken.

Thermocouple elements shall be electrically isolated from their sheaths but each terminal head shall have facilities for earthing the thermocouple and for terminating the screen of the extension or compensation cable. Amplifier chassis shall have facilities both for being earthed to the instrument case via a capacitor and for being electrically isolated from the instrument case.

2.16.4. TEMPERATURE SWITCHES

Temperature switches shall have contacts with differing 'cut-in' and 'cut-out' values. Their nominal operating points shall be fully adjustable over the whole range of the instrument and the set-value shall be clearly indicated by a dial and pointer.

2.17. PRESSURE TRANSDUCER LEVEL MEASURING EQUIPMENT

2.17.1. CONSTRUCTION

Pressure transducer level measuring equipment shall comprise a strain gauge or differential transformer type pressure transducer, a controller/transmitter and be complete with all necessary cable, conduits etc. as detailed below.

The pressure transducer shall be enclosed within an all welded, stainless steel case not less than 19.0 mm dia. and shall:

1. Have a single moulded cable which is securely bonded to the transducer case and comprise electrical connections, venting tube, strain wire or cord and an outer covering of material suitable for the application.
2. Be suitable for continuous immersion on all wastewater applications including raw sewage, primary sludge, secondary sludge and thickened sludge.
3. Be constructed so that the sensor diaphragm is protected against damage by shock, debris etc., without restricting the transference of pressure changes from the surrounding medium.
4. Incorporate automatic temperature compensation.
5. Withstand a continuous overpressure of up to 400% without sustaining permanent deformation or calibration change.

The controller/transmitter shall:

1. Be suitable for mounting within a control panel.
2. Accept the signal from the transducer and provide a 4-20 mA output proportional to level (gauge pressure), for indication and control.
3. Include independent zero and span adjustment.

The complete system shall:

4. Operate with up to 100 m of cable between transducer and controller/transmitter.
5. Provide an accuracy within $\pm 0.1\%$ of the span with a linearity better than $+0.1\%$.

2.17.2. PRESSURE TRANSDUCER INSTALLATION

For installations where the sump depth is in excess of 3 m or where the available headroom over the sump is limited, the pressure transducer shall be installed within a 100 mm dia. GRP tube to provide protection against mechanical damage to both the transducer and the cable. The GRP tubing shall have an adequate number of holes and/or slots to allow it to fill and drain as the level varies. The tubing shall be fixed to the sump wall at intervals not exceeding 2.5 m.

For installations where the sump depth does not exceed 3 m, the sensor shall be supplied and installed as a rigid assembly comprising a stainless steel tube, a tube holder (both as used for control electrodes) and the transducer, with the cable passing through the tube. The transducer shall be a close fit located completely within the tube at the lower end. The assembly shall be fixed at not less than two places to the sump wall and installed with the bottom of the tube clear of the sump invert.

For all installations, the cable between the transducer and the controller/transmitter shall be a continuous length, and kept as short as is reasonably possible. This cable shall be run in conduit and installed well clear of all a.c. mains and power cables.

All fixings, brackets etc. as required for the complete installation shall be provided.

2.18. APPLICABILITY

2.18.1. INDICATING METERS AND METER RELAYS

All indicating meters and meter relays for use in control and instrumentation panels, control desks, mimics, etc. shall comply with this chapter and the appropriate sub-chapter.

2.18.2. GENERAL REQUIREMENTS

All meters and meter relays:

1. Shall comply with IEC 51 to accuracy Class 1 for instruments having a d.c. input and accuracy Class 1.5 for instruments having an a.c. input.
2. Shall have a linear scale with clear graduations and markings.
3. Shall have the units of the measured variable and any multiplying factor clearly marked on the scale plate.
4. Shall have an external zero adjustment.
5. Shall be flush mounting with matt or semi-matt black bezel.
6. Shall match all other instruments on the same panel or on similar panels in the same room as regards style, finish and appearance.
7. Intended for installation within a control room shall be fitted with anti-glare or low reflectivity glass.
8. Intended for installation on an inclined surface shall be suitable for that application, and when so mounted, the accuracy shall be maintained over the full range.
9. Having a 4-20 mA input shall have an off-set zero, so that an input of less than 4 mA will result in an indication below the scale zero.
10. Shall be specified by the manufacturer as being designed for operations over the range 0°C to 50°C at up to 75% humidity and be suitable for storage over the range -10°C to +65°C.

2.18.3. INDICATING METERS - RECTANGULAR

These shall comply with chapter 2.17.2:

1. Shall have a rectangular format of not less than 48 x 96 mm.
2. Shall be multifunctional one channel display with universal input, loop power supply, limit monitor and analogue output.

