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1. GENERAL CONDITIONS

1.1 CONDITIONS PREVAILING AT SITE OF WORKS

Before submitting his tender, the Contractor is deemed to have familiarized himself with the conditions prevailing at the Site of Works and its surroundings, concerning weather conditions, communications, availability of water and electricity, conditions of roads, availability of labor and all other factors that may have an impact on the good execution of the Works. All Works, Material, Equipment and Tools supplied for this contract shall be designed for operation at the conditions prevailing at Site.

1.2 BOUNDARIES OF WORK

The Contracting Authority shall provide the Site upon which the Permanent Works are to be constructed. Where a drain or pipeline is to be within an existing road or track reservation or is otherwise located in a land designated as Public Domain, the Site width will be restricted to the limit of the public land. The existing boundary fences and walls shall not be disturbed without the prior approval of the Supervisor and unless road divisions and closure notices are approved and posted, roads and tracks shall be left available for the safe passage of traffic.

The Contractor shall not enter upon or occupy with men, tools, equipment or materials any land other than the Site without the written consent of the owner of such land and the Supervisor's approval.

On occupation of the Site or other land the Contractor shall provide temporary fencing or immediately install permanent fencing where such is required. Where the Permanent Works do not include fencing, the Contractor shall submit a proposal to the Supervisor as to how he intends to fulfill his obligations under the Contract which shall be to the approval of the Supervisor.

1.3 LEVEL DATUM, BENCHMARKS & DIMENSIONS

Pipelines, networks, levels of reservoirs and all other facilities falling under the scope of this contract shall be referred to the National Height datum. Where possible construction drawings and all levels used for construction shall be referred to the National Height Datum. The Contractor shall be responsible for obtaining the location and values of the permanent bench marks. In cases where such bench marks do not exist, the site datum shall be agreed with the Supervisor.

Before commencement of construction works, the Contractor shall establish at each site in a position to the approval of the Supervisor, a steel datum peg which shall be securely concreted in and for all purposes temper proof. The level of this peg shall be established and agreed with the Supervisor and all levels used in the construction Works shall be referred to this established datum. The correctness of this established datum shall be checked at regular intervals during the construction period as agreed with the Supervisor.

Moreover, benchmarks in the area of the work shown on the drawings shall be established by the Contractor. The Contractor shall be responsible for preserving these benchmarks and re-establishing them in case they are destroyed or disturbed.

Where required or upon the request of the Supervisor, the Contractor shall establish at his own expense temporary benchmarks he might need for the execution of the work.

Wherever dimensions or levels are not shown on the Drawings, instructions shall be obtained from the Supervisor.

1.4 SETTING OUT / LOCATING OF THE WORKS

The conceptual Site layout drawings show indicative Site layouts. Prior to commencing construction, the Supervisor will agree with the Contractor upon the basic information supplementary to that shown on the Drawings such as the position of center-lines and base-lines sufficient for the Contractor to locate the Works.

1.5 TOPOGRAPHIC SURVEY

In case approved by the Supervisor to carry out topographic survey, the Contractor shall carry out his Mapping at 1:1000 with contours at a vertical interval of 1 meter. A ground profile along the centerline of the pipe route shall be provided and shall be at the same scale as for the contract drawings if applicable.

In case of pipelines routed below carriage ways, the extent of mapping shall be the width of roads or dual carriage ways up to the property lines on either side of the public land or one meter from the edge of road whichever is nearer to the pipeline centerline.

In open areas and along water courses, the mapping corridor width shall be 20 meters. The mapping shall be supplied on polyester film plotted from digital data, and shall be field verified before final submission.

Ground control and mapping shall be related to an Approximate National or National Datum. A description of the system used shall be quoted on each survey drawing. All control points, and heights shall be related to the National Height Datum in meters, and stated on each survey drawing.

1.6 STANDARDS

- All references to codes, specifications and standards referred to in the Contract Documents shall mean, and are intended to be, the latest edition, amendment or revision of such reference standards in effect.
- Whenever the Contract Documents require that a product complies with certain Standards or Specifications, the Contractor shall present a certificate from the manufacturer ensuring that the product complies therewith. Where requested or specified, the Contractor shall submit supporting test data to substantiate compliance.

Each and every part of the works shall be designed, constructed, manufactured, tested and installed in accordance with an internationally recognized Standard, Code of

Practice, or Regulation applicable to that part of the works. The Technical Specifications could refer to one or more standards, but it is still accepted that any international recognized standard, code of practice or regulation could be applicable with the prior consent of the Supervisor.

If any clarification or additional information regarding technical aspects, the Contractor must submit a request for information.

1.7 EQUIVALENCY OF STANDARDS AND CODES

Wherever reference is made in the Contract including the Specifications, Drawings and Bill of Quantities to specific standards and codes to be met by the goods and materials to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the Contract.

Where such standards and codes are national or relate to a particular country or region, other authoritative standards that ensure a substantially equal or higher quality than the standards and codes specified will be accepted subject to the Supervisor's prior review and written consent. Differences between the standards specified and the proposed alternative standards shall be fully described in writing by the Contractor and submitted to the Supervisor at least 28 days prior to the date when the Contractor desires the Supervisor's consent.

In the event the Supervisor determines that such proposed deviations do not ensure substantially equal or higher quality, the Contractor shall comply with the standards specified in the Contract.

1.8 SILENCE OF SPECIFICATIONS

The apparent silence of the specifications, plans or other Contract Documents as to any detail or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best general practice is to be used. All interpretations of the specifications will be made by the Supervisor on this basis.

1.9 LANGUAGE OF CORRESPONDENCE AND RECORDS

All communications from the Contractor to the Supervisor shall be in English language. All books, time sheets, records, notes, drawings, documents, specifications and manufacturers' literature etc. shall be in English language.

1.10 UNITS

The International System of (metric) Units shall be used throughout the Contract except where otherwise provided.

1.11 INTENTION OF TERMS

Where "as shown", "as indicated", "as detailed" or words of similar import are used, it shall be understood that reference to the drawings accompanying the Specifications is

made unless otherwise stated. Where “as approved”, “as directed”, “as required”, “as accepted”, or words of similar import are used, it shall be understood that the approval, direction, requirement, permission, authorization, review, or acceptance of the Supervisor is intended, unless otherwise stated. “Provide” shall be understood to mean “complete in place”, that is, “furnish and install”.

Whenever anything is, or is to be done, if, as, or, when, or where “contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered, considered necessary, deemed necessary, permitted reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected or condemned”, it shall be understood as if the expression were followed by the words “by the Supervisor” or “to the Supervisor”.

The phrases “or equal” and “or equivalent” shall be construed to mean that material or equipment will be acceptable only when composed of parts of equal quality, or equal workmanship and finish, designed and constructed to perform or accomplish the desired result as efficiently as the named brand, pattern, grade, class, make or model.

1.12 INTENT OF CONTRACT

The intent of the Contract is to provide for the construction and completion in every detail of the works described. The Contractor shall furnish all labor, materials, equipment, tools, transportation and supplies required to complete the work in accordance with the plans, specifications and terms of the Contract Documents.

Unless otherwise specified, the Contractor shall allow a minimum of 21 days for approval of drawings and documents by the Supervisor.

1.13 BILLS OF QUANTITIES

Detailed Bills of Quantities shall be prepared by the Contractor in accordance with the measurement rules described in the price schedule and as approved by the Supervisor.

1.14 SIGN BOARDS

The Contractor shall provide one site sign board in a form and to the specification specified and erect and mount on suitable temporary supports, in positions and at heights as required by the Supervisor.

The Contractor shall maintain, alter, move and adapt the sign boards from time to time as instructed by the Supervisor. The display of any named Subcontractors or any other information associated with the Works shall be to the approval of the Supervisor.

Sign boards will not be paid for directly but shall be deemed to be included in the rates of other items of the project.

1.15 EQUIPMENT AND MATERIALS

1.15.1 *General*

All materials and equipment that are part of the permanent works shall be new, recently manufactured and shall meet the quality requirements of the Contract. They must, in all cases, be approved by the Supervisor prior to their procurement and installation.

1.15.2 *Equivalency*

Wherever reference is made in the Contract, including the Specifications, Drawings and Bill of Quantities, to specified manufacturers or suppliers for the supply of goods, materials and equipment for the Works; goods materials and equipment from alternative manufacturers and suppliers will be permitted, unless otherwise expressly stated in the Contract, providing these other goods, materials and plant are substantially equal or of higher quality than those of the specified manufacturer or supplier and are approved in writing by the Supervisor.

Differences between the specified goods, materials or equipment and the proposed alternative shall be described in writing by the Contractor and submitted to the Supervisor, together with such manufacturer's or supplier's technical literature and samples as the Supervisor may reasonably require, at least 28 days prior to the date when the Contractor seeks the Supervisor's consent. In the event the Supervisor determines that such proposed alternative goods, materials or plant do not ensure substantially equal or higher quality, the Contractor shall obtain the goods, materials or equipment from the manufacturer or supplier specified in the Contract.

1.15.3 *Toxicity*

Any material which will come into contact with potable water or with equipment to be used for potable supply, shall comply with UK, US or French regulations on the use of materials for potable water supply.

1.15.4 *Dimensions*

Equipment and materials shall be supplied to the general arrangements and dimensions, or to suit the dimensions, shown on the Drawings or otherwise indicated in the Contract. Where no such dimensions are shown the Contractor shall be responsible for sizing the Equipment. Any redesign, extra design, additional construction or any other costs resulting from the use of Equipment to other arrangements or to other dimensions shall be the responsibility of the Contractor.

1.15.5 *Packing and protection*

All items shall be adequately crated or packaged to withstand damage and prevent deterioration due to shipping, handling and storage. The methods of protection and shipping shall be to the approval of the Supervisor.

1.15.6 ***Shipping Marks***

All Equipment shall be properly marked before shipping. Crates or packages shall be marked on two sides with indelible paint with the name of the project, the Contracting Authority and the Contract number and shall bear marks indicating the contents.

1.15.7 ***Storage***

Equipment and materials shall be stored and handled in such a manner as to preserve its quality and condition to the standards required by the Contract. Storage conditions shall be damp free and prevent ingress of dust, vermin and rodents. Stored materials and equipment, even though approved before storage, may again be inspected prior to their use in the work.

1.15.8 ***Manufacturer certificate***

The Contractor shall furnish the Supervisor with a manufacturer's certificate confirming compliance to the specification in respect of all items of Plant, equipment and materials.

The original and one copy of the manufacturer's certificate shall be delivered to the Supervisor not later than 14 days prior to the intended date of delivery of the item to Site.

1.15.9 ***Inspection and testing***

The performance of each item of Equipment shall be tested in accordance with the Specification to the requirements of the Supervisor.

Test certificates in triplicate shall be submitted by the Contractor to the Supervisor within 2 weeks of the date of the tests. Type tests are not acceptable. Test certificates shall be supplied for tests carried out on the actual equipment being supplied.

Equipment shall not be shipped out of the manufacturer's works until it has passed the specified tests and approval has been given by the Supervisor.

The Supervisor shall at his discretion witness tests of individual items of Equipment at the Manufacturer's Works. The Supervisor shall be given three weeks notice in writing before such tests are carried out.

The acceptance by the Supervisor of any Equipment after testing at the manufacturer's works shall in no way relieve the Contractor of his responsibility for the correct performance of the Equipment under consideration.. All materials delivered to the Site are subject to additional laboratory testing when requested by the Supervisor even if the materials do have a certificate of guarantee or laboratory test certificate from the manufacturer.

All costs in connection with certificates of guarantee or laboratory tests and certificates shall be borne by the Contractor. Falsification of such documents shall be just cause for rejection of the materials and all cost of transportation and handling of the rejected materials shall be the sole responsibility of the Contractor.

1.15.10 Proprietary Materials

Material shall be supplied in suitable containers and in appropriate batch sizes for the work to be undertaken.

The following information shall be marked:

- Storage instructions;
- The manufacturer's name;
- Shelf life and dates of manufacture;
- Material identification;
- Batch reference number;
- Net weight;
- Mixing instructions;
- Any warnings or precautions concerning the contents and their safe use.

The Contractor shall supply with each consignment of proprietary material delivered to the Site, certificates furnished by the manufacturer or his agent stating:

- The manufacturer's name and address;
- The agent's name and address where applicable;
- Material identification;
- Batch reference numbers, size of each batch and the number of containers in the consignment;
- Date of manufacture.

1.15.11 Spare parts

Spare parts for mechanical and electrical materials must be strictly interchangeable and suitable for use in place of the corresponding parts supplied with the Works. They shall comply with the Specifications and must be suitably marked and numbered for identification and packed for storage under the climatic conditions prevailing at the Site.

1.15.12 Rejected Materials

Should any materials or manufactured articles be in the judgment of the Supervisor, unsound or of inferior quality or in any way unsuited for the purpose in which it is proposed to employ them, such materials or manufactured articles shall not be used upon the Works but shall be branded, if in the opinion of the Supervisor this is necessary, and shall forthwith be removed from the Site.

The Supervisor shall refuse to accept or shall reject any materials or Equipment that in his opinion is defective or otherwise fails to comply with the standards required by the Contract. All such defective items shall be removed from Site or repaired as directed by the Supervisor at no extra cost to the contracting authority.

1.15.13 Installation

Skilled labor shall be employed for the equipment installation. They shall be technically competent to read drawings, troubleshoot faults occurring during the erection, to carry out

testing and commissioning and to report on all matters pertaining to the installation and running of the equipment.

1.16 APPROVAL OF CONSTRUCTION SUBMITTALS

After Contract start date and no later than the period specified in the Special Conditions of the Contract if any, the Contractor shall submit all data, details, sources of supply, manufacturers, calculations, sketches and samples as necessary and as reasonably requested by the Supervisor of all materials and equipment that the Contractor proposes to use in the works. Method statements which adequately demonstrate the Contractor's proposed method of working and of maintaining safety and compliance with the program shall be submitted for the Supervisor's approval prior to the commencement of work on any area of the Site.

The Contractor is responsible for the preparation of Construction Documentation as described in the respective section above. Such Construction Documentation shall be approved prior to the procurement of any materials or execution of any work to which such documentation relates.

No materials or equipment shall be procured by the Contractor and no work, permanent or temporary, shall start without first obtaining the Supervisor's approval.

Samples of materials shall be submitted to the Supervisor for approval as required by the Supervisor. Materials subsequently supplied shall conform to the quality of the samples, which have been approved by the Supervisor. No standard, method of manufacture or specification shall be changed without the approval of the Supervisor. Where possible equipment and materials shall be supplied to the same standards or to compatible standards.

1.17 PROJECT MANAGEMENT

1.17.1 *Project control*

The Contractor shall provide within his site organization a project management section to support and be directly responsible to the Contractor's Project Manager (Contractor's chief site representative). The duties of this section shall include the following:

- a) Planning and program preparation, particularly in relation to the requirements of public authorities and the requirements to maintain water supply services where careful detailed arrangements have to be made and adhered to.
- b) Planning the execution of the works in a manner, which minimizes disruption to the water supply and other utilities and will permit the efficient and effective commissioning of the water supply network.
- c) Ensure that the execution of the works will not jeopardize maintenance of adequate potable water supplies to all consumers.

- d) Continuous surveillance of progress and anticipation of factors likely to affect the timely performance of the Contract.
- e) Making proposal for modification to forward planning and to the program at an early stage in the light of factors resulting from (d).
- f) Continuous appraisal of the Contractor's methods and routines particularly as to their effectiveness relating to speed of execution and to their effect on the community and property.
- g) Forward planning for resource requirements taking due account of possible shortages and delays in the arrival on site of materials, equipment, plant and personnel and their mobilization for effective usage.
- h) Acquisition and process of up-to-date information for progress meetings with the Supervisor. The preparation of monthly progress reports including an update of the detailed programme and cash flow forecast.
- i) Preparation of progress reports to be submitted to the Supervisor and monthly work execution statements.

A qualified Supervisor having had at least 5 years' experience on similar projects shall be in charge of the project management section. He shall be fully familiar with project planning techniques (Microsoft project, Primavera, etc....).

Supporting staff for this section shall be in adequate numbers to carry out their duties and shall be of adequate ability and experience to the Supervisor's approval.

1.17.2 *Monthly statements and certificates*

Monthly statements certificates shall be submitted in an approved manner and format as per the Supervisor's instructions. In addition to the statements submitted in hard copy the contractor shall submit a computer copy as prescribed by the Supervisor. The Statements and certificate shall detail the measured value of the work completed on each item of the Works in such detail that the Supervisor can identify the location and measurement of each item. A location shall constitute a single structure such as a reservoir or section of a pipeline or a valve chamber.

1.17.3 *Coordination between services*

The Contractor shall appoint a co-ordinator who will provide a single point of contact for all matters concerning M & E installations and their coordination with the civil and building works.

1.17.4 *Progress Meetings*

The Contractor shall provide a suitable meeting room in the vicinity of the Site and arrange progress review meetings to be chaired by the Supervisor at monthly intervals to coincide with submission of monthly work progress statements. The Contractor shall allow for attendance by the Supervisor and up to 4 representatives of the Supervisor or Contracting Authority. The meetings shall be attended by the Contractor's senior representative, M & E Coordinator, Planning Supervisor and other members of his senior staff as deemed necessary.

1.18 QUALITY & QUALITY CONTROL

The materials and workmanship shall be the best of their respective kinds and to the approval of the Supervisor. The words "to the approval of the Supervisor" shall be deemed to be included in the description of all materials and workmanship for the due execution of the Works.

The Contractor shall be responsible for his own quality control and shall provide sufficient competent personnel for supervising the Works, taking and preparing samples and for carrying out all necessary tests.

1.19 OFFICES & FACILITIES FOR THE CONTRACTOR

1.19.1 *Staff offices*

The Contractor shall provide and maintain offices for the use of his representative and staff and to which written instructions by the Supervisor can be delivered. Any instructions delivered to such offices shall be deemed to have been delivered to the Contractor.

Offices shall be located to give convenient access to the works and shall be subject to the approval of the Supervisor. The Contractor shall be responsible for obtaining the land on which to establish any temporary site offices.

Such facilities shall be removed at contract completion unless specified otherwise by the Supervisor.

1.19.2 *Yards stores and workmen accommodations*

The Contractor shall be responsible for obtaining the land and for the provision of all temporary, yards, stores, workshops, offices, mess rooms, shelters and for all services in connection therewith. The location of all such facilities shall be agreed beforehand with the Supervisor and shall be such as to avoid obstruction and nuisance to the public.

The Contractor shall provide and maintain suitable and sufficient shelters and mess rooms for his workmen and supervisory staff as are customary and necessary.

The Contractor shall provide sufficient closets or latrines to the satisfaction of the relevant authority. They shall be properly screened and maintained at all times in a clean and sanitary condition. The Contractor shall be responsible for making all arrangements for the proper disposal of waste from workshops mess rooms, closets and latrines.

The Contractor shall construct on the Site, or at suitable locations, secure storage compounds and storage buildings where he shall store at his own risk all equipment and plant delivered to Site and awaiting erection. The compound shall be of sufficient size to accept all such delivered equipment.

Covered storage buildings shall be weatherproof and shall be of sufficient size to accommodate all items requiring covered storage.

Stored materials shall be located so as to facilitate their prompt inspection. Any costs for the use of privately-owned land for storage and/or for the parking of Contractors plant and equipment shall be borne by the Contractor. Private property shall not be used for storage purposes without written permission and release of the owner or lessee. A copy of such written permission and release shall be furnished to the Supervisor prior to any use of the land by the contractor.

The Contractor shall also provide secure and proper storage for all samples submitted to the Supervisor for approval.

The storage compounds and buildings shall be completed prior to delivery to site of any material or equipment. Materials shall be so stored as to assure the preservation of their quality and condition. Stored materials, even though approved before storage, may again be inspected prior to their use in the work.

All activities in workshop shall be carried in a way as not to cause annoyance to nearby living quarters if any and minimize pollution as regarding used oil dumping and burning fuels.

1.20 OFFICES & FACILITIES FOR THE SUPERVISOR

1.20.1 *Staff offices*

The Contractor shall provide, furnish and maintain adequate office space for the use of the Supervisor and his supervisory staff. The facilities should be adequate for at least 2 members of the Supervisor's staff at the location of each site office established by the Contractor or at such other location as may be agreed by the Supervisor. These offices shall have an area of no less than 50m² and shall be constructed, equipped and furnished as directed by the Supervisor. These facilities shall be completed and ready for occupancy within sixty (60) days from the date of signing the Contract.

The Contractor shall submit to the Supervisor, for approval, details of the offices space to be constructed, equipped and furnished before construction of these offices is started.

The Contractor shall supply electricity, water and sanitary facilities for the Supervisor's offices. The Contractor shall be fully responsible for the maintenance and operation of the offices, including labor and materials.

The Contactor shall provide adequate space and facilities at a convenient location for meetings between the Supervisor and Contractor.

1.20.2 *Communication equipment*

The Contractor shall supply the Supervisor with mobile radios or telephones as necessary to enable efficient communication between the Contractor and Supervisor's site supervision staff.

1.20.3 *Support equipment and labor*

The Contractor shall make available technicians and such labor, materials and safety equipment as the Supervisor may require for inspections and survey work in connection with the Works. The Contractor shall provide all necessary tools, test equipment, labor, staff and any other item or service the Supervisor may reasonably require in order that he may safely, conveniently and quickly carry out such inspections as he deems necessary at any time during the execution of the Works and during the Defects Liability Period. The Supervisor, his representative and assistants, shall not inspect any area of the Works where they deem the safety provisions to be inadequate.

1.21 FACILITIES FOR SURVEY AND INSPECTION BY THE SUPERVISOR

The Contractor shall make available technicians and such labor, materials and safety equipment as the Supervisor may require for inspections and survey work in connection with the Works. The Contractor shall provide all necessary tackle, test equipment, access, labor, staff and any other thing the Supervisor may reasonably require in order that he may safely, conveniently and quickly carry out such inspections as he deems necessary at any time during the execution of the Works including the Tests on completion.

1.22 WORK THROUGH PRIVATE PROPERTY

In order that the necessary easements may be obtained and /or the owners of private property may be served with the requisite notices it shall be an obligation of the Contractor to supply the Supervisor from time to time with full information of his program sufficiently in advance of the dates upon which the Contractor will wish to enter upon each parcel of private land.

The Contractor shall consult with Owners and Tenants (if any) and have written approval before entering on their land or cutting through any ditch, bank, hedge, wall, fence or any other form of boundary marking and he shall ascertain and carry out their reasonable requirements as approved by the Supervisor in the matter of reinstatement.

1.23 PUBLIC UTILITY MAINS AND SERVICES, LOCATING, ETC.

It shall be the responsibility of the Contractor to obtain all information available from the Public Utility Authorities regarding the position of mains and services and he shall make this information available to the Supervisor as soon as he obtains it.

The absence of such information shall not relieve the Contractor of his liability for the cost of any repair work necessitated by damage caused by him to any mains or services in the course of his work and for the cost of all losses arising from the disruption.

All locating work shall be carried out in advance of further excavation work. The Contractor shall obtain all information and assistance available from the Public Utility Authorities for the locating of the mains and services and shall agree with the Supervisor any trial excavation which may be necessary to confirm or establish these locations.

Any temporary or permanent diversion of mains and services will only be permitted after agreement with the appropriate Public Utility Authority.

1.24 SAFEGUARDING EXISTING UTILITIES

It shall be the Contractor's responsibility to safeguard by means of temporary or permanent supports, works, shields or otherwise all existing pipes, cables, structures or other utilities which would be liable to suffer damage if such precautionary measures were not taken.

Temporary safeguards shall be to the approval of the Supervisor and of the Operator or Owner concerned.

Permanent safeguards shall also be to the approval of the Supervisor and of the Operator or Owner concerned.

At points where the Contractor's operations are adjacent to properties of telegraph, telephone and power agencies or companies, or adjacent to other property, damage to which might result in considerable expense, loss or inconvenience, the work shall not be commenced until all arrangement for the protection thereof have been made. The Contractor shall cooperate with the owners and / or operators of any underground or overhead utility services concerning their removal and rearrangements in order that such relocation may progress in a smooth manner and avoid duplication of rearrangement work as well as keep interruptions of such services to a minimum.

In the event of interruption to water or utility services as a result of accidental breakage or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority for the restoration of service. If essential public utility service is interrupted, repair work shall be continuous until the service is restored.

The cost of all repairs to utilities and consequent disruptions, due to lack of proper measures taken by the Contractor to safeguard such utilities against damage, shall be born by the Contractor.

1.25 CONNECTING TO EXISTING UTILITIES (PIPES, CABLES, ETC.)

The Contractor shall be responsible for connections between pipes, cables etc .laid by him and existing pipes, cables etc. The Contractor shall submit to the Supervisor details of the connections and shall state the date on which any particular connection could be made. The work shall not proceed until the Supervisor's approval has been given.

The Contractor shall be responsible for the connections and ensuring complete compatibility between the new equipment and existing utilities.

1.26 LIGHTING, WATCHING, SIGNALING & TRAFFIC CONTROL

Where necessary for the safety of the public or where required by the Supervisor or his Representative, the whole of the Works shall be properly fenced, signed and lighted from half an hour before sunset until half-an-hour after sunrise and at other times when visibility is poor. On all occasions, the Works shall be properly flagged.

The signalling lights shall be approved by the appropriate Authority and shall be kept in a clean and proper condition. The position and number of the lights shall be such that the extent and position of the works are clearly defined and the arrangement shall comply with the requirements of the appropriate Authority. Each site of the Works shall be provided with night and week-end watchmen as may be required.

Whenever works are being carried out on roads, the Contractor shall submit 15 days before starting such works a traffic control plan to the Supervisor to include all signalling devices, signalmen and all necessary measures to make the roads in question as safe as possible to the public.

The Contractor shall provide two site information sign boards in a form as requested by the Supervisor erected and mounted on suitable temporary supports, in positions and at heights as required by the Supervisor. Signboards shall give information to the public on the Project, the Contracting Authority and further details as will be prescribed by the Supervisor. The location of the signboards at the sites will be indicated by the Supervisor.

The Contractor shall maintain, alter, move and adapt the signboards from time to time as instructed by the Supervisor. The display of any named Subcontractors or any other information associated with the Works shall be subject to the approval of the Supervisor.

Site lighting, signboards and any other type of signaling will not be paid for directly but shall be deemed to be included in the rates of other items of the project.

1.27 ACCESS TO PROPERTIES

The Contractor shall not disrupt any private or public access way without first providing alternative arrangements.

Access to properties affected by the Works shall be maintained. Adequate road plates shall be provided for trench crossings.

Such measures are deemed to be included in the Contractor's prices and shall not be paid for separately.

1.28 WATER & ELECTRICITY SUPPLY

The Contractor shall make all arrangements for and provide an adequate supply of raw and potable water to each Site and facility as necessary for the execution and testing of the Works and for use by his workmen.

The Contractor shall make arrangements for and provide any electricity supply required for each site and facility as necessary for the execution of the Works, testing, site lighting and signaling, offices and workmen living quarters.

1.29 PIPELINES CLEANSING & DISINFECTION

Upon Works and satisfactory Tests completion and prior to commissioning, the Contractor shall disinfect the whole of the Works in contact with potable water. All tanks, pipes, channels, equipment, etc. shall be filled with water containing residual chlorine according to a method approved by the Supervisor. The solution shall be thoroughly flushed out before the works is put into operation. On initial start up of the Works, the water shall be run to waste and samples shall be taken and tested by the Contractor to demonstrate that the water is of satisfactory bacteriological quality before the water is made available for supply. If the tests indicate that contamination is present, the Contractor shall search for and remove such contamination, disinfect and re-test as necessary until the supply water is shown to be satisfactory.

The Contractor shall ensure that water discharged to waste is not harmful to plant or animal life.

1.30 TESTING

The Contractor shall submit to the Supervisor a detailed description, method statement and schedule of the tests to be carried out. During testing on Completion, the Contractor shall provide training to the Contracting Authoritys operators and technical staff in the correct operation and functioning of all equipment installed under the scope of this contract.

1.31 AS BUILT DRAWINGS

After completion of construction works, Contractor shall submit final as-built drawings to the Supervisor for his review and approval as per submitted time schedule. After review and approval by the Supervisor of the final as-built drawings, the Contractor shall within 10 days thereof, produce a final set of "as-built drawings" and submit to the Supervisor the following:

- One (1) soft copy of each as-built drawing on CD;
- 3 prints of each as-built drawing.

As built drawings shall be clearly stamped "AS BUILT" and shall bear labels having the same information as for shop drawings. As Built drawings shall show all works having been rehabilitated, extended or newly constructed.

1.32 OPERATION AND MAINTENANCE MANUALS

The Contractor shall submit to the Supervisor for approval draft copies of the Operation and Maintenance Manuals. A separate set of instructions shall be provided for each installation. The Contractor shall incorporate any amendments or additions required by the Supervisor in the production of the final Manuals.

The draft O&M Manuals shall be available on site at all times during Tests on Completion for the instructions to be verified. Any modifications found necessary shall be incorporated in the final version.

The Contractor shall supply the final version of the Operation and Maintenance Manuals prior to the issue of the Taking Over Certificate for either the whole of the works or the respective section or part of the works.

The Contractor shall, as necessary, carry out survey work, take measurements, collect details, produce drawings and undertake all other work required to enable him to prepare the manuals.

Operation and Maintenance Manuals shall be supplied written in the English and Arabic languages and all parts and equipment listings shall be in English.

1.33 TEMPORARY WORKS

The Contractor shall be responsible for designing and constructing any temporary works he requires during the construction phase of the project. These works shall be to the approval of the Supervisor. At Contract completion, the Contractor shall be responsible for removing all temporary works and reinstating the site unless the Contracting Authority wishes to purchase some of those works at a mutually agreed price and thereby give them the status of permanent works.

1.34 DISMANTLED ITEMS

All items dismantled by the Contractor shall be considered the property of the Contracting Authority and they shall be disposed of as instructed by the Supervisor. The Contractor shall properly store such items in his yards until instructed by the Supervisor to ship them to a location specified by the Supervisor.

Storage and transportation of dismantled items shall be at no extra cost to the contracting authority and are considered to be included in the Contractor's B.O.Q prices.

1.35 INSPECTIONS BY THE SUPERVISOR DURING DEFECTS LIABILITY PERIOD

The Supervisor will give the Contractor due notice of his intention to carry out any inspections during the Defects Liability Period and the Contractor shall thereupon arrange for a responsible representative to be present at the times and dates named by the Supervisor. This representative shall render all necessary assistance and record all matters and things to which his attention is directed by the Supervisor.

1.36 ENVIRONMENTAL MATTERS AND POLLUTION CONTROL

1.36.1 *General measures*

The Contractor shall take all reasonable steps to minimize the adverse affects of both the temporary and permanent works on the environment. Before any work starts, the Contractor shall submit an environmental protection plan describing how potential adverse impacts will be reduced. These adverse environmental impacts could be:

- Pollution of soil and water due to improper dumping of excavated and construction material, used oils, chemicals / solvents, human wastes, garbage.
- Erosion of soil, sedimentation and drainage due to excavation and bedding.
- Noise and air pollution due to operation of machinery, untuned vehicles and excavation.
- Disturbance to recreational, archaeological and tourist sites.
- Unauthorized cutting of trees and damage to forests, agricultural land, vegetated areas and wildlife habitats.
- Unauthorized burning of construction material waste and garbage.

All required environmental activities shall not be subject to separate payment but shall be deemed to be included in the rates of other items of the project.

1.36.2 *Dust control*

The Contractor shall, throughout the execution and completion of the Works, take all reasonable steps to avoid damage or nuisance to persons or property resulting from dust and shall carry out preventative measures, such as spraying the ground with water, and /or soil covering, as instructed by the Supervisor.

1.36.3 *Dumping sites*

The Contractor shall remove and cart away all rubbish, excess materials, debris, etc. to dumping sites approved by the Supervisor. It shall be the Contractor's sole responsibility to establish the locations of these sites and get the necessary approvals from concerned authorities for using them.

Dumped material shall be spread over the whole area of the dumping site in layers not exceeding 80 cm. In case a dumping site is abandoned, the Contractor shall grade the area in an acceptable manner and to the satisfaction of the Supervisor.

1.37 HEALTH, SAFETY & HAZARD CONTROL

1.37.1 *Planning*

Before any work commences on the Site, the Contractor shall submit a Health Safety and Hazard (HSH) control plan which shall be specific to the Contract. The plan shall detail the Contractor's site HSH organization, rules, procedures and methods of monitoring and enforcing these procedures.

All health, safety and hazard control requirements and activities shall not be subject to separate payment but shall be deemed to be included in the rates of other items of the project.

The Project HSH Plan shall cover all aspects of site activities and shall typically include the following:

- Health, Safety and Hazard control policy and primary Objectives:

The plan shall demonstrate that management of HSH control is an integral part of the management and co-ordination of the project.

- Organization and Responsibilities:

A designated competent person shall be designated as the Contractor's HSH control Officer with overall responsibility for the establishment, implementation and enforcement of HSH control procedures and methods of working. The Contractor's organization structure and responsibilities with respect to safety shall be detailed.

- Hazard Identification and Risk Assessment:

The Contractor shall assess the risks to workers and others that require access to the site or may be affected by the undergoing construction operations.

A systematic general examination of each activity and assessment is to include:

- Identification of the hazards generated by construction operations.
 - Identification of the people at risk.
 - The extent of the risk evaluated after considering the existing Hazard control measures.
 - Further assessments to be made for new activities.
 - Plant and equipment to be identified and those responsible for its operation and maintenance to be identified.
 - Review and revision if assessments are no longer valid or where there has been a significant change.
 - Planned review of assessments at regular intervals.
 - Inform employees about the nature of the hazard and the risks identified by the assessments, the preventative and protective measures devised, the emergency procedures and the competent personnel.
 - Significant findings of assessments to be recorded.
- Emergency Procedures:

Effective procedures for contingency in event of serious and immediate danger. All employees shall be able to stop work and immediately proceed to a place of safety if exposed to imminent and unavoidable danger.

- Cooperation and Coordination:

All competent persons to liaise and assist in assessing the shared risks and coordinating any necessary measures, primarily by providing information. The Contractor to take full responsibility in coordination arrangements.

- Capabilities and Training:

Provision of health and safety training for all employees upon recruitment and on exposure to new or increased risks.

- Monitoring:

Scheduled hierarchical audit system conducted by the Contractor. Safety performance to be monitored and measured against the project HSH plan.

- Health and Safety Performance Standards to be specified, i.e.:
 - Relevant statutory legislation
 - Standard specifications (BSI/ISO)
 - Approved codes of practice
- Specific Project HSH Plan Information:

Nature of the Project

- Name of Contracting Authority
- Location
- Nature of construction work to be carried out
- Time scale for completion of the construction work

The existing environment

- Surrounding land uses and related restrictions - e.g. premises (schools) adjacent to the proposed construction site.
- Existing services - e.g. underground and overhead lines.
- Existing traffic systems and restrictions.
- Existing structures - e.g. special health problems from materials in existing structures which are being demolished or refurbished, any fragile materials which require special safety precautions, instability problems etc.
- Ground conditions - e.g. contamination, instability, possible subsidence, underground obstructions etc.

Existing drawings

Available drawings of structure(s) to be demolished or incorporated in the proposed structure(s)

The design

Significant hazards of work sequences.

The principals of the design and any precautions that might be needed or sequences of assembly that need to be followed during construction.

Detailed reference to specific problems with proposals for managing these problems.

Construction materials

Health hazards where either because of their nature or the manner of their use, particular precautions are required.

Site wide elements

- Outline emergency arrangements including access and egress.
- Positioning of site access and egress points.
- Location of temporary site accommodation. Location of unloading, layout and storage areas.
- Traffic / pedestrian routes.

Overlap with other undertaking

Consideration of the health and safety issues which arise when the project is to be located in premises occupied or partially occupied by the Contracting Authority or other authority.

Site Rules

Specific sites rules which the contracting authority or the planning supervisor may wish to lay down as a result of points above or for other reasons - e.g. specific permit to work rules, emergency procedures.

Continuing liaison

- Procedures for considering the health and safety implications of work elements.
- Procedures for dealing with unforeseen eventualities during project execution.

1.37.2 *Protective clothing and safety equipment*

The Contractor shall provide for his working personnel safety hats, overalls, goggles, safety boots, ear protectors and all necessary safety implements in order for them to carry out their duty while being protected as much as possible from bodily injuries and physical impairments.

The Contractor shall make provisions to equip the Supervisor and all authorized site visitors with safety hats during inspection tours. No person is allowed to work or enter the construction site without wearing as a minimum a safety hat. Safety boots for workers is mandatory.

The Supervisor shall ask the Contractor to remove from the site any personnel contravening such measures.

1.37.3 *Contamination prevention*

The Site and all permanent and temporary works shall be kept in a clean, tidy and sanitary condition. The Contractor shall at all times take measures to avoid contamination of existing water courses and drains by petrol, oil or other harmful materials.

The works shall be kept clean and free from rubbish, cleaning shall be carried out permanently as the work is progressively completed. Before requesting inspection for preliminary or final handing-over of the works or any section thereof, the Contractor shall inspect the works and assure himself that they are clean and in a satisfactory condition for such inspection.

The Contractor shall satisfy the Supervisor that his personnel who may be in contact with a public water supply are medically fit. Contractor's personnel shall undergo any necessary medical tests to show that they are free from any infectious diseases and are not carriers of any such diseases. Such tests shall be carried out at the Contractor's expense.

The Contractor shall ensure that his Construction Equipment and labor resources are dedicated to either the water supply or wastewater works in case such works are carried out by the Contractor in conjunction with the Works under the scope of this Contract. The Contractor shall not permit the transfer of plant and labor from wastewater related activities to work on the water supply systems without first taking all necessary precautions against contamination. The Supervisor shall be notified of any such transfer which shall be subject to his approval.

The Contractor shall give strict instructions to all persons employed by him to use proper sanitary facilities which shall be provided by the Contractor.

1.37.4 **Hazards**

Potential hazards associated with the Sites may include, but will not be limited to the following:

- Any chamber, pipeline, borehole, excavation or other structure (whether above or below ground) not effectively ventilated.
- Compressed air vessels without safety relief valves or defective ones.
- Toxic Fumes and Gases: (generated by combustion engines, chlorine, ammonia, treatment processes).
- Chemicals that are strongly alkaline, acidic, toxic or otherwise aggressive.
- Electricity Cables buried and overhead of all voltage ratings.
- Buried water pipes under relatively high pressure.
- Moving Machinery, it may start without warning if automatically controlled.
- Noise (high frequency noise) due to operating machinery or tools. Long term hearing damage may occur if ear protectors are not worn.
- Traffic.
- Contact Lenses: In areas where arcing can occur (welding processes are carried out) wearers of contact lenses can sustain irreparable damage to their eyes. This can occur whether or not safety goggles are worn over the contact lenses.
- Confined Spaces, the following measures are recommended:

- a) Provide, when work is in progress, radio or telephone communication or safe visual and oral communication where this is appropriate and background noise levels permit.
 - b) Ensure that all electrical tools and equipment are of the appropriate type.
 - c) Provide appropriate protective clothing.
 - d) Provide hygiene facilities if appropriate.
 - e) Ensure that all persons entering or working in a confined space are trained and authorized to enter.
 - f) Provide fire extinguishers where appropriate
- Explosives: The Contractor shall at all times take every possible precaution and comply with the Explosives Laws of Lebanon and regulations relating to the handling, transportation, storage and use of explosives and shall at all times when engaged in blasting operations post sufficient warning flagmen to the full satisfaction of the Supervisor. When the use of explosives is necessary during work, the Contractor shall exercise the utmost care not to endanger life or property, including new work. The Contractor shall be responsible for all damages resulting from the use of explosives. The Contractor shall store all explosives in a secure manner marked clearly in Arabic and English "Danger Explosives". Storage shall be in compliance with all local laws and ordinances. It is the Contractor's responsibility to contact the authorities and secure their approval of his proposed method of storage. Storage shall be in general, not closer than three hundred (300) meters from the road or from any building or camping area. In no case shall the Contractor store explosives on the Site without prior approval of the local authorities or the Supervisor.

Contractor shall provide experienced men with valid blasting licences, for handling explosives to the satisfaction of the Supervisor and the authorities concerned.

Prior to starting any blasting operations, the Contractor shall submit a written comprehensive procedure to be approved by the Supervisor prior to blasting operations. Approval of blasting plans shall not relieve the Contractor of his responsibility or liability for the safety of persons and property.

1.37.5 Site cleaning

During the execution of the work, the Contractor shall keep the site clean by removing and carting away to approved dumping sites all rubbish, debris, wastes, etc.

Upon completion of the work and before handing over, acceptance and final payment, the Contractor shall clean the Site and any property used by him. He shall remove in connection with the Work, all rubbish, excess materials, debris, false work, temporary structure and equipment.

The entire site and Works shall be left in a neat and presentable condition and as approved by the Supervisor.

1.37.6 Safety barriers

The Contractor shall provide safety barriers and necessary warning lights to protect the public as specified or as per the Supervisor's recommendations. Safety barriers and warning lights shall be erected each side of all open trenches and excavations, around open manholes and at such other locations as required by the Supervisor.

2. EARTH & EXTERNAL WORKS

2.1 SITE SURVEY

Site survey shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.1.1 *Survey work*

Prior to the commencement of work on any site, the Contractor shall conduct a site survey that will involve the following:

1) Mapping of the sites general condition that will include the location of all boundaries, survey beacons, existing structures, terraces, ditches, watercourses, roads, tracks, fences and other features relating to the Site, and which may affect or be affected by the works.

2) Cross-sectional elevations and measurements of the existing ground surface. Sections shall be at such intervals as are necessary to give a representative record of existing conditions and in no case will the intervals exceed 25 meters. The Contractor shall prepare drawings showing the various cross-sections obtained from the survey and shall stake out the designed work. The original of the drawings shall be signed by the Supervisor and the Contractor as an agreed record of the existing ground levels. These drawings shall be used as the basis for re-measurement of the works as specified.

Failing such surveys and the agreements being signed by the Contractor, the surveys of the Supervisor shall be final and binding on the Contractor.

The Contractor will give the Supervisor 48 hours notice of his intention to carry out survey work in any particular section of the site, and the Supervisor may nominate a representative to be present to observe the survey.

No survey work shall be carried out without prior written approval of the Supervisor.

No operations on earthwork shall be started until the Supervisor has checked and approved the Contractor's surveys drawings.

2.1.2 *Bench Marks, Monuments and Markers*

Before commencing the works, the Contractor shall obtain from the Supervisor all information pertaining to project related bench marks and monuments bearing the National grid coordinates. The Contractor shall be responsible for maintenance of these bench marks and monuments throughout the Contract period. He shall also establish supplementary bench marks and monuments as may be necessary or as directed by the Supervisor. All pertinent levels, lines and locations must be checked and verified by the Contractor before commencing the works.

Right of way for pipelines and other Site boundaries will be defined by the Contracting Authority. For each Site and where needed, the Contractor shall provide erect and

maintain in position, from beginning to final completion of the Works, approved markers not less than 1.5m high indicating the position of the Site boundary at 100m or other such intervals as the Supervisor may direct. In case any boundary or survey mark installed by the Contractor for the purpose of land title is disturbed or displaced, the Contractor shall forthwith replace the marker. Where necessary the Contractor shall employ the services of an approved licensed surveyor for the purpose of setting out boundaries.

2.1.3 Submittals

Before beginning site surveys in any area, the Contractor shall submit to the Supervisor for his approval a work procedure, methods statement and time schedule regarding site surveys. His submittal shall include the equipment and material to be used, the extent and methods of survey, the surveyor's credentials, a time schedule for the related works, a safety plan and all other information requested by the Supervisor.

The Supervisor will determine the extent and limits of the survey works.

2.2 CLEARING AND STRIPPING

The areas upon which new construction is to take place, the rights-of-way along which pipelines are to be laid and all other such areas as may be designated by the Supervisor and/or indicated on drawings as required for auxiliary purposes (site offices and workshops, transport and machinery yards, borrow pits, stockpile sites, etc.), shall be cleared and stripped as described below to remove all elements that may affect and interfere with the progress of the Works.

2.2.1 Clearing existing structures and utilities

The Contractor shall remove wholly or in part all structures, obstructions and utilities within the construction site or the Right of Way which have not been designated by the Supervisor to remain.

Unless otherwise indicated on the Drawings or directed by the Supervisor, the Contractor shall demolish and remove all structures and disused utilities together with all foundations and retaining walls, piers, partitions and columns down to a plane not less than 1 meter below the ultimate grade in the area.