2.18.4. LEVEL/CONTENTS INDICATIONS

Meters indicating levels, tank contents and Indicators similar quantities shall comply with chapter 2.17.2, have a vertical edgewise format and shall be solid state bar graph indicators. Instruments having a curved scale plate will not be acceptable for these applications. The top water level shall be marked on the scale.

Bar graph indicators shall have a dot matrix LED display and minimum dimensions of 144 x 36 mm.

2.18.5. POSITION INDICATION

Indicator lamps for valves and penstocks indication position shall comply with chapter 2.17.2.

2.18.6. METER RELAYS

Meter relays shall comply with chapters 2.17.3 or 2.17.4 but shall additionally incorporate one or two adjustable set point contacts for alarm or control.

The set points shall be visible and adjustable from the front.

The alarms/controls shall have volt-free output contacts.

2.19. INTEGRATORS AND COUNTERS

2.19.1. GENERAL

The integrator and counter may be combined into the flow measurement instrument, or the integrator may be mounted remotely from the numerical display unit.

The counter shall be flush mounting with a matt or semi-matt black bezel, and shall match all other instruments on the same panel as regards style, finish and appearance.

If a counter reset facility is provided, this shall be arranged such that accidental operation is impossible, and should preferably not be located on the front panel.

A low signal cut-off facility shall be provided on all integrators, and this shall be adjustable over the range 0.5% to 5% of the flow.

Integrated flows shall be in cubic meters per second and this, together with the measurement designation and any multiplying factor shall be clearly marked on the face of the counter, or on a matching label immediately below the counter.

Unless otherwise stated in the specific application Clause, the multiplying factors shall be as follows:

Multiplying factor	Instrument	Range
x 1	0	5 000 m ³ /day
x 10	5 001	50 000 m ³ /day
x 10 ²	50 001	500 000 m ³ /day
Alternatively		

x 1	0	60 l/s
x 10	61	600 l/s
x 10 ²	601	6 000 l/s

The Contractor shall submit for approval to the Engineer details of integration rates and multiplying factors for all integrators to be supplied under the Contract.

2.19.2. PREDETERMINING COUNTERS

Where a sampler is to be operated as a function of flow and/or where indicated in the application Clauses, the relevant integrator shall incorporate a predetermining counter having a minimum of 3 digits. The predetermining counter shall be on the front of the instrument with thumb-wheel setting facilities and shall operate such that a relay with change-over contacts is energised when the preset quantity is reached. The relay shall remain energised for approximately 10 seconds, following which the counter shall automatically reset and start counting again.

The accuracy shall be $\pm 0.2\%$ of span or better.

2.20. PENSTOCKS POSITION INDICATORS

Penstocks position indicators shall be automatic two position indicators on local control panels, which show the state of the remote penstock. During changes of state or loss of supply, the indication shall remain at that last position until either a fully open or fully closed position is reached at which time it shall move to the appropriate vertical or horizontal position.

2.21. STATUS INDICATOR LAMPS

2.21.1. GENERAL

Where an instrumentation and control DC voltage supply is available, status indicator lamps shall be supplied from this source.

In applications where a DC voltage supply is not available, status indicator lamps shall operate on available a.c. supplies. For these applications, the indicator shall be a low voltage lamp supplied via a transformer incorporated within the light unit. The lamps shall have a voltage rating higher than the transformer secondary.

2.21.2. D.C. OPERATED LAMPS

On all mimics and elsewhere as practicable, indicators shall be by light boxes or illuminated LED incorporating two lamps. Multi-colour, single aspect indications on mimics may be single lamp units if twin lamp versions are not available.

All lamp status indications on control panels, mimics, instrumentation and control sections of MCC's shall be switched by relays located within the panel or enclosure incorporating the display, and powered by the local DC voltage supply. This is to ensure that all lamps in the display are of the same brightness.

Where resistor shall be connected in series with each lamp or pair of lamps, the circuit shall be arranged so that the relay contact shorts out the resistor to illuminate the lamp. The resistor value shall be such that, when in series with the lamp (or lamps), the filament shall start to glow when maximum DC voltage is applied.

The lamp relays shall be reed relays mounted with the lamp resistors on printed circuit boards. This requirement is to reduce space and DC power requirements. The relay contacts shall be adequately rated: for the duty of switching filament lamps.

All indicator lamps on instrumentation and control panels, mimics, etc., shall be incorporated within a lamp test facility.

2.22. ILLUMINATED PUSHBUTTONS AND OPEN/CLOSE INDICATORS

The illuminated pushbuttons shall have bezel dimension of not less than 24 x 36 mm, and shall be mounted in pairs to provide remote hand control of louvers, valves, penstocks and similar devices.