Such structures and disused utilities may include buildings, sheds, walls, slabs, reservoirs, foundations, culverts, catch basins, standpipes, manholes, pipes, poles, fences, gates, curbs, gutters, ditch lining, barriers, electrical cables, etc.....

The Contractor shall inspect each structure and disused utility he is to demolish and remove and determine for himself the work involved and the equipment and materials required for the job to be done in a satisfactory way.

Upon receipt of the Supervisor's approval, the Contractor shall take over all responsibility of the structures expropriated by the Contracting Authority or put at his disposition, and shall proceed with the demolition and removal thereof as specified.

All structures shall be neatly trimmed off and the reinforcement shall be cut or burned off close to the concrete and made safe. Floor slabs and the like shall be broken into pieces.

For demolishing concrete structures, please refer to sub-section 3.18 below.

The Contractor shall arrange for the discontinuance of any services to the structure in accordance with the requirements and/or regulations of the Authority or owner concerned. The Contractor shall disconnect and properly seal in an approved manner any pipework serving the structure which is designated to remain. The Contractor shall keep the Supervisor informed of his plans for the performance of any work in connection with the sealing off of such outlets in order that proper inspection can be carried out during execution.

The Contractor shall conduct his operations in such a manner as to avoid hazards to persons and vehicles. After demolition work is started on any structure, it shall be continued to completion promptly and expeditiously.

Holes, cavities, trenches or depressions left by the removal of structures or obstructions shall be backfilled with acceptable materials to the grade required and to the type of compaction and within the moisture range designated on the plans or required by the Supervisor.

The Contractor shall salvage designated material and satisfactorily dispose of all the remaining rubble as instructed by the Supervisor. Existing pipes to be removed shall be carefully handled and stored for later re-use as per the Supervisor's instructions.

Preservation of surroundings and adjacent structures shall be of primary importance and concern.

No demolition work shall be carried out without prior written approval of the Supervisor.

Unless stated otherwise in the price schedule and priced in the B.O.Q, demolition works shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.2.2 *Removing trees, vegetation and boulders*

Trees and shrubs to be removed shall be uprooted or cut down as near to the ground level as possible under strict control, the roots grubbed up to a depth of not less than 1.0m and removed from the area. Where required, all holes left by the stumps or roots shall be backfilled with suitable material in a manner approved by the Supervisor.

All trees shall remain the property of the Contracting Authority and the Contractor shall collect these trees and store them until required by the Contracting Authority. All trees near to and about the Works except those to be removed, shall be carefully protected from damage by the Contractor during the period of construction. No trees shall be removed without the prior consent of the Supervisor. The Supervisor may require that individual trees, shrubs and hedges are preserved and the Contractor shall take all necessary precautions to prevent their damage.

All other scrub, vegetation, rubbish, etc., shall be cleared or burnt down to ground level and removed from the area as instructed by the Supervisor. Boulders located within 1m of any pipe centerline shall be removed as directed by the Supervisor.

In the case of Right of way for pipelines and the like, the Contractor shall preserve as far as practicable all grass and other vegetation outside the limits of trenches and permanent works, and shall not unnecessarily destroy crops or any vegetation whose removal would not be essential to his operations.

The Contractor shall take particular care at all times to prevent soil erosion on every site and elsewhere on land which may be affected by his operations. For that purpose, the Supervisor may impose such reasonable limitations and restrictions upon the method of clearance and upon the timing and season of the year when clearance is carried out as the circumstances seem to him to warrant.

No clearing of trees, vegetation and the like shall be carried out without prior written approval of the Supervisor.

Trees, vegetation and boulder's clearance work shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.2.3 **Stripping**

Areas on which compacted fill is to be placed and areas of excavations from which material for fill is to be extracted, including borrow areas, shall be stripped of top soil containing organic or otherwise deleterious and objectionable matter to a depth of at least 15 cm. or to such greater depth as may be determined by the Supervisor.

Topsoil shall mean the surface layer of soil which by its humus content supports vegetation and is unsuitable, as a formation to roads and concrete structures or as a backfill or bedding material in pipe trenches. The stripped soil shall be stored in separate dumps for subsequent re-use in covering borrow areas after excavation has been finished or shall be otherwise disposed of as directed by the Supervisor. Under no circumstances shall such stripped material be used as compacted fill.

Stripping shall not be carried out unless the Contractor is able to proceed immediately with the further earthworks upon the stripped areas. Over stripping shall be backfilled and compacted at the Contractor's own expense to the satisfaction of the Supervisor.

No stripping shall be carried out without prior written approval from the Supervisor.

Stripping work shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.2.4 **Submittals**

Before beginning demolition, surface clearance and stripping work, the Contractor shall submit to the Supervisor for his approval a work procedure, methods statement and a time schedule regarding these activities. His submittal shall include details of the

equipment and material to be used, the extent and methods of work, the way to remove from site and dispose of or store the resulting material (rubble, pipes, topsoil, trees, construction material, etc...), the designated spoil sites, the method of preserving utilities which are to remain, a time schedule for the related works, a safety plan and all other information requested by the Supervisor.

The Supervisor will determine the extent and limits of all demolition, surface clearance and stripping works.

2.3 EXCAVATIONS GENERAL REQUIREMENTS

2.3.1 General

Excavation in public streets is subject to the following:

- Decree-law No. 68 dated 9/9/1989
- Decree-law No. 98 dated 9/9/1989
- Circular issued by the Prime Minister's Office No. 6/95 dated 13/3/1995

Where shown on the Drawings or required or approved by the Supervisor, the Contractor shall execute surface excavation in advance of trench excavation, to the lines and grades shown on the Drawings or ordered by the Supervisor.

Any surface excavation not shown on the drawings and not ordered by the Supervisor that the Contractor may wish to execute for the convenience of his work shall be subject to the Supervisor's approval, but shall be done entirely at the Contractor's expense.

Trench excavation shall be made in open cutting unless tunnelling or heading is specified or approved by the Supervisor and shall be taken out as nearly as possible to exact dimensions and levels so that the minimum of infilling will afterwards be necessary.

The Contractor shall ensure the stability and safety of excavations and shall take all measures necessary to ensure that no collapse or subsidence occurs.

Except where described in the contract or permitted under the Contract, excavation shall not be battered. The sides of all excavations shall be kept true and shall where necessary be adequately supported by means of timber, metal struts, poling boards, sheeting, bracing and the like.

Excavations shall be kept free from water and it shall be the Contractors responsibility to construct and maintain temporary diversions and drainage works and to carry out pumping and to take all measures necessary to comply with this requirement.

Trench formations shall be in undisturbed ground. In the event of unsuitable ground being encountered at formation level or if the formation is damaged or allowed to deteriorate, the Contractor shall forthwith inform the Supervisor. The Contractor shall excavate to such extra depth and refill with compacted granular or other approved fill or lean concrete as the Supervisor may require.

This work shall be paid for by the Contracting Authority provided that the unsuitability of the formation is not due to the method of working of the Contractor, in which case the Contractor shall carry out the work at his own expense.

With respect to the side face of any excavation against which concrete or other Work will be in contact, the Supervisor may require that the net dimensions of the Work be increased as he deems necessary.

The Contractor shall excavate refill and restore in advance of his program such trial holes as he may require for determining the nature of the subsoil and the location of existing underground services and obstructions.

Maintenance of natural waterways and allowance for the passage of surface water during construction is the Contractor's responsibility and any damage occurring in this respect shall be corrected at the Contractor's expense.

Excavations shall be done without damaging existing pipes, cables and any other utility or structure. In this respect the Contractor shall inform the Supervisor of any utilities or structures encountered during excavations and take instructions accordingly. All repair of damage to existing utilities due to the Contractor's intervention and the resulting losses shall be at the Contractor's expense.

No excavation shall be carried out without prior written approval from the Supervisor and only such areas approved or ordered to be excavated shall be measured and paid for. The Contractor shall have no right to claim any expenses or delays resulting from his failure to abide by the Supervisor's directions.

2.3.2 **Classification**

All excavation will be classified as one of the following:

- a) Common Excavation: Common excavation consists of the excavation and disposal of all materials of whatever character encountered in the work except rock.
- b) Rock Excavation Rock is defined as a sound and solid mass, layer, or ledge of mineral matter in place and 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 between 385 and 410 net flywheel horsepower operating in low gear.

In areas where the use of the ripper described above is impracticable, rock is defined as sound material of such hardness and texture that it cannot be loosened or broken down by a manual drifting pick.

Boulders and detached stones having a volume of 0.75 cubic meters or more shall be classified as rock.

- c) Unclassified Excavation: “Unclassified Excavation” shall be that volume of excavation consisting of the removal of all materials regardless of their physical properties.

2.3.3 ***Excavation in excess***

If any part of any excavation is excavated deeper and/or wider than is required, the extra depth and/or width shall be filled with lean concrete or compacted granular or other approved fill to the original formation level and/or dimensions as the Supervisor directs.

In pipe trenches where the pipe is not bedded or surrounded with concrete, excess excavation shall be filled with compacted granular material. Excess excavation in rock trenches shall be filled with lean concrete up to 150mm below pipe invert.

All excavations in excess shall be solely at the Contractor's expense.

2.3.4 ***Mechanical excavation***

Mechanical excavation shall be employed only if the subsoil is suitable and only in such manner which will allow adequate support of the excavations walls. The Contractor shall ensure that there are no pipes, cables, mains or other services or property which may be disturbed or damaged by its use.

Whenever mechanical excavation is taking place, proper safety procedures shall be followed as required by the Supervisor.

2.3.5 ***Manual excavation***

The Contractor shall excavate manually in the vicinity of all services, utilities and structures, in confined areas where the passage of excavating equipment is impossible or where the Supervisor deems the use of such equipment impracticable or undesirable or for any reason whatsoever and any areas all as directed by the Supervisor.

All requirements related to excavations in the present specifications shall apply to manual excavation. No extra payment shall be made for manual excavation.

2.3.6 ***Excavated materials suitable for re-use***

In so far as they are suitable and comply with the Specification, materials arising from excavations shall be used for backfilling, as subgrade material for road trenches and at such other places as directed. During excavation, the Contractor shall ensure that all material suitable for re-use are kept separate and set aside and protected as necessary to prevent loss or deterioration. All hard materials shall be kept free from soil or other excavated waste.

The materials forming the surface and foundations of roads, road verges, tracks and footways shall when excavated, and if required for further use, be carefully separated.

During excavation of pipe trenches the Contractor shall ensure that all granular or other approved material suitable for filling around and over pipes shall be kept separate and re-used for this purpose.

Paving slabs, bricks and similar surfaces shall be carefully removed and stacked. Prior to the starting of excavation, the number of badly broken and unsuitable paving slabs, bricks etc. shall be agreed with the Supervisor.

In verges and other grass surfaces the grass and top soil shall be stripped and separately stacked.

Any materials wasted without the written permission of the Supervisor shall be replaced by the contractor at his own expense if found necessary by the Supervisor.

2.3.7 *Disposal of Unsuitable and Surplus Materials*

The Contractor shall be responsible for the disposal of surplus excavated material and material unsuitable for backfill, in designated spoil areas off site. Unsuitable and surplus materials shall be spread, levelled and shaped as directed so as to present a neat and tidy appearance. The spoiled material and surplus material shall be compacted to a reasonable density as required by the Supervisor. No materials shall be disposed of in such a way as to adversely affect natural drainage courses or to cause damage to the road or adjacent public or private property.

If approved by the Contracting Authority, Government land can be used for disposal to the maximum extent practicable. If private land is used for disposal, the Contractor shall secure the consent of the landowner or tenant and, if necessary, and at his own expense, pay for the use of such land. The use of cropland for disposal purposes will not be permitted.

The Contractor shall not deposit excavated materials on public or private land except where directed by the Supervisor or with the consent in writing of the relevant authority or of the owner or responsible representative of the owner of such land and only then in those places and under such conditions as the relevant authority, owner or responsible representative may prescribe.

2.3.8 *Submittals*

Before beginning excavation in any area, the Contractor shall submit to the Supervisor for his approval a work procedure, methods statement and a time schedule regarding excavation works. His submittal shall include the equipment and material to be used, the extent and methods of excavation, the designated spoil and storage areas for the excavated material, a time schedule for the related works, a safety plan and all other information required by the Supervisor.

The Supervisor will determine the extent and limits of the excavation works.

2.4 EXCAVATION IN ROADS AND STREETS, ASPHALT REMOVAL

Where pipes have to be laid under existing paved areas such as roads or sidewalks, cutting into the pavement shall be done with appropriate tools, to ensure straight and neat cuts. The trench shall be vertical and its width across the top edges shall not exceed the values shown in table A below.

TABLE A

Maximum width of the trenches at the top in paved areas (in m)

Depth of trench from paved surface to pipe invert (m)	Maximum width of trench at the top in paved areas (m)
≤1.50	O.D(*) + 0.55
1.51 - 2.50	O.D(*) + 0.85
2.51 - 3.50	O.D(*) + 1.15
3.51 - 4.50	O.D(*) + 1.45
4.51 - 5.50	O.D(*) + 1.85
5.51 - 6.50	O.D(*) + 2.25
6.51 - 7.50	O.D(*) + 3.00

(*)OD = Outer diameter of pipe barrel.

The Contractor shall take all necessary measures, such as shoring, bracing, etc....to keep the width of the trenches within the limits given in the table.

Prior to any excavation in roads and streets, a license request together with all detailed drawings and work methodology showing the locations of the excavations and a written commitment to restore roads and streets to their initial condition shall be submitted to the General Manager of the Department of Roads at the Ministry of Public Works.

The Contractor shall be responsible for the timely submission of work schedules and the necessary drawings to the Supervisor to enable the Contracting Authority to submit the necessary requests to the Ministry. Consequently the Contractor should plan ahead of time the documents submission in order to avoid construction delays.

The Contractor shall also submit his safety plan including a traffic control and signaling plan detailing all labor (warning flagmen) and signalization implements he intends to use in order to ensure safe operations during excavations in roads and streets.

Excavation in streets, roads or highways shall not start without written approval from the Supervisor. The Contractor shall strictly stick to his submitted work schedule to avoid delays and undue disturbance to the public.

Asphalt removal is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

2.5 EXCAVATION FOR PIPELAYING

Pipe trenches shall be excavated to the typical cross-sections shown on the Drawings or as per the Supervisor's recommendation. In no case shall the trench width exceed that shown on the Drawings or specified by the Supervisor. The width of trench excavation shall be the minimum required for efficient working after allowance has been made for any timbering and strutting.

The Contractor shall ensure that at any point the width of the pipe trench is sufficient to allow the pipeline to be laid, jointed, bedded, the trench backfilled and the bedding and fill compacted to the Supervisor's satisfaction.

When pipes are laid directly on the bottom of the trench, the latter shall be straight and even so as to provide a good support for the pipe over its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating. In case of Bell & Spigot pipes, proper allowance shall be made in the trench bed to seat the Bell without disturbing the proper invert of the pipe.

Where jointing of pipes and / or accessories is required to be done in the trench, the latter shall be widened and / or deepened to form bell-holes of sufficient size as directed by the Supervisor so as to easily allow the proper execution of all connecting and fixing works in all their stages, all necessary repairs to the pipe and coating and for the thorough inspection of all these operations.

Where excavation for pipe laying is carried out behind thrust blocks on existing pipelines, the contractor shall provide adequate support arrangements to transfer thrusts to the surrounding ground.

The length of trench to be kept open at one time shall be determined by the Supervisor and shall in no case be exceeded. At any one spread the maximum length of open excavation shall not, without the prior approval of the Supervisor, exceed 100 meters.

Should there be any danger that trenches may erode, then sections shall be left unexcavated for as long as possible and the laying, testing and backfilling of pipelines shall follow excavation as soon as possible.

The excavated material shall be placed alongside the trench at least half a meter away if site conditions allow or in such a manner as not to interfere with the work and to prevent its falling into the trench.

In case this arrangement would obstruct any road or footpath and prevent the passage of traffic or pedestrians, the Contractor shall excavate the trench in such lengths and stockpile the excavated materials at such places as the Supervisor may require.

In the case of asphalted roads or if it is the opinion of the Supervisor that the excavated material is not suitable for backfilling, spoil shall be removed from Site the same day and disposed of according to the Supervisor's instructions.

Trench walls excavated in rock shall be as nearly vertical as possible. The Contractor shall consolidate the walls wherever they have been loosened by blasting or other

reasons and shall remove all loosened material. If rock occurs at a level higher than the required level of the trench bottom, the clearance between the pipe and the trench sides and bottom shall, where in rock, be made to the dimensions that follow or as shown on the Drawings or as directed by the Supervisor to allow for sand or concrete bedding or surround.

Trenches in rock for pipes up to 110 mm OD shall be excavated to provide a minimum clearance of 100 mm around the outside of the pipe and joints. For pipes exceeding 110mm bore the minimum clearance shall be increased to 150mm. In such case, refill shall be with compacted granular fill.

In confined areas, where the passage of excavating equipment is impossible, or where the Supervisor deems the use of such equipment impracticable or undesirable for any reason whatsoever, trench excavation shall be done by hand. All requirements specified above shall apply to trench excavation by hand.

If, in the opinion of the Supervisor, there is undue delay in testing the pipelines; removing surplus material; general tidying up of areas where pipes have been laid; partial restoration of maintenance of surfaces or similar operations, then the Supervisor may order that no further trenches be opened until the outstanding work has been carried out to his satisfaction. The Contractor shall have no ground for a claim against the Contracting Authority on this account.

No laying of pipes or bedding in any section of trench shall be started until the trench formation of that particular section has been approved by the Supervisor.

Excavation for pipe laying is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

2.6 STRUCTURAL EXCAVATION

The Contractor shall notify the Supervisor a sufficient time in advance of the beginning of any excavation for the foundations or any other part of a structure in order for the Supervisor to observe the cross-sectional elevations and measurements taken of the existing ground and structure if any. Any materials removed or excavated before these measurements have been taken and approved by the Supervisor shall not be paid for.

The excavation shall be carried to the outlines of the foundations as shown on the Drawings or as required by the Supervisor and shall be of sufficient size to allow the placing of the full width and lengths of the foundation with full horizontal beds. Rounded or undercut corners and edges of foundations will not be permitted.

No concrete shall be poured prior to the approval of the excavation by the Supervisor. Excavation in excess below the foundation elevation approved by the Supervisor and beyond the lateral limits set for the same as shown on the Plans or directed by the Supervisor shall be backfilled with an identical class of concrete designated for the foundation and shall be poured monolithically with the latter. No payments shall be made for unauthorized excess excavation in depth and / or in width and the backfill as specified above shall be at the Contractor's expense.

Where unstable material or other unsuitable material is encountered at excavation bottom, directly below designated foundation levels of reinforced concrete structures, the Contractor, at the direction of the Supervisor, shall excavate such unstable material and replace with gravel backfill or blinding concrete as shown on the Plans or directed by the Supervisor.

Specified gravel backfill shall be placed in layers not more than 250 mm thick before compaction with each layer compacted to 95% of the maximum dry density. The foundation stabilization, necessary depth of excavation and suitability of the proposed backfill material shall be approved by the Supervisor prior to the Work.

Suitable and practically watertight cofferdams, or other watertight equipment and materials to maintain a water free excavation shall be used whenever water-bearing strata are encountered above the elevation of the bottom of the excavation. They shall be sufficiently large to give easy access to all parts of the foundation formwork and shall be of dimensions not less than those for which payment for excavation is made and shall be deemed included in the excavation price. The provision of dewatering equipment and all operations required to maintain a water free excavation shall be carried out and considered subsidiary to the items of structural excavation.

Before excavations for foundations of structures are completed according to the relevant drawings, the Contractor shall give sufficient notice to the Supervisor to enable him to inspect and approve foundations excavations before further work is carried out. After satisfactory inspection is completed, the Supervisor may withdraw his approval if work is not commenced within 48 hours or the formation is subsequently allowed to deteriorate.

In case requested by the Supervisor, a bottom layer of excavation of not less than 75mm thickness shall be left undisturbed and subsequently taken out by hand immediately before concrete or other work is placed. Where concrete or other materials is to be placed in contact with the side face of an excavation the Contractor shall, where Supervisor directs, excavate the last 75mm thickness of the face immediately before the concrete is placed.

Formations which are to receive concrete blinding shall have the blinding layer executed immediately after the excavation has been completed, inspected and approved by the Supervisor.

Surfaces against which permanent works are to be placed shall be kept free of oil, water, mud or any foreign material.

Unless otherwise specified, bottom of structural excavations for foundations shall be covered with a minimum of 100 mm thick blinding concrete pad as working platform.

No concrete or other materials shall be placed until formations have been approved.

Where rock is attained at the bottom of an excavation, the excavation shall be carried out in such manner as to allow the solid rock to be exposed and prepared in properly serrated horizontal bed which will leave the rock in as sound a condition as may reasonably be expected according to the rock quality. Rock surfaces shall be thoroughly cleaned by

compressed air and water jet or such means as the Supervisor may direct before concrete is placed. All loose and disintegrated rock and thin strata shall be removed.

In case Concrete is to be placed on a capping layer above the rock bed, the rock excavation shall be taken down to a depth of 1.0 m below the underside of the structure and the excavation backfilled with granular capping materials to the required formation level.

The capping material shall be compacted in 150mm layers to achieve a density of not less than 95% maximum dry density determined by the Moisture – Density curve of the material.

Excavation for structures is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

2.7 BLASTING

When blasting of rock slopes is carried out, a reasonably uniform face shall be left, regardless of whether or not the excavation is carried beyond the specified side slopes as shown on the drawings. All breakage and slides shall be removed by the Contractor and disposed of as directed.

All drilling and blasting shall be done in such a manner as will most nearly complete the excavation to the required grade lines and produce the least practicable disturbance of the material to be left in place. Blasting by means of drill holes, tunnels, or any other methods shall be entirely at the Contractor's risk. All requirements and obligations specified in General Requirements shall be strictly observed.

Excessive blasting will not be permitted. Overbreakage and the backfilling thereof shall be at the Contractor's expense. Any material outside the approved cross section limits which may be shattered or loosened because of blasting shall be removed by the Contractor at his own expense. All rock slopes with loose material shall be scaled by workmen and all loose material removed.

Backfilling of overbreakage shall be carried out as directed, using approved soil or crushed materials or other special aggregate or cyclopean concrete, as shown on the Drawings or as directed by the Supervisor. Undrained pockets shall not be left in the surface of the rock. Backfilling of overbreakage shall be at the Contractor's expense.

If the flow of traffic is to be interrupted during blasting operations, the Contractor shall secure approval of his schedule for such interruptions and his proposed methods for safeguarding the public and property.

Where necessary or directed, the Contractor shall provide heavy mesh blasting mats for protection of persons, properties, and the Works. If, in the opinion of the Authorities and/or the Supervisor, blasting would be dangerous to persons or adjacent structures, or is being carried out in an unsafe or unacceptable manner, the Supervisor may prohibit blasting and order the rock to be excavated by other means.

The Contractor shall at all times make full liaison with and inform well in advance and obtain such supervision and permission as is required from the Police and all

Government Authorities, public bodies and private parties whosoever concerned or affected by blasting operations.

Blasting shall only be carried out on those sections of the Works for which permission in writing shall have been given by the Supervisor and the relevant authorities and shall be restricted to such hours and conditions as may be prescribed. Blasting within 10 metres of existing water mains will not be permitted.

Blasting shall not be permitted in the vicinity of concrete which has not cured for at least 14 days.

Blasting shall be carried out so as not to weaken existing structures or the foundations or ground adjacent to the existing and proposed works. The Contractor shall take all necessary precautions to prevent loss, injury or accident to persons or property and shall be entirely liable for any accident or damage that may result from the use of explosives.

The Contractor shall submit to the Supervisor for his approval a method statement including details of the intended drilling patterns, depths of holes, the amounts of explosives at each location and the method or sequence of setting off that he proposes to use.

Blasting work shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.8 BACKFILLING GENERAL REQUIREMENTS

2.8.1 General

Backfilling whether for structural excavations or for pipe trenches shall be thoroughly compacted by ramming whether manually or mechanically and any subsidence due to consolidation shall be made up with extra compacted material.

Thorough compaction shall be carried out by means which will not damage the Works. The moisture content of the backfill material shall be uniform and within the moisture range designated.

Any subsidence resulting from insufficient compaction shall be the Contractor's liability and he shall forthwith add the necessary extra material which shall then be thoroughly compacted.

Additional water to be added during backfilling to achieve required compaction shall be fresh water or brackish water approved by the Supervisor.

Backfilling of structural excavations and pipe trenches shall be with suitable material approved by the Supervisor.

Granular material as backfill is defined as unconsolidated, crushed stone, quarry dust, gravel, sand or similar in which the clay or silt content is not predominant.

Timbering shall be removed from the excavations before or during the process of backfilling except in so far as this removal of timber would be likely to cause damage to

adjacent property, structures or structure foundations in which event the Contractor shall leave in the excavation such timbering as he considers necessary or as may be ordered by the Supervisor.

No backfilling shall be carried out without prior written approval from the Supervisor and only such Works approved or ordered to be backfilled shall be measured and paid for.

2.8.2 Submittal

Before beginning backfilling in any part of the Site, the Contractor shall submit to the Supervisor for his approval a work procedure, methods statement and a time schedule regarding backfilling works. His submittal shall include the equipment and material to be used, the extent and methods of backfilling, the fill and bedding material to be used, the characteristics of borrow areas if required, the compaction method, compaction levels and moisture content to achieve, a time schedule for the related works, a safety plan and all other information required by the Supervisor.

The Supervisor will determine the extent and limits of the backfilling works.

2.9 PIPE BEDDING

Pipe bedding or backfill in contact with the pipes up to 300 mm above the pipe crown, shall be selected material and shall not contain large stones, rocks, tree roots or similar objects which through impact or by concentrating imposed loads might damage the pipes. It shall be free-draining and readily compactable i.e. the material shall be capable of being compacted without the use of heavy rammers and should be free of clay lumps or other material larger than 75mm or stones larger than the maximum particle size specified for pipe bedding.

Pipe bedding shall be as follows:

TYPE A: Sand Bedding and Surrounds for DCI Pipes

The bedding and surrounds material shall be fine, uniformly graded sand (to comply with BS 882 grading zone c) clean and free of stones, rubbish, clay or organic matter. Free draining, incompressible, fine granular material may be used instead of sand, subject to written approval of the Supervisor.

The beddings and surrounds up to 30 cm above the pipe shall be wetted and thoroughly compacted in layers not exceeding 15 cm in thickness after compaction. Special care shall be taken to obtain proper compaction under and around the pipe.

TYPE B: Granular Material Beddings and Surrounds for HDPE Pipes

HDPE pipes shall be laid in suitable granular material bedding or surround. Suitable bedding and surround material shall be broken stone or gravel from 3/8" (9.5 mm) to 3/16" (4.8 mm) size, sand as specified above or other material having a compaction factor not exceeding 0.1. The compaction factor shall be obtained using the compaction fraction test as follows:

Material used

1. Open-ended cylinder 225 mm long and 150 mm internal diameter (a pitch fibre or P.V.C. pipe is suitable).
2. Metal rammer with striking face 40 mm diameter and weighing 0.9 to 1.1 kg.
3. Ruler.

Method

Obtain a representative sample more than sufficient to fill the cylinder viz. about 11.5 kg. It is important that the moisture content of the sample should not differ materially from that of the main body of material at the time of its laying in the trench.

Place the cylinder on a firm surface and gently pour the sample material into it, loosely and without tamping. Strike off the top surface level with the top of the cylinder and removal all surplus spilled material. Lift the cylinder up clear of its contents and place on a fresh area of flat surface. Place about one-quarter of the material back in the cylinder and tamp vigorously until no further compaction can be obtained. Repeat with the second quarter, tamping as before, and so on for the third and fourth quarters, tamping the final surface as level as possible.

Measure down from the top of the cylinder to the surface of the compacted material. This distance in millimetres divided by the height of the cylinder (250 mm) is the Compaction Fraction of the material under test.

To obtain a representative sample, about 50 kg of the proposed material should be heaped on a clear surface and divided with the spade down the middle into two halves. One of these should then be similarly divided, and so on until the required weight of sample is left.

Pipe bedding is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

2.10 BACKFILLING OF PIPE TRENCHES

Backfilling of pipe trenches, except at joints in case the hydrostatic test is not completed, shall be done as soon as practicable after the pipes have been satisfactorily laid in position and jointed and in no case shall more than five pipe lengths be left uncovered after laying. Where shown on Drawings, the first stage of the backfill, up to 30 cm above the crown of the pipe, shall consist of selected material as described in clause 2.9 above. This backfill shall be spread simultaneously on both sides of the pipe in layers not exceeding 150mm thickness after compaction and compacted by the use of hand rammers taking particular care to compact the material under the barrel of the pipe and around joints.

Compaction shall reach at least 92% of modified A.A.S.H.T.O. density or not less than 95% maximum dry density at optimum moisture content as determined by the BS Heavy Compaction Test to BS 1377.

The second stage of backfilling covering the remainder of the pipe trench, from 30 cm above the crown of the pipe to bottom of the sub-base course of the road or to the top of the trench in open areas, shall be carried out after the completion of testing, by one of the following methods:

- Where the pipeline crosses or runs underneath roads or pavements, backfilling shall be of type B, type A will be used when directed by the Supervisor or shown on the Drawings. It shall be placed in layers not exceeding 15 cm after compaction, wetted as necessary and compacted at least 90% of modified A.A.S.H.T.O. and the last 600 mm below the road sub-base course shall be compacted at least 95% of modified A.A.S.H.T.O. density.
- In open areas, the second stage backfill may be done with excavated material dumped into the trench by means of a bulldozer or similar equipment, provided that the fill material does not contain any large stones, that the trench is completely filled without leaving any voids and the fill is finished with a neat mound raised to about 30 cm above the trench edges to allow for future subsidence.

Do not use heavy compactors in or over pipe trenches until there is 700 mm cover over the pipe. If the cover over the top of the pipe is less than 700 mm, use concrete bedding as specified on the drawings and directed by the Supervisor in case heavy compacting equipment is used. Otherwise, the Contractor shall use suitable small compactors (mechanical vibratory tampers) and shall be responsible for any damage caused to the pipe by non compliance with this requirement.

When backfilling pipeline trenches with concrete beds and surrounds, do not start second stage backfilling before 24 hours or allow heavy compactors and traffic over the pipes before 72 hours of placing concrete.

In trenches where there is a continuous accumulation of groundwater, the trench shall after obtaining the approval of the Supervisor, be over-excavated by 150mm and shall be backfilled using compacted granular material. Where ground water conditions are such that the bedding material would be likely to act as a carrier for ground water from higher to lower ground, the Supervisor may instruct flow barriers of suitable selected earth or concrete to be inserted in lieu of bedding material. Such barriers to be erected at reasonable intervals close to flexible joints in the pipe.

Use temporary crossing over the trench to prevent damaging the pipes due to traffic during the construction stage.

The Contractor shall be responsible for any subsidence of trench backfill and shall make good any damage to road or structures caused thereby during the Period of Maintenance.

Where lengths of trench are excavated partly in rock, stony ground or in other material unsuitable for backfilling, there may not be sufficient suitable material available from the excavation for backfilling as specified above and in such cases the Contractor shall transport suitable material from other parts of the work or from borrow areas. The Contractor can also screen the excavated material to salvage as much as possible for backfilling.

Backfilling of pipe trenches is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

2.11 BACKFILLING FOR STRUCTURES

Backfill materials shall be uniformly graded granular material capable of being compacted to required compaction and having adequate permeability to permit free drainage through it. Backfill material shall also conform to the following:

- Minimum D10 value : 1mm
- Maximum plasticity index : 10 %

Structural excavation backfill shall not be placed until the structure has been inspected by the Supervisor and backfilling approved. Backfill shall not be placed against any structure until approval is given. In general, no structure shall be subjected to the pressures of backfilling or to live loads until the 28 day strength of the concrete has been reached or three (3) days after the expiration of the period designated for the removal of formwork whichever is longer. At the direction of the Supervisor, this period may be extended if subnormal curing conditions exist, or reduced if site conditions allow.

Backfill placed around a wall or particular structure, shall be deposited on both sides to approximately reach the same elevation at the same time. Special care shall be taken to prevent any wedging action against the structure to avoid undue strains. The slopes bounding the excavation shall be stepped when necessary, to prevent such wedge action.

Whenever backfill is placed against walls, the fill shall be first placed midway between the ends of the structure, working equally both ways from the center of the structure toward the ends.

If not specified elsewhere or indicated on the plans, the backfill around structures shall be completed to the level of the original ground or to the finished ground level, whichever is lower unless otherwise specified.

The material shall be placed in layers and compacted by means of suitable equipment or by tamping with mechanical tampers or hand tampers. Each layer shall be compacted to a density equal to or greater than ninety five (95) percent of the maximum density determined by AASHTO T 180-74, Method D. Each successive layer shall contain only that amount of material which will ensure proper compaction, but in no case shall any layer be greater than 150 mm thickness after compaction.

Backfilling for structures is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

2.12 COMPACTING EQUIPMENT

Compacting equipment shall be of a design, weight and quantity so as to obtain the required density.

Pneumatic Roller shall consist of pneumatic tires arranged in a manner so as to provide a satisfactory compacting unit. The roller shall have an effective rolling width of at least 150 cm. and shall give a compression of at least 130 kg. per cm. of width of tread when fully loaded. The tires shall be uniformly inflated.

Smooth Roller shall be self-propelled or power roller and shall weigh at least 10 tons and may be of the tandem or three-wheel type. The wheels of the roller shall be equipped with adjustable scrapers.

Other equipment, such as vibrating machines, may be used for compacting and consolidating the embankments, subgrades, and other areas, upon approval of the Supervisor. Such equipment shall be routed over the area being compacted and shall be operated until the required density is obtained.

Suitable mechanical and hand tampers shall be used in specific locations as for compaction around and directly above pipes in trenches, in confined places or in the direct vicinity of structures. Mechanical compaction shall not be allowed in trenches for backfill depth less than 300 mm above crown of pipe.

Watering shall be carried out by means of tank wagons, tank trucks, or distributors equipped with a suitable sprinkling device. Satisfactory equipment shall be maintained on the site at all times when embankment construction is in progress.

2.13 REINSTATEMENT OF SURFACES GENERAL REQUIREMENTS

2.13.1 *General*

All surfaces such as roads, spoil areas, land over which temporary facilities are erected, borrow areas, etc...whether public or private that are affected by the Works shall be reinstated after completion of the construction works to the satisfaction of the Supervisor and the responsible authority or owner. Reinstatement shall be carried out immediately after the construction works are completed.

Should subsidence occur after any surface reinstatement has been completed the surface reinstatement shall first be removed, the hollows made up and then the surface reinstatement re-laid to the approval of the Supervisor or responsible authority. The Contractor shall inform the Supervisor before carrying out this work.

Any subsidence that occurs adjacent to the Site of the works which is attributable to the Contractor's activities shall be reinstated to the full satisfaction of the Supervisor. Should the Contractor not remedy the defect to the Supervisor's satisfaction forthwith any remedial work considered necessary may be undertaken by the Contracting Authority and/or the responsible authority at the Contractors expense.

For the purposes of reinstatement in paved roads and unless specified otherwise, the width of trenches shall be increased by 150mm on each side of the trench for a depth of 75mm to provide a solid abutment for the paving material.

Where the surface of roads (other than those which lie immediately above the trench) are damaged either by the concentration of traffic caused by an open trench, by subsidence

or other causes arising from the operations of the Contractor, he shall permanently reinstate the whole of the surface so damaged to its original condition. Reinstatement of surfaced roads shall be carried out to the approval of the relevant authority.

The responsible authority shall have the right to carry out permanent reinstatement at the Contractors expense.

Trenches in open ground shall be reinstated to the condition in which the ground was before excavation was started. The surface of the trench after settlement shall be flush with the surrounding ground. Trenches shall not be topped up above the original surface level to allow for settlement unless specifically mentioned.

If any trench becomes dangerous due to surface subsidence, the Supervisor may call upon the Contractor for its reinstatement at three hours' notice. In case of non performance, the Supervisor can have the work done by others at the Contractor's expense.

Top soil shall be carefully set aside and replaced at the surface of the backfilling.

If at any time during the Defect & liability period any reinstatement deteriorates, the Contractor shall restore it to a proper condition immediately.

No surface reinstatement shall be carried out without prior written approval from the Supervisor.

2.13.2 Submittals

Before beginning surface reinstatement in any area, the Contractor shall submit to the Supervisor for his approval a method statement and work procedure regarding reinstatement of a particular surface. His submittal shall include the equipment and material to be used, the extent and methods of work, the compaction method and compaction levels to achieve, a time schedule for the related works, a safety plan and any other information requested by the Supervisor.

The Supervisor will determine the extent and limits of the reinstatement works.

2.14 AGGREGATE SUB-BASE AND BASE COURSES FOR PAVEMENT

2.14.1 General

These Works shall consist of furnishing aggregate sub-base and base course material of the required Class, mixing, spreading on prepared subgrade or sub-base, compacting and finishing, all as and where shown on the Drawings.

The materials used as aggregate shall meet all quality requirements of the Contract. All materials shall be tested and approved before use. The Contractor shall notify the Supervisor of the sources of materials and the Supervisor shall approve the sources prior to delivery of materials to the site. Where a source of material does not meet Specification requirements, the Contractor shall furnish material from other sources. Delivery of materials produced from commercial manufacturing processes shall be

accompanied by the manufacturer's certification and test report showing the materials comply with the Specification requirements.

Materials shall be so stored and handled as to ensure the preservation of their quality and fitness for the Work. Handling and stockpiling of aggregates shall at all times be such as to eliminate segregation or contamination of the various sizes. Stockpiles shall be kept flat and the formation of high cone-shaped piles shall not be permitted.

When trucks are used to construct stockpiles, the stockpiles shall be constructed one layer at a time with trucks depositing their loads as close to the previous load as possible. The use of tractors or loaders to push material deposited at one location to another location in the stockpile shall not be allowed during the construction of the stockpile and their use shall be limited to levelling the deposited material only.

The Supervisor shall have authority to request samples and tests of aggregates supplied to the site from any source whatsoever in order to establish their compliance with Specifications and to accept or reject as he deems necessary. Samples shall also be taken from completed work to determine compliance with the Specifications. No rejected materials, the defects of which have been corrected, shall be used until approval has been given by the Supervisor.

2.14.2 *Description of aggregate material*

Aggregate sub-base and base courses shall be in compliance with ASTM D 2940 and shall consist of crushed mineral aggregates or natural mineral aggregates of the gradation and thickness indicated in the Specifications and / or on the Drawings.

Natural aggregate sub-base and base courses shall consist of coarse and fine mineral aggregates which have been blended to the various grading and constructed to the thickness as indicated on the Drawings and the Specification.

Crushed aggregate sub-base and base courses shall consist of crushed coarse aggregate and crushed or natural fine aggregate screened and blended in accordance with the required gradation and constructed to the thicknesses as indicated on the Drawings and in the Specifications.

Coarse aggregate retained on the No.4 (4.75mm) sieve shall consist of durable particles of crushed stone, gravel, or slag capable of withstanding the effects of handling, spreading and compacting without degradation productive of deleterious fines. Of the particles which are retained on a 3/8 -in (9.5 mm) sieve, at least 75% shall have two or more fractured faces.

Fine aggregate passing the No.4 (4.75mm) sieve shall normally consist of fines from the operation of crushing the coarse aggregate; where available and suitable, natural sand or finer mineral matter, or both, may be added. The fraction of the final mixture that passes the No. 200 (75µm) sieve shall not exceed 60% of the fraction passing the No. 30 (600µm) sieve. The fraction passing the No. 40 (425-µm) sieve shall have a liquid limit no greater than 25 and shall not have a plasticity index greater than 4. The sand equivalent value of the fine aggregate shall be no lower than 35.

2.14.3 *Types of Aggregate Sub-Base and Base Courses*

The combined gradation including fine and coarse aggregates shall conform to the gradation for Sub-Base and Base Courses as indicated in the Table 1 below. The continuous smooth gradation of materials used shall be kept within the specified gradation limits and gap grading must be avoided.

Sub-base course material shall have a 4-day soaked CBR of not less than 30% when compacted at 100% modified Proctor (AASHTO T 180-D) and tested in accordance with AASHTO T193.

Base course material shall have a 4-day soaked CBR of not less than 80% when compacted at 100% modified Proctor (AASHTO T-180-D) and tested in accordance with AASHTO T 193.

TABLE 1
GRADATION OF SUB-BASE & BASE COURSE AGGREGATES

Sieve Size: (square openings)	Design Range (weight percentages passing)		Job Mix Tolerances (weight percentages)	
	Bases	Sub-bases	Bases	Sub-bases
2 in. (50mm)	100	100	-2	-3
1-1/2 in. (37.5mm)	95-100	90-100	±5	+5
3/4 in. (19.0mm)	70-92		±8	
3/8 in. (9.5mm)	50-70		±8	
No.4 (4.75 mm)	35 – 55	30 - 60	±8	±10
No.30 (600 µm)	12-25		±5	
No.200 (75 µm)	0-8	0-12	±3	±5

2.14.4 *Construction requirements for aggregate sub-base and base courses*

Prior to commencing the construction of the sub-base and base courses, it is necessary to make sure that the sub-grade conforms to the specifications and is compacted to the maximum Dry Density as indicated in section 2.10 above “Backfilling for pipe trenches”, and that the surface thereof conforms to the levels and slopes indicated in the Drawings or approved by the Supervisor. In all cases the approval of the Supervisor must be obtained before commencing spreading for the sub-base and bases course.

Screening shall be required for the materials used in aggregate sub-base and base courses. Screens shall be of the size and number required to remove oversize aggregate and, if necessary, to separate the materials into two or more fractions so that they may be combined to meet the required gradation. Stockpiling aggregate should be done in a manner to prevent segregation.

Mixing of material can be achieved through mechanical means as the travel mixer or prior to delivery.

After carrying out the screening and mixing of aggregate material, samples of the approved material shall be taken in order to determine the optimum Moisture Content.

Material shall then be spread in the trench or on the road surface to thicknesses that would result in layers not more than 250mm thick before compaction.

The natural moisture content of materials constituting the sub-base and base courses shall be determined. If the natural moisture content is less than the optimum moisture content, the necessary amount of water must be added to obtain the optimum content allowing for the quantity which may be lost by evaporation in the process of raking, levelling and compacting, depending on atmospheric temperature, quantity of material and the equipment and plant to be used in this operation, provided that the layer shall be compacted when the moisture content therein is within $\pm 2\%$ of the optimum moisture content in order to obtain Maximum Dry Density, and the moisture content is uniform in all parts of the section where the work is being carried out and in the various depths of the layer thickness.

Thorough compaction shall start immediately thereafter, by means of suitable steel rollers that can be used in trenches or with mechanical tampers. Standard rollers shall be used if a road is being paved and in accordance with the instructions of the Supervisor. Compaction must continue until the in-situ dry density is not less than 95% of the Maximum Dry Density by the Moisture Density Relationship Test AASHTO T 180.

In case of road paving, compaction must start with rollers from extreme sides proceeding gradually toward the road axis.

During all the above-mentioned operations of mixing, spreading, compacting and levelling of sub-base and base courses material, care must be taken so that layers already compacted under the layer being executed are not affected, or that the finished sub-grade or base surface is also not affected. This aspect must be given special attention in places where equipment makes turns in going back and forth and any such damage resulting in mixing the various layers constituting the different sub-grades and base courses shall be carefully made good by the Contractor at his own expense and to the satisfaction of the Supervisor.

If more than one sub-base or base course is required for reaching the required thickness described in the Specifications, each such course will be constructed as hereinbefore described.

Where the finished compacted thickness indicated on the drawings exceeds 250 mm, placing shall be executed in composite layers each layer not exceeding 250 mm before compaction and as directed by the Supervisor.

Compaction shall be tested in accordance with AASHTO T 191, AASHTO T 205 or any acceptable method. If there is a significant delay between the construction of any layer and the following layer, the Supervisor may require the compaction of the lower layer to

be verified again to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

2.14.5 Protection of Surface

The Contractor shall protect the sub-base or base course so that it shall be maintained sound during work progress, after its completion and prior to receiving the bituminous layers or prior to laying the surface overlay thereon. Any damage caused to the layer if exposed to traffic or natural conditions resulting in damage to its surface shall be made good at the expense of the Contractor and to satisfaction of the Supervisor.