Each pair shall consist of one “open” (or “lower”) pushbutton with red translucent screen, and one “close” (or “raise”) pushbutton with green translucent screen. The screens shall be engraved and filled to show the action (open or close) and the device reference number.

Operation of the pushbutton shall initiate the appropriate action.

With the valve, penstock or louver fully closed, the green (close) lamp only shall be illuminated; and with the device fully open, the red (open) lamp only shall be illuminated. While the device is changing from one state to another, both lamps shall be illuminated.

The pushbutton contacts shall have a minimum rating of 5 amps at 240 volts 50 Hz.

The switch and associated circuits shall be arranged so as to provide the required operating characteristics for each device. All pushbutton circuits shall operate in the same manner. Circuit arrangements requiring the pushbuttons to be held down while the device is changing from one state to another, will not be accepted.

The open/close indicators shall be of the same type and appearance as the illuminated pushbuttons, with the same lamp colours and indicating sequence, but the screens shall be engraved “opened” and “closed”.

All indicator lamps shall be included within a lamp test facility.

2.23. TRIP AMPLIFIERS

Trip amplifiers shall operate on various analogue signals and shall:

1. Operate from a 230 VAC or 24 VDC.
2. Have an input impedance in the order of 20 ohms.

Trip amplifiers or analogue alarm relays shall have single or dual set points as required and shall:

1. Have switched outputs with changeover contacts of suitable material and rating for the application.
2. Have set points which is infinitely variable over the whole input range by means of a lockable knob calibrated 0-100%.
3. Have a dead band of not less than 2.5% of input span.

4. Have a trip repeatability of $\pm 0.25\%$ of span.

2.24. CONTROL AND INTERPOSING RELAYS

All relays shall operate on a supply not exceeding 55 volts (nominal) to earth unless otherwise specified in the application clauses, and shall:

1. Operate reliably over the range +10% to -15% of the nominal supply voltage.
2. Be of the plug-in type complete with plastic cover and retaining clip.
3. Have vacuum impregnated coils and be suitably treated for operation under the specified environmental conditions.
4. Have contact material suitable for each application.
5. Have relay bases of the front connected, screw clamp type.

Mixed voltage shall not be connected to the contacts of any relay.

All relays and the associated wiring shall be protected by suitably rated fuses.

Relays having different contact arrangements or coil voltages shall not be interchangeable.

A permanent means of identification shall be fixed to each relay base and this identification shall be in accordance with the circuit diagram reference.

Where voltages from a remote source (i.e. voltages which cannot be isolated from within the cubicle) are connected to a relay or associated terminals, fuses etc., the Contractor shall ensure that all such live parts are fully shrouded and that appropriate warning notices are fitted.

The Contractor shall be responsible for ensuring that a.c. relays cannot be held in due to capacitance effects on long switching lines. Where such a possibility exists, a d.c. supply shall be provided.

2.25. PLANT CONTROL AND INDICATION

The requirements detailed below are written with specific reference to control/Indication circuits associated with power actuated valves and penstocks, but shall apply equally to all other plant control/indications where similar conditions occur.

Although two or more auxiliary or limit switches may initially be set up to give simultaneous operation, it is impossible to ensure that such simultaneous operation will be maintained over an extended period. To avoid the possibility of a system malfunction due to the above, the use of duplicate auxiliary or limit switches to provide the same effective status signal will not be accepted.

Where a valve or penstock status signal is to be used in more than one circuit (e.g. control and indication), one set of auxiliary or limit switch contacts only together with a slave relay if necessary, shall be used to initiate the operation of all such circuits.

2.26. OPERATION OF CONTROL PENSTOCKS AND VALVES

2.26.1. GENERAL

In each case where flow or level is to be controlled by a modulating penstock or valve, the installation shall be complete with local manual operation, remote/local selection, local open/close PB's, a controller and a suitably sized actuator with a position indicator. All installations shall be in accordance with this Clause unless otherwise specified in the particular application clause.

Each system shall comply with the operational requirements for the control of the process, but shall include such timers or other means as may be necessary, to ensure that the number of actuator starts and the total actuator running time are within the limitations recommended by the manufacturer.

2.26.2. HAND CONTROLS

For each system there shall be a remote/local selector switch, and raise/lower pushbuttons (non-maintained action). In the case of valves, the pushbuttons shall be labelled "open/close".

2.26.3. POSITION INDICATION

Unless otherwise stated in the application clause, the valve or penstock position and status shall be connected to the control and monitoring system via a dedicated Profibus network.

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PART 4 – DRAWINGS – REFER TO VOLUME 3