In the case of paving roads, when the rolling develops irregularities, the irregular surface shall be loosened, then refilled with the same kind of material as used in constructing the course and again rolled according to specifications.

Work on the sub-base courses shall not be permitted during rainy weather.

In the case of complete road paving, hauling equipment may be routed over the completed portion of the sub-base and base courses provided no damaged results and provided that such equipment is routed over the full width of the course to avoid rutting or uneven compaction.

The Supervisor has the right to stop all hauling over completed or partially completed sub-base and base courses when in his opinion such hauling is causing damage.

Following the completion of the courses the Contractor shall perform all maintenance work necessary to keep the course in a condition for priming. The prime coat shall be applied after preparation of the previously compacted surface, all in accordance with the present specifications and the Supervisor's requirements.

Aggregate sub-base and base course for pavement shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.15 BITUMINOUS WORKS FOR PAVEMENTS

2.15.1 General

Materials specified for use in the construction of the bituminous pavement courses for this project include the following:

- Coarse and fine mineral aggregates and fillers.
- Bitumen cement products like cutback and penetration bitumen.

All material sources and the quality of materials proposed for use in the Works shall be approved prior to procuring or processing material from such sources. Inspection, sampling, testing and retesting as necessary, shall be at the Contractor's expense.

Storage and handling of all aggregate materials shall conform with section 2.14 above and the following specifications.

Approval of sources for material shall in no way relieve the Contractor of his responsibilities in respect of producing aggregates which conform to the Specifications and in the quantities required for the completion of the Works on time.

Approval of specific sources of materials shall not be construed as final approval and acceptance of materials from such sources.

Stockpiling procedures shall not result in degradation or segregation of the stockpiled material, or introduction of foreign materials into the stockpile. Heights of aggregate stockpiles shall not exceed 5 m.

Sampling and testing procedures shall conform with the general requirements of these specifications and with the following:

The Contractor shall submit to the Supervisor. 30 days prior to the start of the works a statement of origin and composition of all aggregates proposed for use in the Works. In order to ascertain the properties of aggregate materials, the Contractor shall submit for testing and approval, representative samples of all materials intended for incorporation in the bituminous works. The representative samples shall be taken by the Contractor in the presence of the Supervisor.

2.15.2 *Description of aggregate material*

Coarse aggregate shall be the fraction of crushed aggregate material retained on 4.75 mm (No. 4) sieve.

Fine aggregate shall be the fraction of crushed aggregate material passing 4.75 mm (No. 4) sieve.

Mineral filler shall be added when the combined grading of coarse and fine aggregates is deficient in material passing 0.075 mm (No. 200) sieve.

The material from hot bins passing the number 40 sieve (0.425mm) when tested in accordance with AASHTO T90 shall be non plastic. In addition the material from cold bins should not have a PI larger than 4.

Aggregates shall not contain more than 1 % gypsum and the coarse fraction of the aggregate shall not contain more than 5% chert.

Aggregates shall be of uniform quality, free from decomposed stone, organic matter, shale.

The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO TI 12.

Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.

The flakiness index and the elongation index test should be conducted in accordance with BS 812, the following are maximum limits:

	Wearing Course	Binder & Bituminous Base Course
Flakiness Index F.I	25	30
Elongation Index E.1	25	30

Aggregates shall be washed if directed, to remove any clay lumps, organic matter, adherent dust or clay films or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.

Mineral filler shall consist of finely divided mineral matter such as limestone dust if added; hydrated lime; other non-plastic mineral filler free from clay and organic impurities; or Portland cement, conforming to AASHTO M 17.

Combined coarse and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T 27 and T11, shall conform to the gradations shown in Table 3 below

TABLE 3

GRADATION OF AGGREGATES FOR BITUMINOUS WORKS

Sieve size and designation (Square openings)	Total percent passing by weight				
50 mm (2 in.)	100				
37.5 mm (1-1/2 in.)	90-100	100			
25.0mm (1 in.)		90-100	100		
19.0mm (3/4 in.)	56-80		90-100	100	
12.5 mm (1/2 in)		56-80		90-100	100
9.5mm (3/8 in)			56-80		90-100
4.75mm (No.4)	23-53	29-59	35-65	44-74	55-85
2.36mm (No.8)	15-41	19-45	23-49	28-58	32-67
1.18mm (No. 16)					
0.60mm (No. 30)					
0.30mm (No.50)	4-16	5-17	5-19	5-21	7-23
0.15mm (No. 100)					
0.075mm (No.200)	0-5	1-7	2-8	2-10	2-10

2.15.3 Bitumen general

The grade of bitumen may be changed by the Supervisor by one grade either side of the specified grade at no extra cost to the Contracting Authority. When more than one type or grade is specified under any item, the Supervisor will select the type and grade to be used in the Works.

All transporting of bitumen shall be by conveyances that are free from contamination. Tank cars or tank trucks used for transporting bitumen shall be carefully inspected, drained, and cleaned if necessary, before loading, to prevent contamination of the bitumen from residues of previous loads. Bitumen may also be delivered and transported in metal drums.

Tank trucks or trailers used to transport bitumen shall be equipped with an approved sampling device which shall be built into the tank, or recirculation or discharge line in such a manner that a sample can be drawn during circulation or discharge.

The Contractor shall provide an adequate storage facility for bitumen, at the site of the mixing plant. This facility should be clean and stable and provided with cover and shelter from excessive temperatures.

No open fires or smoking shall be allowed in or around storage areas for bitumen

The storage capacity should be sufficient to maintain a uniform operation while allowing for delayed shipments and time for testing. Different batches of bitumen should be separated, so as to allow for easy identification.

If the bitumen is delivered to the site in metal drums, on arrival the drums shall be inspected for perforations rusting, melting or other defects that would directly cause pollution or chemical changes to the bitumen. Any drum(s) showing any of these defects shall be rejected at the discretion of the Supervisor.

The stored bitumen products should be protected from temperatures which may exceed the range of -5 deg. C to +60 deg. C.

2.15.4 ***Bitumen heating***

Heating equipment shall be of an approved type. Any method of agitation or heating that introduces free steam or moisture into the bitumen will not be approved. During the process of its manufacture, conveyance, storage, or construction use, bitumen of whatever type shall not be heated to temperatures more than 10 deg. C above the maximum application temperature specified for the respective type of bitumen nor above 170 deg. C, whichever is the lower. Materials heated in excess of these temperatures will be rejected and shall not be used in the Works.

Tanks for heating and storage of bitumen shall be capable of heating the material, under effective and positive control at all times, to the specified temperature. The system shall provide uniform heating for the entire contents of the tank. The circulation system shall be of adequate size to insure proper and continuous circulation of the bitumen during the entire operating period. Suitable means shall be provided, either by steam or oil jacketing, or other insulation, for maintaining the required temperature of bitumen, weigh buckets, spray bars, and other containers.

Thermometers of approved type and adequate range (calibrated in 2 degrees C increments) for accurately measuring the temperature of the bitumen while heating, shall be located so as to be readily visible and shall be kept clean and in proper working order at all times.

Bitumen materials, wasted through careless handling or rendered unsuitable for use by overheating shall not be used in the Works.

2.15.5 ***Bituminous prime coat material and application***

Procedures for sampling of bituminous materials shall conform to AASHTO T 40.

MC cutback bitumen prime coat shall be applied to a previously constructed subgrade, aggregate sub-base or base course or concrete pavement.

MC cutback bitumen for prime coats shall be as recommended by ASTM D2399-83. Generally MC 70 shall be used unless otherwise specified.

MC 70 cutback shall conform to the requirements of AASHTO M82. Sampling and testing shall be in accordance with the AASHTO standard methods listed in AASHTO M 82.

MC 70 cutback bitumen spraying temperature ranges shall be 45 – 80 °C

All equipment used for surface cleaning, heating bitumen (if required) and application of prime and tack coats, shall be adequate for the purposes intended and shall be approved before use.

All surfaces to receive prime or tack coats shall conform with the specified tolerances and compaction requirements and shall be properly cleaned using brooms or power blowers. The surfaces shall be approved before applying any bitumen material.

Application of prime coats shall be performed only when the surface to be treated is sufficiently dry, for tack coat and sufficiently moist for prime coat, and when the atmospheric temperature is above 10°C for the application of tack coat, 15°C for the application of prime coat. There should be no fog, rain, strong winds, dusty conditions, or dust storms.

The surfaces of all structures, curbs, gutters and other road appurtenances shall be protected in an approved manner to prevent them from being splattered or stained with bitumen or damaged during equipment operation. The Contractor shall be responsible for making good any such staining or damage to the satisfaction of the Supervisor.

Traffic shall not be permitted on surfaces after they have been cleaned and prepared for prime or tack coat application.

If there are undue delays in scheduling priming or subsequent paving after priming, the surface tolerances and compaction of the granular course shall be verified again and deficient areas corrected or replaced in an approved manner at the Contractor's expense.

The Contractor shall maintain prime coats intact until they are covered by the subsequent pavement course. Any area where the coats have been damaged shall be cleaned of all loose material, any surface defects repaired and the coat applied again at the Contractor's expense.

If required by the Supervisor, when the surface is an untreated subgrade or a granular surface, the cleaned surface shall be given a light application of water and allowed to dry

to the condition deemed appropriate by the Supervisor before the bituminous material is applied.

Heating of MC cutback bitumen and its temperature at the time of application shall conform with the requirements started above.

Application rates for prime coat will be determined by the Supervisor from the trial sections, and shall be generally between 0.75 to 2 litres / m² for untreated subgrade surfaces, sub-base and base courses.

Hand spraying will be approved only for priming sub-base courses in trenches and small patches or inaccessible areas that cannot be primed by normal operation of a pressure distributor.

When required by the Supervisor, a light covering of blotting material shall be applied to the prime coat 48 hours after spraying and when it has not dried sufficiently to withstand damage by traffic. The blotting material shall be a smooth fine sand, or other approved material.

Prime coats shall be cured for 3 days before traffic is allowed on it or before the succeeding pavement layer is placed, or as directed by the Supervisor.

2.15.6 ***Bituminous base course material***

Bituminous base course shall consist of a mix generally composed of coarse mineral aggregate, fine mineral aggregate, mineral filler or cement if required and cutback bitumen whenever standard road paving is carried out.

At least 30 days prior to the date the Contractor intends to proceed with paving works, and after receiving approval of the aggregates and bitumen, the Contractor shall submit for approval his proposed Job Mix Formula.

The Job Mix Formula shall stipulate a single combined grading of all aggregate and filler materials showing the specific % by weight passing each sieve size and the specific % by weight of each material to be used in the total mix.

Mix design procedures shall conform to the Marshall method of mix design and relevant procedures contained in Asphalt Institute Manual MS-2. All trial mixes shall be prepared and tested by the Contractor in the presence of the Supervisor.

The job mix requirement for bituminous base course shall be as follows

Marshall Stability at 60 deg. C (Kg)	700
Flow (mms)	2-4
Voids in Mineral Aggregate (VMA)	12 min
Air Voids (%)	3-5

Unless otherwise shown on the Drawings, bitumen for base course construction shall be 60/70 penetration graded bitumen.

2.15.7 Bituminous base course transportation

A sufficient number of haul vehicles shall be provided so that adequate supplies of mix are delivered to ensure that continuous paving will be achieved.

Hauling equipment for aggregates and bituminous mixes shall consist of vehicles having dump bodies suitable for dumping materials in a windrow or in spreader boxes. The bodies shall be so constructed that their volume measurement can be accurately determined. They shall be constructed and maintained such that loss of materials during hauling operations will not occur. Dump controls shall be capable of operation from the driver's seat.

Hauling equipment for hot bituminous mixes shall have tight, clean, smooth metal beds which are periodically thinly coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type cover which shall be used to cover the hot material upon loading at the mixing plant and shall not be removed until the mix is discharged. Hot mix material may be transported without such cover only if permitted by the Supervisor in special circumstances.

2.15.8 Bituminous base course application

Bitumen mix shall be delivered and placed at least 90 minutes before sunset to allow sufficient time for compaction, unless the use of artificial light is approved.

The minimum temperature for the commencement of rolling is 120 °C. Mix loads of temperature less than 120 °C shall not be accepted, and the load shall be disposed of and another load used. If there is consistent failure to meet the temperature requirement, the Supervisor shall order paving operations to stop until suitable measures are taken by the Contractor to ensure that temperature requirements are met.

Bituminous mixes shall be laid only when the air temperature is at least 5 degrees C or above, when the existing surface is free from moisture, and when the weather is not foggy, rainy, dusty or excessively windy (particularly at low temperatures).

When the bituminous mix is to be placed on a prepared subgrade, subbase, or base, the surface shall be prepared to meet the appropriate specified compaction and surface tolerance requirements. The surface shall then be primed as specified hereabove.

No bituminous mix shall be laid on a prime coat until it has been inspected and approved.

After completion of surface preparation, the bituminous mix shall be spread and finished true to crown and grade. The mix may be spread and finished by approved hand methods only where the Supervisor determines that machine methods are impracticable like the reinstatement of trenches in paved areas. Hand methods include heated hand tampers of at least 10 kg weight and approved type mechanical (vibratory) tampers.

The Finish shall be smooth, true to cross section, uniform in density and texture and free from hollows, transverse corrugations and other irregularities.

Contact surfaces of curbing, gutters, manholes, and similar structures shall be painted with a thin, uniform coating of tack coat material. The bituminous mixture shall be placed uniformly high near the contact surfaces so that after compaction it will be 10 mm above the edge of such structure.

If during the paving operations 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 the scheduled operations, the use of the equipment shall be discontinued, until faults are corrected to the approval of the Supervisor. If this is not possible, other satisfactory spreading and finishing equipment shall be provided by the Contractor.

Unless otherwise directed by the Supervisor, where successive bituminous layers are to be placed, the surface of each existing layer shall be swept clean with a broom, or by other approved means and a tack coat applied at the rate designated by the Supervisor.

Transverse joints in succeeding layers shall be offset by at least 2 m. Longitudinal joints shall be offset at least 150 mm.

Bituminous base course shall be spread in one or more layers so that, after rolling, the nominal thickness of each layer of the compacted bituminous material does not exceed 2 to 3 times the maximum size of aggregate. This maximum thickness may be increased slightly when such increase is more appropriate to total pavement thickness and provided the Supervisor determines that such increased thickness will not be detrimental to the quality of the finished bituminous course, and the Contractor can show that the required density is attained throughout the layer thickness.

If vibratory rollers are used, when it is required to change direction the vibration should be turned off before the roller is stopped, and turned on after motion in the new direction begins. Speed of vibratory rollers shall not exceed 4.5 Km/hr.

Rolling shall begin as soon as the mixture will bear the roller weight without undue displacement. The minimum temperature of the mat at which rolling shall be allowed to start is 120 deg. C.

The speed of the rollers, rolling pattern and, in the case of vibratory rollers, the frequency and amplitude of vibration, shall be approved by the Supervisor. To prevent adhesion of the mix to the rollers, the wheels shall be kept properly and lightly moistened with water. An excessive use of water will not be permitted.

The compacted density of the bituminous base course shall be equal or greater than 97% of the average Marshall bulk density for the batch used if applicable..

The Contractor shall compensate for minor deficiencies in the thickness of any bituminous course in the pavement structure by increasing the thickness of the subsequent bituminous course. After completion of the final course any deficiencies in the

thickness of any course which have not been compensated for by increasing the thickness of a subsequent course, will be considered deficiencies in the final course.

Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.

Bituminous works for pavements shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.16 REINSTATEMENT OF ROADS

In all paved or bitumen sprayed roads, the trenches shall be refilled and compacted to the underside of the sub-base layer of the road as per clause 2.10 above and at a depth below the road finish level as shown on the drawings or recommended by the Supervisor but no less than 450 mm.

An aggregate base layer shall then be laid consisting of approved free draining crushed limestone as specified in sub-section 2.14.2 & 2.14.3 above.

The aggregate base course application shall be as per sub-section 2.14.4 above. It shall be placed in layers not exceeding 250 mm loose thickness (before compaction) and compacted using mechanical compactors.

After completion of the aggregate base course and prior to receiving the bituminous base material, the surface of the aggregate base course and excavation shoulders shall be thoroughly cleaned and primed as described in section 2.15 above.

A bituminous base course shall then be placed in layers not exceeding 70 mm and compacted using vibratory compactors all according to the requirements of section 2.15 above. Unless ordered to the contrary by the Supervisor, the top layer shall be compacted by steel wheeled roller, of not less than 12 ton mass. It is important to note that to apply such load the pipe underneath the pavement should be at a minimum depth of 0.7 meter.

Reinstatement of roads is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

2.17 REINSTATEMENT OF OTHER SURFACES

Reinstatement of other surfaces shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

2.17.1 *Unpaved roads*

In all unpaved roads the trenches shall be refilled and compacted to within 150 mm of the surface. The trench shall then be finished with 150 mm compacted thickness of aggregate base layer material as per the requirements of section 2.14

2.17.2 ***Borrow and fill areas***

Any spoil tips and borrow areas developed by the Contractor for the purpose of the Works shall be finished to an acceptable to the approval of the Supervisor. Dumped materials in spoil tips shall be spread, leveled and shaped as directed so as to present a neat and tidy appearance. The fill shall be placed in layers not exceeding 150 mm thick, each layer being thoroughly compacted by an approved roller to the satisfaction of the Supervisor.

2.17.3 ***Top soiling and grassing***

In verges and other grass surfaces and after the backfilling has been thoroughly consolidated the topsoil shall be re-laid rolled and planted with grass or other vegetation as-directed by the Supervisor and watered until the grass has become well established. Should the planting fail it shall be replanted as required until a satisfactory growth is obtained.

All trees, shrubs and plants requested by the Supervisor to be preserved shall be carefully transplanted and shall be returned to their original location after the refilling of the excavations. Return of old or mature trees may be waived in cases where the age of the tree makes return impracticable.

Where required, surfaces shall be soiled with fine sifted soil or silt not less than 100 mm compacted thickness which shall be raked and brought to a fine consistence.

The Contractor shall supply labor during the Defects Liability Period to ensure that all rehabilitated surfaces are properly maintained.

2.17.4 ***Free draining fill***

Free draining fill for use as backing to walls shall consist of sound hard stone or broken rock or concrete derived from demolition of structures. The particles shall be roughly cubical and shall be between 75 mm and 25 mm in size. All smaller particles dust rubbish and organic matter shall be excluded.

3. CONCRETE WORKS

3.1 DESCRIPTION

This work shall consist of furnishing and placing concrete and reinforcement for structures and construction in accordance with the specifications and in conformity with the lines, grades and dimensions as shown on the drawings or established by the Supervisor.

The used concrete class for the different concrete works shall be mentioned in this present specification manual or in the execution drawings or as directed by the Supervisor.

3.2 CONCRETE MATERIALS

3.2.1 Cement

3.2.1.1 Characteristics

The cement to be used is type PAL 42.5 for all concrete structures according to the Lebanese norm.

It shall be originating from manufacturers approved by the Supervisor, shipped and sealed, labeled bags only. Cement delivered in bulk shall not be used unless authorized by the Supervisor.

A sack of cement shall weight 50 (fifty) kilograms.

3.2.1.2 Mixing of cements

Only one (1) type or brand of cement shall be used in any one structural member. Mixing of types or bands will not be permitted.

3.2.1.3 Test and acceptance

All shipments of cements shall be accompanied by a manufacturer's certificate of guarantee and/or laboratory test certificate.

The temperature of the cement shall be measured at any arrivals.

The Supervisor reserves the right to order a retest of the cement at any time.

Approval of a cement quality shall not relieve the contractor of the responsibility to fabricate concrete of the specified strength. The contractor shall bear all costs in connection with the certificates of guarantee and laboratory test. When tests of factory or field tests subsequent to the original approval tests show that the cement does not comply with the specifications, the entire consignment from which the sample was taken will be rejected and the contractor shall immediately remove the rejected material from the site and replace it with cement, which meets the required specifications.

3.2.1.4 *Storage*

Storage capacity shall be sufficient to meet the requirements for 30 (thirty) working days unless in the opinion of the Supervisor the supply from the manufacturer is so limited that more storage capacity is necessary.

Cement shall be stored in moisture proof storage sheds in such a manner that the oldest is used first. Neither stale nor reclaimed or re-sacked cement shall be used. The contractor shall not store cement in areas subject to flooding.

Cement remaining in bulk storage at the mill prior to shipment for more than six (6) months or cement stored in bags in local storage by the contractor or a vendor for more than three (3) months after shipment from the mill, may be retested before use and will be rejected if its fails to meet any of the requirements of these specifications.

3.2.2 **Aggregates**

3.2.2.1 *Source of supply*

The aggregates shall be extracted from any official natural quarries (stone or sand) approved by the Supervisor. The loss by Abrasion Test (Los Angeles) shall not be more than 35.

3.2.2.2 *Fine aggregates*

Fine aggregates shall conform to AASHTO M6 and shall consist of natural sand and crushed rock having hard and durable particles having a maximum of 30 as Los Angeles or, if approved by the Supervisor, other inert materials having similar characteristics 100% passing 9.5 mm sieve and 2% to 10% passing 0.15 mm sieve. It shall not contain harmful materials such as iron pyrites, coal, mica, shale or similar laminated materials such as flat and elongated particles or any materials which may attack the reinforcement in such a form or in sufficient quantity as to adversely affect the strength, durability and texture of the concrete.

The "sand equivalent" (Piston method) of the nature sand shall not be less than 70%

3.2.2.3 *Coarse aggregates*

Coarse aggregates shall conform to AASHTO M 80 and shall consist of gravel, crushed gravel, or crushed stone free from coating of clay or other deleterious substances. It shall not contain harmful or any other materials in such a form or in sufficient quantity as to adversely affect the strength and durability of the concrete. If necessary or requested by the Supervisor, coarse aggregate shall be washed to remove deleterious substances. The loss by Abrasion Test (Los Angeles) shall not be more than 30.

3.2.2.4 *Combined aggregates*

Combined aggregates are composed of a mixture of coarse aggregates and fine aggregates. They shall be used only in proportions with the prior approval of the Supervisor. In no case shall materials passing no. 200 (0.075 mm) sieve exceed 3% by weight of the combined aggregates.

3.2.2.5 *Testing*

In order to ascertain the properties of all aggregates materials, the Contractor shall submit, for approval by the Supervisor, test certificates from an approved testing laboratory for all materials intended for incorporation in the work.

The Contractor may, if approved by the Supervisor, conduct the necessary tests in the laboratory. The tests shall be conducted in the presence of the Supervisor. The resume of the qualifications must be submitted to and approved by the Supervisor prior to any testing operations.

This testing whether performed at an approved testing laboratory or in the project laboratory, shall be solely the Contractor's responsibility and will be at the Contractor's expense.

3.2.2.6 *Approval and Inspection*

All processed materials shall be tested and approved before being stored on the site or incorporated in the work and may be inspected and tested at any time during the progress of their preparation and use.

Questionable materials shall not be unload and incorporated with materials previously approved and accepted. If however, the grading and quality of the material delivered to the site do not conform to the grading and quality as previously inspected and tested, or do not comply with the specifications, the Supervisor reserves the right to reject such materials at the site of the work. Only materials conforming to the requirements of the specifications shall be used in the work.

Samples must meet all test requirements. The Contractor shall permit the Supervisor to inspect any and all material used or to be used at any time during or after its preparation or while being used during the process of the work or after the work has been completed. All such materials not complying with the required specifications, whether in place or not, shall be rejected and shall be removed promptly from the work.

3.2.2.7 *Storage*

Materials shall be stored so as to insure preservation of their specified quality and fitness for the work. They shall be placed on hard, clean surfaces and, when required by the Supervisor, they shall be placed under cover. Stored materials shall be located as to facilitate prompt inspection and control. Private property shall not be used for storage purposes without written consent of the owner or lessee and payment to him, if necessary.

3.2.3 **Water**

All sources of water to be used with cement whether for mixing or curing of concrete, or compaction of backfill around the concrete structures, shall be approved by the Supervisor. If at any time during construction, water from an approved source becomes unsatisfactory, the contractor shall provide satisfactory water from other main sources.

Water shall be free from injurious quantities of oil, alkali and vegetable matter and salt as determined by the Supervisor. The water shall be reasonably clear and shall contain not more than one quarter (0.25) percent solids by weight. If the specific conductance is less than 1500 micro ohms per centimeter the total solids contents requirements may be waived.

3.2.4 Admixture

Where direct by the Supervisor, all the necessary additives shall be used (air entrained agent, plasticizers and super plasticizers, protection of concrete in contact with water from the evaporation of lime, waterproofing.....). In particular a retarding admixture set shall be used. The admixture proposed for use shall be approved by the Supervisor before it is incorporated into the work.

The admixture shall be type D as specified in AASHTO M 194.

3.3 REINFORCING STEEL

3.3.1 Reinforcing Bars

3.3.1.1 Type

All reinforcing bars shall be of a deformed or plain type in accordance with AASHTO M31.

3.3.1.2 Quality

All deformed steel reinforcement shall be of Grade 60 and the plain ones of Grade 40. Tying wires shall be galvanized.

3.3.1.3 Certification

A copy of a mill test report shall be furnished to the Supervisor for each lot of billet steel reinforcement bars proposed for use on the project.

The mill test report shall show the following information:

- The process or process used in the manufacture of the steel from which the bars were rolled.
- Chemical and physical properties of the heat from which the bars were rolled.

3.3.1.4 Inspection and sampling

The sampling and testing of reinforcement bars may be made at the source of supply when the quantity to be shipped or other conditions warrant such inspection. Bars not inspected before shipment will be inspected after arrival on the work, test samples obtained at the destination of the steel shall be duplicate bars not less than one (1) meter in length and bars from which such samples are taken shall be replaced at the contractor's expense. The Supervisor reserves the right to resample and inspect all reinforcement steel upon its arrival at the work site.

All reinforcement bars shall be free detrimental dirt, mill scale, rust, paint, grease, oil or other foreign substance, fins or tears. The contractor will not be required to remove slight rusting which discolors the metal, but he shall remove all loose mill scale and scales rust.

Brushing to clean blue metal will not be required. There shall be no evidence of piping or visual flaw in the test specimen or on the sheared ends of the bars.

3.3.1.5 Protection and storage

Reinforcing steel shall be protected at all times from damage. Reinforcing steel shall be stored above the ground on plate forms, skids, or other supports. It shall be stored in such a manner and adequately marked to facilitate inspection and checking. When placed in the work, the reinforcing steel shall be free from dirt, detrimental scale, paint, oil or other foreign substance.

3.3.2 Wiremeshes for shotcrete

The wiremeshes for shotcrete shall be of Grade 40.

The dimensions of the wiremesh should be as follows:

- 6mm diameter, 15 x 15 cm mesh, or
- 5mm diameter, 12 x 12cm mesh, or
- 4mm diameter, 10 x 10 cm mesh

3.4 ASSEMBLY AND HANDLING OF MATERIALS

3.4.1 Assembly of aggregates

Aggregates shall be assembled in such quantities that sufficient material approved by the Supervisor is available to complete any continuous pour necessary for structures. The batching site shall be of adequate size to permit the stockpiling of sufficient, non segregated materials, having proper and uniform moisture content to ensure continuous and uniform operation. Aggregates shall enter the mixer in a manner approved by the Supervisor and in such a manner to ensure that no matter foreign to the concrete or matter capable of changing the desired proportions is included. In the event two (2) or more sizes or types of coarse or fine aggregates are used on the same project, only one (1) size or type of each aggregate may be used on one (1) continuous concrete pour.

3.4.2 Stockpiling of aggregates

All aggregates shall be stockpiled before use in order to prevent segregation of material, to ensure a uniform moisture content, to provide uniform conditions for proportioning plant control and to aid in obtaining concrete that is uniform as to materials and moisture content.

The use of equipment or methods of handling aggregates which results in the degradation of the aggregates is strictly prohibited. Bulldozers with metal tracks shall not be used on coarse aggregate stockpiles. All equipment used for handling aggregates shall be approved by the Supervisor.

Stockpiling of aggregates shall be in the manner approved by the Supervisor and in the addition, every precaution shall be taken to prevent segregation shall be prevented by making no layer higher than one and one-half (1.5) meters and if two (2) or more layers

are required, each successive layer shall not be allowed to “cone” down over the next lower layer.

Aggregates shall not be stockpiled against the supports of proportioning hoppers and weighing devices.

Aggregates shall be stockpiled and protected at locations which preclude contamination by brackish groundwater during periods of high water or contamination from other sources which might detrimentally affect aggregates. Contaminated aggregates shall not be used in the concrete.

When required, the aggregate stockpiles shall be sprinkled with water, twelve (12) hours prior to use, to maintain moisture content in the aggregates equivalent to the water absorption value of the aggregate as determined by AASHTO T 84 and AASHTO T85.

3.4.3 Segregation

Segregated aggregates shall not be used until they have been thoroughly remixed and the resultant pile is of uniform and acceptable gradation at any point from which a representative sample is taken. The contractor shall remix aggregate piles when ordered by the Supervisor.

3.4.4 Transporting of aggregates

If aggregates are to be transported from a central proportioning plant to the mixer in batch-boxes or dump trucks, such equipment shall be of sufficient capacity to carry the full volume of materials for each batch of concrete. Partitions separating batches shall be approved by the Supervisor and shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped.

3.4.5 Cement storing and stockpiling

Cement in storage or stockpiled on the site shall be protected from any damage by climatic conditions. Methods of storing or stockpiling shall be approved by the Supervisor. Cement shall be transported to the mixer in the original sacks. Each batch shall contain the full amount of cement for the batch. Batches where cement is placed in contact with the aggregates may be rejected unless mixed within one and one – half (1-1.5) hours.

3.5 COMPOSITION OF CONCRETE

3.5.1 Requirements

The mix proportions shall be proposed by the contractor to ensure:

- that the required strength is respected
- that the workability of the fresh concrete is suitable for the conditions of handling and placing, having regard to the structural element being constructed.

The maximum cement content in any mix shall not exceed 500 kg/m³ for normal structures and 450kg/m³ for liquid retaining structures.

In all cases of mix proportioning the added water shall be included with due allowance for the moisture contained in the aggregates and shall be the minimum consistent with the workability requirements.

3.5.2 ***Mix proportions and strength***

The contractor shall be responsible for the design of the concrete and shall consult with the Supervisor as to mix proportions at least forty five (45) days prior to beginning concrete work. The actual mix proportions of cement, aggregates and water shall be determined in accordance with BS 5328 parts 2,3 and 4, by the contractor under the supervision of the Supervisor.

The contractor shall, in the presence of the Supervisor, prepare trial mixes for each class of concrete required for the project, made with the approved materials to be used in the work. The proportions of the trial-mixes shall be such as to produce a dense mixture containing the cement content specified and meeting the plasticity requirements and one hundred fifteen (115) percent of the strength requirements specified for the designated classes of concrete. If the materials supplied by the constructor are of such a nature or are so graded that proportions based on minimum cement content cannot be used without exceeding the maximum allowable water content, the proportions will be adjusted so as to require the least amount of cement which will produce concrete of the required plasticity and workability without exceeding such allowable water content. No additional payment will be made for increased quantity of cement. Test cylinders shall be made from the trial – mixes.

The Supervisor will review the contractor's trial mixes and break the test cylinders at seven (7) and twenty eight (28) days. The Supervisor will then determine which the trial mixes shall be used. If none of trial – mixes for a class of concrete meets the specifications, the Supervisor will direct the contractor to prepare additional trial-mixes. No class of concrete shall be prepared or placed until its job-mix proportions have been approved by the Supervisor.

The approval of the job-mix proportions by the Supervisor or his assistance to the contractor in establishing those proportions, in no way relieves the contractor of the responsibility of producing concrete which meets the requirements specified in these specifications.

All costs connected with the preparation of trial-mixes and the design of the job-mixes shall be done by the contractor, including all laboratory tests and the breaking of the tests cylinders.

The limiting values which shall govern for each class of concrete are as follows:

The cement content specified herein shall be determined from a yield test in accordance with AASHTO T 121.

Concrete for structures. Cement, water and slump requirements for the various classes of structural concrete are specified in the following table:

Schedule for the specification requirement of designed mixes			
1. Mix reference (class of concrete)	A	B	C
2. Minimum compressive strength at 28 days (N/mm ²)	25	20	15
3. Nominal maximum size of aggregate, mm	25	25	25
4. Types of aggregate: Coarse	M80	M80	M80
AASHTO			
Fine AASHTO	M6	M6	M6
5. Permissible cements	PAL	PAL	PAL
	42.5	42.5	42.5
6. cement content , kg/m ³	350	300	250
7. Maximum free water/cement ratio	0.50	0.55	0.55
8. Slump requirements (cm)	1-5	5-10	7.5-10

The seven (7) days compressive strengths shall not be less than seventy (70) percent of the required twenty – eight (28) day strength.

The ultimate compressive strength of the concrete shall be determined on test specimen obtained and prepared in accordance with ASHTO T 23 and AASHTO T126, except that only six (6), inches [one hundred fifty two (152) millimeters] by (12) inches [305 millimeters] cylinders shall be used for compression tests. The contractor shall furnish single use cylinder molds conforming to AASHTO M 205, or when approved by the Supervisor, reusable vertical molds made from heavy gauge metal.

3.5.3 *Changes in proportion*

As the work progress, the Supervisor reserves the right to require the contractor to change the proportions from time if conditions warrant such changes to produce satisfactory results. Any such changes may be made within the limits of the specifications at no additional compensation to the contractor.

3.6 MIXING OF CONCRETE

Concrete shall be mixed in quantities for immediate use. Concrete shall not be used which has developed initial set or is not in place one-half (1/2) hour after the water has been added for non-agitated concrete or if agitated, the concrete must be in place one and one-half (1-1/2) hours after the water has been added. Retempering concrete by adding water or by other means will not be permitted. Concrete that is not within the

specified slump limits at the time of placement shall not be used and shall be disposed of as directed by the Supervisor.

The concrete may be mixed at the site of the work, in a central-mix plant, or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are in the drum.

When mixed at the site of the works or in a central-mixing plant, the mixing time shall not be less than fifty (50) seconds nor more than ninety (90) seconds.

The mixer shall be operated at a drum speed as shown on the manufacturer's nameplate on the approved mixer. Any concrete which, in the opinion of the Supervisor, is mixed more or less than the specified time shall be described and disposed of by the contractor at his experience. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meters, as shown on the manufacturer's standard rating plate on the mixer, except that an overload up to ten (10) percent above the mixer's nominal capacity may be permitted when approved by the Supervisor, provided concrete test data for strength, segregation and uniform consistency are satisfactory and provided no spillage of concrete takes place.

The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first fifteen (15) seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

3.7 CYCLOPEAN CONCRETE

Cyclopean concrete shall consist of class "C" concrete containing embedded stones. The embedded rubble stones shall be of approved quality, sound and durable, and free from segregations, seams, cracks and other structural defects or imperfections tending to destroy its resistance to the weather. It shall be free from rounded, worn, or weathered surfaces. All weathered stone shall be rejected. The stone shall be kept free from dirt, oil, or any other injurious material which may prevent proper adhesion. The largest dimension of any rubble stone shall not exceed 20 centimeters. The distance between two adjacent rubble stones or between a rubble stone and the form shall not be less than 5 centimeters.

The stone shall be carefully placed – not dropped or cast-so as to avoid injury to the forms or to the partially set adjacent masonry. All stones shall be washed and saturated with water before placing. The total volume of the stone shall not be greater than one third of the total volume of the portion of the work in which it is placed.

3.8 BLIND CONCRETE

Blind concrete shall consist of class "C" concrete and will be used where specified in the drawings.

3.9 TRANSPORTING

Concrete shall be transported to the place of final deposit by approved means.

Barrows, spades and other equipment used in the process of transporting concrete shall be thoroughly cleaned before each day's work or after a long interruption and they shall be free from hardened concrete.

Concrete shall be transported as soon as possible after mixing by methods which will prevent the segregation, loss or contamination of the ingredients.

Bridging for traffic over reinforcement shall be provided so that the reinforcement is not distorted damaged or displaced.

Where approval is obtained for concrete to be conveyed by chutes, these shall have a slope (not exceeding 1/1 vertical to horizontal) such as to ensure a continuous flow of concrete. Additional water shall not be introduced to assist the flow. If deposition is to be intermittent the chute shall be arranged to discharge into a storage hopper. In no case a clear fall of more than 1 m be permitted at the discharge end of the chute.

Where approval is obtained for pumping the concrete, the pump manufacturer's recommendations as approved by the Supervisor shall be followed. The pumps used shall be of adequate capacity and power to ensure delivery of a continuous supply.

Wherever transport of concrete is interrupted for any period of over half an hour the chutes, pumps, pipes and any other means of distribution shall be thoroughly flushed out and cleaned. These shall also be flushed out immediately prior to resumption of concreting and shall be kept free from hardened concrete. All washing water used shall be discharged outside the formwork and clear of any freshly placed concrete.

3.10 HANDLING, PLACING CONCRETE AND COMPACTING

Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Supervisor. The forms shall be clean and free of all debris before concrete is placed. The method and sequence of placing concrete shall be approved by the Supervisor.

The external surface of all concrete shall be thoroughly worked during the placing by means of tools of an approved type. The working shall be such as to force all coarse aggregate from the surface and to bring mortar against the forms to produce a smooth finish, substantially free from water and air pockets, or honeycomb.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. Concrete shall not be deposited in large quantities at any point in the forms and the run or worked along the forms, this causing segregation of the materials.

The concrete shall be deposited in the forms in horizontal layers and the work shall be carried on rapidly and continuously between predetermined planes agreed upon by the contractor and the Supervisor. Key ways shall be formed between layers.

Concrete shall not be dropped in the forms a distance of more than one meter, unless confined by approved closed chutes or pipes and care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

Unless otherwise directed, the concrete shall be compacted with suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by spending with suitable tools to assure proper and adequate compaction.

Vibrators shall be of an approved type and design.

Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angels of the forms. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish compaction, but shall not be prolonged to the point where segregation occurs.

The operation of placing the concrete shall be continuous until complete, except where joints are provided on the plans or authorized by the Supervisor. When a special sequence or method of concrete placing operations is indicated on the plans, or designated by the Supervisor, this sequence or method shall be followed.

3.11 HOT WEATHER CONCRETING

Concreting shall not be permitted if its temperature at placing is in excess of 38°C. In order to maintain the temperature of the concrete below this value the following precautions shall be taken wholly or in part as instructed by the Supervisor.

All aggregate stockpiles, water lines and tanks as well as the mixer shall be protected from the direct rays of the sun.

Coarse aggregate shall be cooled by constant watering where possible.

Mixing water shall be cooled by the addition of ice to the storage tanks where necessary.

Rapid-hardening cement shall not be used.

Where the above precautions are inadequate concreting shall be carried out during the cooler parts of the day or during the night as may be directed by the Supervisor.

When the air temperature is above 20°C loss of mixing water by evaporation shall be considered in arriving at the amount of water to be added to the mix. To maintain the water/cement ratio within permissible limits an approved water-reducing agent shall be included in the mix.

The maximum water/cement ratios may be increased with the Supervisor's permission by 0.05 during mixing, but on no account shall water be added to concrete once it has left the mixer.

In order to reduce premature drying of the concrete during transporting and placing all chutes, formwork and reinforcement shall be cooled by watering when possible, or shall otherwise be protected from the direct rays of the sun.

As soon as possible after concreting, the formwork shall be stripped and the surface of the concrete shall be treated.

Where drying winds are encountered, wind shields shall be positioned as necessary to protect exposed surfaces of the curing concrete.

3.12 WET WEATHER CONCRETING

Concreting during periods of constant rain shall not be permitted unless aggregate stockpiles, mixers and transporting equipment, and the areas to be concreted are adequately covered.

During showery weather, the Contractor shall ensure that work can be concluded at short notice by the provision of stop ends. On no account shall work be terminated before each section, between one stop end and another is complete. Adequate covering shall be provided to protect newly placed concrete from the rain.

3.13 COLD WEATHER AND NIGHT CONCRETING

No concrete shall be mixed, placed or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated and such night work is approved by the Supervisor.

Unless authorized in writing by the Supervisor, mixing and concreting operations shall be discounted when a descending air temperature in the shade and away from artificial heat reaches five (5) degrees C. When directed by the Supervisor, the Contractor shall enclose the structure in such a way that the concrete and air within the enclosures can be kept above fifteen (15) degrees C for a period of seven (7) days after placing the concrete. The Contractor shall supply such heating apparatus as stoves, salamanders or steam equipment and the necessary fuel. When dry heat is used, means of maintaining atmospheric moisture shall be provided.

When directed by the Supervisor, all aggregates or mixing water or both, shall be heated to a temperature of a least ten (10) degree C, but not more than twenty-one (21) degrees C the aggregates may be heated by steam or dry heat.

The temperature of the concrete shall be not less than fifteen (15) degrees C at the time of placing in the forms. In case of extremely low temperature, the Supervisor may, at his direction, raise the minimum limiting temperature for work, aggregates and mixed concrete. Salt chemicals or other material shall not be used to prevent freezing.

3.14 READY MIX CONCRETE

The contractor may propose to the Supervisor approval the use of Ready mixed concrete.

The composition and mixing of this concrete shall conform to all the requirements established in the specifications.

3.15 SHOTCRETE

3.15.1 *Definitions and requirements*

The shotcrete shall be used as protection of the water earth channels according to the execution drawings and as directed by the Supervisor.

The shotcrete is applied either through dry application (with or without pre-wetting), or through wet application. The wet application is the most recommended way since it ensures a better uniformity and a better productivity of the shotcrete, as well as a more rapid application.

However, dry application could be used whenever the supply of the machine is difficult.

The constituents and the mix of the shotcrete should be in conformity with the specifications cited in this section, with the following specific remarks:

- the maximum size of the aggregates should be 16mm
- the initial dosage has to take into account the fact that the applied shotcrete has a final dosage that is different from the initial one, due to the bouncing and rebounds during application. Hence, an increase in the cement dosage from 10 to 20% is necessary along with an increase of fines from 10 to 20%.
- The additives to be used are either accelerating agents or "raidisseurs", to ensure the immediate adherence and fixation of the shotcrete.
- The nominal compressive strength at 28 days should be 25 Mpa, and the tensile strength at 28 days should be 2.3Mpa.

The shotcrete will be subject to a control procedure including the following tests:

- analysis of fresh concrete once/week or every 100 m³
- compressive strength (on cores of 60mm diameter) 3 to 28days, every 50 m³
- tensile strength 'brasilian' test on cores, 3 to 28 days every 100 m³
- density on all cores

It is best suited to keep a certain humidity to the shotcrete through frequent sprinkling.

3.15.2 *Shotcrete reinforcement*

The wiremesh should be installed in such a way to prevent any movement during the application of the shotcrete (and this through several fixation points per m²). Any movement of the wiremesh after application of the shotcrete is prohibited.

3.16 REINFORCING STEEL

3.16.1 *Description*

This work shall consist of furnishing and placing reinforcing steel in accordance with the specifications and in conformity with the shop drawings to be prepared and submitted for the Supervisor approval.

3.16.2 *Protection and storage*

Reinforcing steel shall be protected at all times from damage. Reinforcing steel shall be stored above the ground on platforms, skids, or other supports. It shall be stores in such a manner and adequately marked to facilitate inspection and checking. When placed in the work, the reinforcing steel shall be free from dirt, detrimental scale, paint, oil or other foreign substance.

3.16.3 *Cutting and Bending*

All cutting and bending of reinforcement bars shall be done by competent workmen and with equipment approved by the Supervisor. Unless shown otherwise or the plans or unless written approval is obtained from the Supervisor, all reinforcement bars shall be cut and bent in an on site fabrication shop.

Bent bar reinforcement shall be cold bent to the shapes shown on the plan, and unless otherwise provided on the plans or by written authorization of the Supervisor, bends shall conform to the following requirements:

- $D = 6d$ for five (5) millimeter through twenty two (22) millimeter bar sizes
- $D = 8d$ for twenty four (25) millimeter through twenty eight (32) millimeter bar sizes
- $D = 10d$ for thirty (30) millimeter and over bar sizes

Where D = minimum pin diameter around which a bar may be bent d = bar diameter

3.16.4 *Placing, supporting and fastening*

All reinforcing steel shall be accurately placed and during the placing of concrete, firmly held by approved supports in the position shown on the plans.

Reinforcing bars shall be securely fastened together, reinforcement placed in any member shall be inspected and approved before any concrete is placed.

Laying or driving bars into the concrete after placement will not be permitted. All horizontal reinforcement shall be supported on metal supports or spacers as approved by the Supervisor.

The use of small stones or wood blocks for supporting reinforcement will not be permitted. The reinforcement shall be held securely in place at the proper position and spacing as indicated on the plans by the use of wire ties at bar intersections and tying to

the supports and spacers. The adequacy of the supports and ties to secure the reinforcement properly shall be subject to the approval of the Supervisor.

3.16.5 Splicing

Splices shall be avoided at points of maximum stress. They shall, where possible, be staggered and shall be designed to develop the strength of the bar without exceeding the allowable unit bond stress. Unless otherwise shown on the plans, in the bottom of beams and girders, and in walls, columns, and haunches shall be lapped a minimum of twenty (20) diameters and bars near the top of beams and girders having more than thirty (30) centimeters of concrete under. The bars shall be lapped a minimum of 40 diameters to make the splice. In no case shall bars be lapped less than thirty (30) centimeters.

3.17 FALSEWORK

Detailed plans for falsework and centering shall be prepared by the contractor and submitted to the Supervisor for approval. The plans must be approved by the Supervisor before the work is started.

Falsework and centering shall be designed and constructed to provide the necessary rigidity to support all loads placed upon it without appreciable settlement or deformation. Falsework columns shall be supported on wood or metal bases when it cannot be founded on rock, shale or thick deposits of other compact material in their natural bed. Falsework shall not be supported on any part of the structure, except the footings without the written permission of the Supervisor. The number and spacing of falsework columns, the adequacy of sills, caps and stringers and the amount of bracing in the falsework framing shall be subject to approval of the Supervisor.

All timber shall be of sound wood, in good condition and free from defects that might impair its strength. If the vertical members are of insufficient length to cap at the desired elevation for the horizontal members, they shall preferably be capped and frames constructed to the proper elevation. Ends of the vertical members shall be cut square for full bearing to preclude the use of wedges. If vertical splices are necessary, the abutting members shall be of the same approximate size, the ends shall be cut square for full bearing and the splices shall be scabbed in a manner approved by the Supervisor.

In designing forms and centering, concrete shall be regarded as a liquid. In computing vertical loads, a weight of twenty-four hundred (2400) kilograms per cubic meter shall be assumed, and not less than thirteen hundred and sixty (1360) kilograms per cubic meter shall be assumed in computing horizontal pressure.

The review or approval of falsework plans by the Supervisor or permission to proceed with the work shall not relieve the contractor of the responsibility for successful erection or satisfactory results.

3.18 FORMWORK

Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations, including

vibrations. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. They shall be designed to permit easy removal without injury to the concrete. Form lining such as smooth, exterior grade plywood or other approved material shall be used for all formed surfaces. The contractor shall submit samples, specifications and other pertinent information thereon to Supervisor and secure his prior written permission to use the form lining.

Forms shall be maintained after erection to eliminate warping and shrinkage. They shall be checked for dimensions and condition immediately prior to the placement of concrete. The Supervisor may at any time require the revision or reconstruction of forms and may refuse permission to place concrete within the forms until they are satisfactorily constructed. If, at any period of the work during or after placing the concrete, the forms show signs of sagging or bulging, the concrete shall be removed to the extent directed by the Supervisor, the forms brought to the proper position and new concrete placed. No allowance will be made to the contractor. For such extra work.

The inside of all forms shall be oiled with a light , clear, paraffin base oil that will not discolor or otherwise injure the surface of the concrete.

The oiling shall be done where possible after the completion of the forms and prior to placement or reinforcement.

Unless otherwise directed, the exterior side of all forms shall be painted with an approved, good quantity high gloss oil base enamel prior to placing concrete. When complete coverage is not obtained with one (1) coat, the Supervisor will order additional coats as he deems necessary to obtain complete coverage. Forms shall be repainted when ordered by the Supervisor.

Shrinkage cracks shall be closed by moistening the forms with water prior to concrete placement.

Forms that are to be reused shall be thoroughly cleaned and roiled and, if necessary, shall be reconditioned by revision or reconstruction. Unsatisfactory lumber will be condemned by the Supervisor, and shall be removed from the site.

Unless provided otherwise on the plans or directed by the Supervisor, all exposed edges shall be beveled by using dressed, mill-cut, triangular molding, having twenty (20) millimeter sides.

All curved surfaces shall be formed with approved plywood or steel.

When instructed by the Supervisor, the contractor shall submit formwork drawings and calculations to the Supervisor in advance of the concreting.

Through-bolts or ties will not be permitted in liquid retaining structures. The contractor shall use only such bolts or ties as are capable of being removed in whole or in part so that no part remaining embedded in the concrete shall be nearer the surfaces of the concrete than the specified thickness of cover to the reinforcement.

On all external arises of the concrete 25 mm chamfers shall be formed.

Before concreting, the areas which are intended to receive the concrete shall be cleaned by jetting with compressed air and all water extraneous material removed.

3.19 REMOVAL OF FORMS AND FALSEWORK

To facilitate finishing forms on handrails ornamental work and other vertical surfaces that require a rubbed finish shall be removed as soon as the concrete has hardened sufficiently that it will not be injured as determined by the Supervisor. In determining the time for the removal of forms, consideration shall be given to the location and character of the structure, weather and other conditions influencing the setting of the concrete.

If removal of forms or falsework is not controlled by beams or cylinders cured with and under the same conditons as the structure, the following periods, exclusive of periods when the temperature is less than four (4) degrees C, for releasing of forms and supports shall be used as a minimum:

- | | |
|--------------------------------|----------|
| • Supports under flat slabs | 14 days |
| • Vertical wall surfaces | 24 hours |
| • Columns | 24 hours |
| • Sides of beams | 24 hours |
| • Top slabs R.C , Box culverts | 14 days |

If high early strength cement is used, the time limits may be decreased as determined by the Supervisor.

3.20 JOINTS

3.20.1 *Construction Joints*

Wherever the works of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. So far, the location of construction joints shall be as shown on the plans, but if not shown on the plans, they shall be planned in advance and the placing of concrete carried continuously from joint to joint. The joints shall be perpendicular to the principal lines of stress and in general be located at points of minimum shear.

Where dowels, reinforcing bars or other adequate ties are not required by the plans, keys shall be made by embedding water-soaked beveled timbers in soft concrete. The key shall be sized as shown on the details, or as directed by the Supervisor, which shall be removed when the concrete has set. In resuming the Works the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance or other soft material with stiff wire brushes and if deemed necessary by the Supervisor, shall be roughened with a steel tool. The surface shall then be thoroughly washed with clean water and painted with a thick coat of neat cement mortar, after which the concreting may proceed.

3.20.2 *Expansion Joints*

Expansion joints shall be constructed at the locations of the materials and to the dimensions shown on the drawings.

The expansion joints previewed for the pipes surrounding concrete shall be equipped with polystyrene sheets and water stops.

The used water stops shall have 25cm width and 6mm thickness and shall be submitted for the Supervisor approval.

3.20.3 Cold Joints

When the continuous placement of concrete in any structural member is interrupted or delayed, for any reason, for a period long enough for the previously partially placed concrete to take its initial set, the Supervisor shall declare such joint a cold joint and the Contractor shall immediately remove the previously partially placed concrete from the forms. No extra payment will be made for the initial placement or the removal of concrete which is wasted because of a cold joint. The Supervisor may suspend all or any part of subsequent concrete work until he deems the Contractor has corrected the cause of the cold joint occurrence.

3.21 HOLES, CAVITIES AND FIXING

Holes shall be accurately marked and boxed-out for before concreting operations commence. No holes shall be formed after the concrete has set. Where bars, if placed to specified spacing would foul holes of size less than 250 mm x 250 mm. The full length of the bar shall be moved to one side unless otherwise indicated on the Drawings. For holes exceeding 250 mm x 250 mm, the bars shall be cut on site and lapped with additional equivalent bars.

Wherever possible, the Contractor shall build in all pipe work, Ironwork, and steelwork which passes through walls. The pipe work, ironwork, and steelwork shall first be thoroughly cleaned and freed from any deleterious matter. Every care shall be taken to ensure that it is thoroughly encased in concrete.

Bolts, hooks and other fixings shall be embedded in concrete, or holes shall be drilled and fitted with threaded expanding anchors to receive the bolts. The Contractor shall ensure that bolts hooks and fixings are accurately positioned Holding down bolts for machinery shall be set to template.

3.22 FINISHING

All top surfaces, such as the top of retaining walls, curbs, abutments, rails, etc, shall be treated by tamping and floating with a wooden float in such a manner as to flush the mortar to the surface and provide a uniform surface, free from pits or porous places. The surface thus obtained shall be toweled to produce a smooth surface and brushed lightly with a damp brush to remove the glazed surface.

Unless otherwise shown on the Drawings, all exposed concrete surfaces shall be smooth finish with epoxy paint and shall be free from honey-combing, fins, projections and air-holes. After removal of the forms, the Contractor, at his own expense, shall make good

faulty surfaces by filling them with cement and sand (1/2 by vol.) mortar and rubbing them with a fine carborundum stone.

Immediately after the curing period, the Contractor shall repair all minor shrinkage cracks identified by the Supervisor. Repairs shall be made as directed by the Supervisor using an approved water resistant, high modulus low viscosity epoxy.

Unless otherwise provided on the plans, all true and even surfaces, obtained by use of a form lining, which are of a uniform color, free from stone pockets, honeycomb, excessive depressions or projections beyond the surface shall be considered as acceptable surfaces and a rubbed surface finish will not be required, except as follows:

The above provisions for surface finish shall not preclude requiring the use of a dry carborundum brick for straightening molding lines, removing fins, etc, or requiring a rubbed Surface finish on all portions of the structure which do not present an acceptable surface even though a form lining is used.

3.23 CURING AND PROTECTION

All concrete shall be cured for a period of time required to obtain the full specified strength, but not less than seven (7) consecutive days beginning immediately after placement. Curing shall be done according to one of the two following pertaining methods:

3.23.1 *water Curing*

Water curing for all surfaces, unless sealed by metal forms or submerged, shall begin within one (1) hour of placement. Where liquid membrane is placed, water curing shall begin within four (4) hours of placement.

The Contractor shall provide sufficient water and equipments to keep the surface of the concrete continually damp until the membrane curing is applied. The water shall be applied with a nozzle that so atomizes the flow that a mist and not a spray is formed. The moisture from the nozzle shall not be applied under pressure directly upon the concrete and shall not be allowed to accumulate on the concrete in a quantity sufficient to cause a flow or wash the surface.

Surfaces to be water cured shall be covered with wet sand, cotton mats, double thickness burlap or other equivalent absorbent material. The absorbent material shall cover the concrete surface completely. The material shall be completely saturated with water and kept continuously saturated throughout the curing period. After initial saturation, all surfaces shall be covered with polyethylene sheeting meeting requirements of ASTM C-171 or other approved impervious material. The sheeting shall be weighted or secured to prevent moisture loss. However, the surfaces of the concrete shall be readily available for inspection of the Supervisor. The sheeting shall be in good repair. Sheeting that contains holes or is otherwise damaged shall be rejected by the Supervisor. The Contractor shall be responsible for thoroughly inspecting and monitoring the concrete surfaces throughout the curing period. Additional water shall be added to any areas which are not still

saturated. Inspections by the Contractor shall be conducted at least twice per day for the duration of the curing period and more often if ordered by the Supervisor.

The Supervisor shall be advised of the inspection schedule and may accompany the workman to verify the acceptability of curing.

3.23.2 *Membrane Curing*

Except for construction joints and surfaces sealed by metal forms, liquid membrane shall be used as follows:

On wood formed vertical surfaces, forms shall be stripped as soon as practical and liquid curing membrane applied immediately except that those areas being rubbed or finished during the curing period shall be kept wet until finishing is complete when clear liquid curing membrane shall be uniformly applied.

On metal formed surfaces, with or without wood lining, liquid curing membrane shall be applied if the Contractor elects to strip the forms within the curing period.

The curing membrane used shall be in accordance with the requirements specified for curing membrane material, AASHTO M 148 Type 1-D. The curing membrane shall be applied in two (2) applications. The rate of each application of curing compound will be as prescribed by the meters of concrete surface. If the concrete is dry or becomes dry, it shall be thoroughly wet with water and the curing compound applied just as the surface film of water disappears. During curing operations, any unsprayed surfaces shall be kept wet with water. Any curing membrane material on construction joints and/or reinforcing steel shall be completely removed before the following concrete pour.

Hand operated spraying equipment shall be capable of supplying a constant and uniform pressure to provide uniform and adequate distribution of the curing membrane at the rates required. The curing compound shall be thoroughly mixed at all times usage.

No traffic of any kind will be permitted on the curing membrane until the curing period is completed, unless the Supervisor permits the placement of concrete in adjacent sections in which case the damaged areas shall be immediately repaired as directed.

3.23.3 *Cold Weather Curing*

When concrete is being placed and the air temperature may be expected to drop below five (5) degrees C, during the curing period, the Contractor shall provide suitable measures such as straw, additional burlap, or other suitable blanketing materials and/or housing and artificial heat curing to maintain the concrete temperature between ten (10) degrees C and thirty-two (32) degrees C as measured on the surface of the concrete.

The surface of the concrete shall be kept moist by the use of an approved moisture barrier such as wet burlap or polyethylene sheeting. The moisture barrier shall be maintained in intimate contact with the concrete during the entire curing period. After the completion of the required curing period, the Contractor shall remove the curing and protection in such a manner that rapid cooling of the concrete will be prevented.

3.24 CONCRETE CONTROL AND TESTS

3.24.1 *Sampling and Testing*

All concrete, aggregate, cement and water shall be sampled and tested during construction as frequently as deemed necessary by the Supervisor. All test samples shall be supplied by the Contractor at his expense. Samples shall be obtained in accordance with AASHTO T 23, T 141, T 2, T 127 and T26. All costs connected with manufacturer's certificates of guarantee, laboratory analysis and all subsequent testing for material acceptance shall be borne by the contractor.

The Contractor shall provide on the site equipment, staff and labor for carrying out the sampling and testing and he shall carry out any or all of these tests at such times and with such frequency as may be requested by the Supervisor.

All equipment shall be calibrated and checked from time to time as the Supervisor may require.

The contractor shall provide all samples required by the Supervisor. Those samples to be tested in an off site laboratory shall be carefully forwarded by the Contractor to an approved laboratory. Results of laboratory and site tests shall be kept on site and copies of all test reports shall be forwarded in duplicate to the Supervisor.

Frequency of tests and the number of samples required will be governed by the results of the previous tests, the quality of the material revealed during the tests and the uniformity of that quality. Should it become evident that the quality of concrete is deteriorating, the Supervisor may require additional samples to be taken and test cubes to be made and tested to determine the cause.

3.24.2 *Quality Control*

Compliance with the specified characteristic strength shall be based on tests on cubes at an age of 28 days. Sampling and testing of concrete shall comply with BS 1881. For major structures the frequency of sampling shall be initially three samples taken each day for 5 days of concreting and thereafter at a frequency of one sample per 10 m³ of concrete but not less than one sample for each day concreting.

For minor structures the frequency of sampling shall be one sample per 20 m³ but not less than one sample for each day concreting. For mass concrete works and concrete works at pipeline appurtenances sampling shall be at an average of one sample per 50 m³.

A minimum of 3 test cubes shall be made for each sample.

Where materials are of an unfamiliar grading type, or where directed by the Supervisor, compression tests shall be carried out at 7 days and adjustments made in advance of the main control methods outlined above.

Cube test results will be examined individually in 10 consecutive sets of four and the standard deviation and mean strength of each set calculated. The concrete mix proportions will only be acceptable if all of the following requirements are complied with:

Not more than two results in 40 are less than the characteristic crushing strength.

No value of the average for any set of four results is less than the characteristic strength plus one-half of the design margin.

When 40 results have been obtained and the mean strength and standard deviation are calculated, the mean strength minus 1.64 times the standard deviation shall be greater than the characteristic strength.

Where the results do not conform to the above requirements the following action shall be taken:

Adjustments to the mix shall be made to obtain the strength required.

In the case where any result is less than 80% of the characteristic strength, the structural implications shall be considered and action taken as ordered by the Supervisor.

For those prescribed mixes required to be tested, requirements (i) and (ii) only still be applicable.

3.24.3 **Concrete Compression and tension tests**

The Supervisor will make and cure the cylinders from concrete as mixed for the work, which will be tested in accordance with AASHTO T 22 after 7 and 28 days. Test specimens shall be made and cured in accordance with AASHTO T 23. These specimens will be the basis for acceptance of the concrete in the structure.

They also provide means for checking the adequacy for laboratory mixture proportions for strength. If the average of the strength tests of the specimens fall below the minimum allowable compressive strength at 7 or 28 days, the concrete mix shall be redesigned. In the determination of the average compressive strength of the specimens, no cylinder specimen shall have strength less than 85% of the allowable strength.

The Supervisor will take a total of 9 cylinders from each day's run of concrete at each structure site. Three cylinders will be for the 7 day test, three cylinders for the 28 day test and three for the 28 day tension test. The contractor shall give the Supervisor full cooperation and, when requested by the Supervisor, labor assistance in preparing the cylinders. When directed by the Supervisor, the Contractor shall transport the cylinders from the structure site to the laboratory.

The Supervisor may make additional test cylinders to ascertain the effectiveness of the methods by which the structure is being cured and also to determine when the structure may be placed in service. These cylinders shall be cured in the field in the same manner as the concrete placed in the structure, and the contractor shall protect the cylinders from all damage.

The contractor shall take every precaution to prevent injury to the test cylinders during handling, transporting and storing. He will be held solely responsible for any test failures caused by improper handling and transportation, or any other cause which may be detrimental to the test cylinder.

In order that the test cylinders may be transported from field to laboratory undamaged, the contractor shall provide a minimum of two approved metal boxes. One for the contractor's use and one for the Supervisor's use. Boxes shall be of such size to receive a minimum of 6 test cylinders and leave space for sawdust packing around all surfaces of the cylinders. Boxes shall be approved by the Supervisor. The contractor shall, when directed by the Supervisor, provide as many additional boxes as may be required by the remoteness and/or magnitude of the concrete work.

When test cylinders fail to meet minimum strength requirements, the Supervisor may require core samples to be taken to determine the acceptability of such structures. The contractor shall, at his own expense, furnish all equipment required for such core samples.

4. MISCELLANEOUS BUILDING WORKS

4.1 PIPE SUPPORTS

Metal pipe supports shall be fabricated of structural steel elements complying with BS 4360 and workmanship with BS 5950. The pipe supports shall be securely fixed to structures using approved expansion bolts. They shall be of suitable section to keep deflection to acceptable limits under load.

All bolts and nuts used for structural steel supports shall comply with BS 3693 except for High Strength Friction Grip Bolts which shall comply with BS 4395.

All structural steel pipe supports shall be protected against corrosion by applying a protective epoxy coat. All bolts and nuts shall be shop galvanized and epoxy coated.

Mild steel electrodes for structural steel welding shall comply with the requirements of BS 639 and High Yield Steel with BS 2540.

All structural steel fabrication shall conform to the requirements of BS 153. The use of High Strength Friction Grip Bolts shall be in accordance with BS 3294.

Before proceeding with the fabrication of pipe supports, the Contractor shall submit to the Supervisor a complete schedule of the supports required with load calculations if requested by the Supervisor and the characteristics of the structural steel members to be used.

Pipe supports shall not be paid for as a measured item, they shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

4.2 WATERPROOFING AND THERMAL INSULATION FOR RESERVOIRS ROOFS

Waterproofing membranes applied to concrete roof decks shall be elastomer waterproofing systems or other approved proprietary system that provides a durable waterproof layer which is able to be flashed into up-stands and sealed into rainwater outlets and the like and can be adequately bonded to the substrate and jointed as necessary.

Membranes shall be reinforced by either Fiberglass at a rate of not less than 50 grams per square meter or by polyester not at a rate of not less than 150 grams per square meter.

Membranes shall be topped up by 50 mm thick medium density fiberglass insulating boards with Kraft paper backing. Boards shall be secured together with an approved adhesive and as per manufacturer recommendations. Thermal insulation shall be covered with 50 mm of fine graded clean sand followed by 50 mm of lean concrete screed or 500x500x30 mm precast concrete slabs sealed at the joints with an approved bitumen sealant all as per drawings details.

Contractor shall submit the data of the waterproofing sub-contractor who will execute the Works and prepare accordingly his technical submittal for the Supervisor's approval.

Waterproofing and thermal insulation of the reservoir roof is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

4.3 POLYETHYLENE SHEET VAPOR BARRIER

For Damp proofing applications, polyethylene vapor barrier membranes shall be laid, as directed by the Supervisor, beneath all floor slabs on grade or blinding concrete pads. They shall be composed of single sheets of minimum thickness 0.300 mm black polyethylene film of an approved manufacturer specifically made for use as damp-proof membrane.

The film shall be laid on sand and turned up around all edges of the slab and with 150 mm margin above the top of the slab to be tucked into the perimeter walls of the building. Where the building size is so large as to exceed the maximum sheet size available, several sheets shall be used and the joints shall be lapped 150 mm and fused together using a welding tool designed for that purpose or alternatively an approved proprietary adhesive. Every care shall be taken by the following trades to prevent perforation of the membrane but in the event of puncture the perforation shall be covered by a patch of similar material of dimensions exceeding the area of the puncture by 300 mm and the two sheets welded together as described above.

Polyethylene sheet vapor barrier is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

4.4 WATERPROOFING COATING INSIDE RESERVOIR

This coating shall be a surface-applied material, which waterproofs and protects concrete in depth and shall be suitable for use in potable water reservoirs. It shall consist of a mix of rapid-hardening Portland cement, specially treated quartz sand, and a compound of active chemicals. The chemical in powder or liquid form according to Supervisors requirements shall be mechanically mixed with clean water to a consistency of thick oil paint. Approximate mixing ratio is 0.8 parts water to 2 parts powder (by volume).

Product must be weather and chemical product resistant and suitable for potable water.

Concrete to be treated with this coating must be clean and have an "open" capillary system. Laitance, dirt, grease, etc. should be removed by means of high pressure water jetting, wet sandblasting or wire brushing.

Cracks, honeycombing etc. should be made good before placing waterproofing on concrete surfaces. Waterproof mastic shall be used to plug concrete holes and cracks.

Surfaces must be carefully pre-watered prior to the application of the coating. The concrete surface must be damp but not wet.

Materials mixed shall be as can be used within 20 minutes. Mixture should be stirred frequently. If mixture starts to set, no water should be added, the mixture should be stirred to restore workability.

The mix is applied by masonry brush or appropriate power spray equipment. When two coats are specified the second coat shall be applied while the first coat is still "tacky".

The treated surfaces should be kept damp for a period of five days and must be protected against direct sun, wind and frost.

Rubber gloves and goggles shall be used during mixing and application of the mixture. Considering that work shall take place in an enclosed space, proper ventilation fans shall be installed.

The Contractor shall submit to the Supervisor for his approval a method statement including details of the waterproofing coating and mastic for surface repairs, the application procedure, the safety plan and any other information requested by the Supervisor.

Waterproofing coating inside reservoir, is a paid item of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

4.5 JOINTS SEALING COMPOUNDS

Joint sealing compounds shall be impermeable ductile materials of a type suitable for the conditions of exposure in which they are to be placed, and capable of providing a durable, flexible and watertight seal by adhesion to the concrete throughout the range of joint movement.

Hot poured joint sealants shall comply with BS 2499, Ordinary Type A1 sealant.

Bituminous sealants are hot applied under temperature ranging from 100°C to 130°C, and with a caulking gum. The nozzles shall be kept at the bottom of the joint to ensure a complete and tight filling.

Cold poured polymer-based joint sealants shall comply with BS 5212: Part 1, Normal Type N sealant.

Two-part poly-sulfide-based sealants shall comply with the relevant provisions of BS 4254. Pouring Grade shall be applied to horizontal upward-facing, joints and Gun Grade to joints of any other aspect or inclination. Other two-part polymer-based sealants of Gun or Trowel. Grade shall comply with the physical and test requirements of BS 4254.

Silicone based building sealants shall comply with the relevant provisions of BS 5889.

Primers for use with joint sealants shall be compatible with, and obtained from the same manufacturers as, the adjacent sealant. Primers shall have no harmful effects on concrete.

Sealants and primers which will be in contact with water to be used for potable supply shall not impart to water taste, colour, or any effect known to be harmful to health, and shall be resistant to bacterial growth.

Prior to filling the joints, the Contractor shall:

- a) make good damaged joints,
- b) grind or saw joints which are narrower than required,
- c) clean by grinding and brushing joint sides,
- d) clean with compressed air.

In the event of a mastic creep in horizontal joints, the Contractor shall re-fill tightly the surface.

4.6 LADDERS

Ladders shall comply with BS 421 1 and shall be of mild steel and shall consist of 65mm x 12mm flats and stringers 400mm apart with 20mm diameter solid rungs at a maximum of 250mm centers shouldered and riveted over. Stringers shall have welded-on feet and brackets for fixing to floors and walls, which fixings shall be not more than 2 meters apart. Brackets shall be 25 x 10mm flats.

Stringers shall be extended 1000mm above the upper platform and suitably opened out for access, or where ladders are below manhole covers, separate hand holds shall be fixed to the upper platform.

Unless otherwise shown on the drawings ladders rising 2500mm or more shall be fitted with safety hoops. The hoops shall have a diameter of 760mm and be of 50 x 8mm flats at not more than 900mm centers, fixed to the stringers and with three vertical straps of 50 x 8mm flats extending from the top to the bottom hoop.

Steel ladders shall be hot dipped galvanized after fabrication.

For measurement purposes, Ladders prices are included in the sundries items of the B.O.Q.

4.7 HANDRAILS, GUARDRAILS & CHAINS

Handrailing shall be approximately 1000mm in height with an intermediate horizontal rail with standards not more than 2000mm apart.

Handrailing shall be designed for a horizontal loading of not less than 220N/mm.

Hoops shall be welded on where required for fixing guard chains.

Standards and rails shall be manufactured from black mild steel tube to BS 1357:1967, from steel tubing to BS 1775, from steel pipe ASTM A120 or from extruded aluminum alloy approved by the Supervisor. The nominal bore of steel tubing shall be not less than 32mm.

Adequate provision shall be made for thermal movement.

Guardrails shall be 750mm in height with a single top rail. In all other respects it shall comply with the specification for handrailing.

Steel handrailing and guardrails shall be hot dip galvanized after fabrication.

Chains across openings in handrails at tops of ladders shall be galvanized mild steel having 3 SWG x 3 links per 100mm and shall be supplied complete with 'S' hooks and split rings.

For measurement purposes, handrails, guardrails & chains prices are included in the sundries items of the B.O.Q.

4.8 ACCESS HATCHES

Steel access hatches shall be to the duty required and sized to suit the opening shown on the Drawings. They shall be complete with frame and shall be weatherproof (prevent the ingress of water) when closed, and shall in all respects be strong and durable.

The covers shall be made out of steel checkered plate of approved thickness depending on their size, hinged and lockable and provided with stays to prevent the covers opening more than 105°. The Contractor shall provide with each cover a heavy duty non-corrodible padlock and four keys.

In case of concrete structures, the steel covers shall be supplied before pouring concrete in order to secure cover to reinforcing rebar around the opening.

The covers and frames shall be galvanized.

For measurement purposes, access hatches prices are included in the sundries items of the B.O.Q.

4.9 HOT DIP GALVANIZING

Where galvanizing has been specified, the items shall after fabrication be hot dipped galvanized in accordance with BS 729 Part I, Galvanizing shall be applied at the rate of 610 g/m² of surface area corresponding roughly to a uniform covering of 100 microns thickness.

Alternatively and where approved, zinc coating shall be applied in accordance with BS 2569 Part I to a thickness of 0.15mm (006").

All items to be hot dip galvanized shall be prepared as specified in the above standards.

The zinc coating shall adhere tenaciously to the surface of the base material. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening, and other fabricating shall be done as far as is practicable before the galvanizing. All members, nuts, bolts, washers, etc. shall be

galvanized before a structural unit is assembled. All uncoated spots or damaged coatings shall be cause for rejection.

Products that are warped or distorted to the extent of impairment for the use intended shall be rejected.

Articles altered at the manufacturers works in any way after galvanizing are to be re-galvanized as specified.

Articles subject to minor alternations at site or requiring minor repair at site shall be wire brushed to remove all rust and coated with 3 coats of approved zinc rich cold galvanizing compound.

Contractor shall submit to the Supervisor for approval the hot dip galvanizing process with details of the workshop where galvanizing will take place.

4.10 ANCHORING

Where fixings to existing structures are to be made by setting a bolt system into preformed holes, such fixings shall be made either by Rawlbolt Projecting Bolt Type or by using an approved proprietary resin anchor system. Where preformed holes have not been provided a self-drilling expanding bolt system shall be used. Where thin sections are involved or where stresses are likely to be set up which might cause damage to the structure the use of the resin anchor system only will be permitted. Only in special circumstances will the Supervisor or the Supervisor's Representative permit rag bolts to be used.

Preformed holes shall be accurately set to template prior to placing the surrounding concrete and shall be kept rigidly in place until the concrete has properly set.

For small load applications, gun driven nails can be used as offered by Hilti or similar subject to the Supervisor's approval.

4.11 WATER RESERVOIRS AND VALVE CHAMBERS SUNDRIES

All metal accessories inside water reservoirs and valve chambers like ladders, access hatches, fixing brackets, pipe supports and the like shall be of hot dip galvanized steel as specified above with epoxy paint as an additional surface protection.

Contractor shall submit to the Supervisor a schedule of all reservoirs and valve chambers sundries including material used, fabrication drawings, load calculations, galvanizing procedure, epoxy paint data and painting procedure, and any other information required by the Supervisor.

Water reservoirs and valve chambers sundries are paid items of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

4.12 WATER RESERVOIRS AND VALVE CHAMBERS PIPEWORK

All metal pipework in valve chambers and reservoirs except for vent pipes and rainwater gutters which are applicable only to reservoirs, shall be of ductile cast iron as specified in

section 2 above. Vents pipes for reservoirs shall be hot dip galvanized steel. Vent pipes shall be gooseneck type with galvanized mesh screen to avoid entry of birds, rodents or insects. Rainwater gutters shall be galvanized sheet metal gage 16.

All pipes shall receive an epoxy coat on top of their bitumen shop coat or zinc coat.

Contractor shall submit to the Supervisor a schedule of all reservoirs and valve chambers pipework including material used, dimension drawings, galvanizing procedure, epoxy paint data and painting procedure, and any other information required by the Supervisor.

Water reservoirs and valve chambers pipework are paid items of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

4.13 PAINTWORK

4.13.1 General

All paints, primers, varnishes, distemper, oil, etc. shall be supplied in original sealed containers, ready to be mixed, bearing the brand maker's name identifying the contents and giving directions for its proper use.

Paint material shall be of the best quality from a well known manufacturers and shall be subject to the approval of the Supervisor. The quality of the finishing colors shall be capable of giving three years minimum satisfactory performance under conditions of high temperatures and humidity, and capable of withstanding temperatures of up to 40 degrees C for long periods without color change. Paints shall also be resistant to oils, acids and alkalis.

Painting shall not be carried out when the following whether conditions are prevalent: temperature is over 30 degrees C or below 5 degrees C, humidity is over 80%, dry weather, dust storm, fog and rain. Paintwork shall not also be applied on frozen or overheated surfaces.

Clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease prior to mechanical cleaning. Program cleaning and application so that contaminants from cleaning process will not fall on wet, newly-painted surfaces. Paint shall only be applied on a properly cleaned surface.

Keep clean all brushes, pails, kettles and the like used in carrying out the work and free from foreign matter. They shall be cleaned before being used for different types or classes of materials.

Use the undercoats, primers and the like manufactured or recommended by the manufacturer of the finishing paint. Mix and apply the materials in accordance with the manufacturer's specification and as required on the drawings.

Do not allow mixing of paints of different brands. No dilution of paint will be allowed except as detailed by the manufacturer.

Submit complete color charts for the paints to the Supervisor for approval and the preparation of the color schedules. The number of coats and film thickness required is the

same regardless of the application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. Sand between applications where sanding is required to produce an even smooth surface in accordance with the manufacturer's directions.

Apply additional coats when undercoats, stains, or other conditions show through final coat of paint until paint film is of uniform finish, color, and appearance. Give special attention to ensure that surfaces, including edges, corners, crevices, welds, and exposed fasteners, receive a dry film thickness equivalent to that of flat surfaces.

Paint surfaces behind movable equipment and furniture same as similar exposed surfaces. Paint surfaces behind permanently fixed equipment or furniture with prime coat only before final installation of equipment.

Paint back sides of access panels and removable or hinged covers to match exposed surfaces.

Sand lightly between each succeeding enamel or varnish coat.

Omit primer on metal surfaces that have been shop-primed and touch unpainted.

Submit for approval all types of paint to be used with manufacturer's certificate showing the following physical properties:

- Viscosity
- Adherence
- Durability
- Abrasion
- Permeability
- Resistance to washing
- Stability of color

Provide samples showing the brand, quality and ingredients for the Supervisor's approval.

Paintwork shall conform to D.T.U. Standard No. 59.1 or BS 6150.

Paintwork shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

4.13.2 ***Metal Work***

In case galvanized metal surfaces are to be painted, these shall first be treated with one coat of mordant solution which shall in due time be carefully washed off the surface which shall then be primed with a calcium plumbate primer. When this has dried thoroughly, the surfaces shall be given one coat of undercoat and one of a gloss finishing paint.

All metalwork shall be cleaned free from all rust, scales, grease, oils and any other surface stains, and shall be given one coat of an approved primer compatible with the metal to be painted, two applications of undercoat and one application of a gloss finishing coat.

Primed or undercoated metal shall not be left in an exposed or unsuitable situation for an undue period before completing the painting.

The Contractor shall seek specific instructions to paint any non-ferrous metal surface.

All metalwork which has been supplied with bituminous protection or painting prior to dispatch from the place or manufacture, such as pipes, tubes, valves, manhole covers, etcetera, shall have all exposed surfaces painted after erection according to the Supervisor's instruction..

The manufacturer's primer or coating shall be made good to, the same standard and specification as supplied, and shall then be given two coats of paint as follows:

1. Pipes, valves, manhole covers, and fittings, etc. exposed to view shall be painted with two coats of an approved "bitumen aluminum paint" or similar approved paint.
2. Pipes, valves and fittings, etcetera in manholes, or chambers shall be painted with two coats of bitumen paint or other approved paint.

4.13.2.1 Shop painting

Painting shall not be undertaken in the shop when the temperature is less than 3° C or when the relative humidity is greater than 85%.

Contact surfaces to be connected by high strength friction grip bolts shall not be painted. Where surfaces are subsequently to be welded, galvanizing, metal spraying or shop painting shall be terminated (except in the case of pre-fabrication primers) within 75mm of the areas to be welded. Machined surfaces shall not be painted, but shall be protected against corrosion by means of a rust-inhibiting coating which can be easily removed on site or is not detrimental to the jointing condition if left in position. Other steel surfaces which, prior to dispatch are to be brought together in permanent contact with each other, shall after cleaning be primed and the work bolted up while the paint is still wet. Finishing paint shall be applied to the connected joint.

Immediately after cleaning, those surfaces which have been prepared by blast-cleaning or pickling shall be treated with an approved pre-fabrication primer. A zinc-rich primer (the metallic content of which shall not be less than 85%) shall be applied in one coat. Finishing coats (one of which shall be applied on site) shall consist of the following:

- a) For normal conditions, a high build system consisting of two coats of chlorinated rubber or epoxy-resin paint shall be applied in equal thickness of 5 mils (125 microns) each.
- b) For submerged or partially submerged conditions, a high build paint system shall likewise be used, but shall consist of two coats of epoxy-pitch paint of similar thickness.

Unless otherwise specified all painting with the exception of the final finishing coat, shall be carried out in the shops.

Those surfaces which have been metal coated, and are required to be painted in addition shall first be treated with a coat of an approved pre-treatment primer.

This primer shall be such that its phosphoric acid content has been adjusted for etch-priming purposes. This shall be followed by one coat of zinc-chrome primer. Unless otherwise specified the finish coat shall consist of two coats of lamellar-pigmented paint, either micaceous iron oxide or aluminum as directed, except where aggressive, submerged or partially submerged conditions prevail, when the finishes shall consist of two coats of epoxy-pitch paint applied in equal thickness of 5 mils (125 microns) each.

Those surfaces which have been mechanically or flame-cleaned shall be brush-primed with one coat of red lead or calcium plumbate paint and finished with two coats of micaceous iron oxide or aluminum paint as directed.

4.13.2.2 Site painting

All surfaces to be painted shall be dried and cleaned free of all oil, grease, dirt or other extraneous matter by the use of white spirit, water or other appropriate cleaning material. Where surfaces have been damaged in transit they shall be made good to the same standard to which they were originally protected. Where as a result of such damage the metal has been bared, the paint immediately adjacent to the affected area shall be trimmed down, the affected area cleaned by wire brushing and the protective paint system restored, to provide a coat by coat lapping at the junction of the new and old paint system. Where welding has been carried out on site, the welds shall be wire brushed, and a protective paint system applied similar to that of the surrounding steel surfaces.

Where surfaces have been left unpainted and are to be connected by High Strength Friction Grip bolts they shall be cleaned as specified above and the contact surfaces brought together without further treatment. After bolting up, those surfaces which, being exposed are not protected, shall be wire brushed, primed and painted to give a coat by coat lapping with adjoining painted surfaces.

Where surfaces have been left unpainted and are to be completely embedded in concrete they shall be cleaned of all oil, grease mill scale or other extraneous matter immediately prior to concreting but shall otherwise be left untreated. Where steelwork is to be partially embedded in concrete the paint system shall be continued into the concrete for a distance equal to the least lateral dimension of the concrete forming the surround.

Unless otherwise specified the final coat of finishing paint shall be applied to the immediate area of all steelwork connections after completion of erection. The main body of the steel work, however, may be painted on site before erection, in which case any damage sustained during the course of erection shall be made good to the satisfaction of the Supervisor. Painting will not be permitted on site when the temperature is below 3°C or when the relative humidity is in excess of 85% or during wet weather.

4.13.3 **Concrete painting**

Concrete surfaces to be painted shall be washed down first and then allowed to dry. Any efflorescence present shall be thoroughly removed with steel brush then wait for a week, If salt reappears, it shall be brushed again and treated with phosphoric acid and zinc chloride. Check also all cracks and holes in the concrete and putty them with a special mastic then leave to dry before application of paint.

Surfaces shall receive then one or more applications of putty filler until smooth surface is obtained to the Supervisor's approval.

Emulsion paint shall be applied by brush or roller and shall consist of a priming coat of porous alkali-resistant primer and three coats of copolymer acrylic type paint after any traces of grease have been removed.

The finishing coat of paint shall be applied after the completion of all other works.

4.14 **WELDING**

The Contractor shall submit to the Supervisor welding procedures for all welding to be carried out on pipes and structural steel. The submittal shall include welder's certifications, welding machine specifications, types of welds adopted, electrodes specifications and type of work to be performed.

Welders should be qualified according to test procedures covered in The American Welding Society Standard B3.0, Part II, or such other qualification test acceptable to the Supervisor. If required by the Supervisor, the Contractor shall submit identifying stenciled test coupons made by any welder whose workmanship is subject to question.

The Contractor shall make any welder to retake the test when, in the opinion of the Supervisor, the work of the welder creates a reasonable doubt as to the proficiency of the welder. Tests, when required, shall be conducted at no additional expense to the Contracting Authority.

Approval of the welder by the Supervisor shall be made only after the former has taken and passed the required test. Welders shall have passed the qualification tests within the preceding twelve (12) month period.

In addition to the welding of structural steel, all welding shown on the plans or ordered by the Supervisor shall conform to the Standard Specifications for Welded Highway and Railway Bridges of the American Welding Society.

In the inspection of welds, the presence of the following defects will result in rejection of the weld as being defective:

- Cracks, regardless of length or location, will not be allowed
- Overlaps, lack of penetration or incomplete fusion will not be allowed.

Defects shall be removed by mechanical means or by oxygen grooving, after which the joints shall be welded again.

4.15 BITUMINOUS COATING FOR BURIED SURFACES

The Contractor must obtain the previous approval of the Supervisor on the support as well on the type of material proposed.

The bituminous coating for damp-proofing should be cold applied emulsion in two coats (of at least 0.750 kg/m² each) and cross applied.

Bitumen primer should be of the same cold bitumen emulsion compound diluted to 50% with water and applied at a minimum rate of 0,400 kg/m². The damp-proof bituminous coat shall be applied around 24 hours after the primer application.

Bituminous coating for buried surfaces shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

4.16 VALVE CHAMBERS

Valve chambers shall be cast in place structures. The concrete in walls and surrounds shall be formed using properly constructed formwork. Chambers shall be constructed concurrently with the laying of adjacent pipe lengths. Where flexible pipes are to be cast into concrete, the Contractor shall submit his proposals for ensuring flexibility.

Selected material shall be carefully filled and compacted behind the walls of the valve chambers after the concrete has hardened sufficiently and the protective tanking has been completed.

All chambers shall be watertight to the satisfaction of the Supervisor. Particular attention shall be given to the joints between the pipes and the manhole walls to ensure that ground water does not cause leaks into chambers.

Valve chambers shall be equipped with a drain pit filled with graded gravel.

The Contractor shall include in his shop drawings details of installation of all fittings and accessories inside each manhole and shall not begin the works without the Supervisor's approval.

Valve chambers are paid items of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

4.17 NEOPRENE PADS

Neoprene pads shall be installed in all applications where strains in structures due to relative movement between their components are to be relieved by allowing lateral and vertical flexibility.

Neoprene pads must comply with the following criteria:

- Relatively easy to install without the need for special skills.

- Must allow horizontal and also rotational movement without critical stress build up due to bending of the structural components in contact with the membrane under permanent loads, working loads and the effects of hydraulic shrinkage and thermal phenomena.

Plain neoprene pads shall have a duro-hardness (shore A) G60.

The neoprene pads can fill all the substrate surface of the wearing walls or only a part of this surface. The unoccupied surface, in this case must be filled by a compressible material to avoid the intrusion of concrete grout between the various elements of the support system.

The substrate surface must be evened to avoid any accidental contact outside the designed contact surfaces. The wearing must be made horizontal.

The Contractor must furnish to the Supervisor all necessary details concerning the elastomeric support and the procedures for the execution of the wearing surface.

The following minimal characteristics must be submitted by the Contractor for the Supervisor's approval:

- a) Maximal constraint which varies with the type of material used, around 30 bars for neoprene.
- b) Minimal constraint to be obtained to avoid slipping of the neoprene pad on its substrate (around 15 bars for neoprene)

This may imply the need to consider the use of strips or pads instead of a continuous band.

A continuous break of ties must be then insured between the pads by incorporating between the pads of neoprene of a compressible material (polystyrene type) and making the joints between pads and polystyrene water tight to avoid concrete grout intrusion.

The required thickness of the neoprene support shall depend on the loads, the amount of sliding and permissible rotations.

The Contractor shall submit technical certificate from the manufacturer to the Supervisor allowing him to control and approve the chosen sizes and thickness of the elastomeric support.

The thickness must be large enough to permit rotation of the support avoiding contact in the maximum compression corner zones.

Neoprene pads are paid items of the B.O.Q. Details of Works description and measurement is to be found in the price schedule to the B.O.Q.

4.18 FENCES & GATES

Fences generally shall be in accordance with the relevant parts of BS 1722 Part 1: 1936.

Chain link fencing shall be Type PLC.213 Grade A with 1.8 m high plastic covered chain link mesh, The mesh and line wires shall be galvanized prior to being plastic covered. The posts shall be reinforced concrete.

The straining posts, intermediate posts and shuns shall be manufactured and erected complete as specified in BS 1722. The fencing shall be true to line and vertical, following the profile of the ground, previously graded so as to present access beneath the bottom wire.

Gates shall be hung on adequate post, and shall be truly vertical.

Ornamental fabricated metalwork fences and gates shall be constructed of mild steel bar, strip or tube in accordance with the Drawings if applicable. All welded joints and drillings for bolts shall be made before painting, and all bolts, nuts and washers shall be galvanized or plated in an approved manner. Any metalwork sunk into the ground shall be treated with two coats of bituminous paint.

5. WELL DRILLING WORKS

5.1 SCOPE

This section describes the works to be carried out for the complete drilling and casing of well. The work shall include all labor, materials, supplies, equipment, tools, transportation, recommendations, testing, and services, without any limitation, to execute the following tasks:

- Site preparation including disinfection,
- Mobilization and demobilization of drilling equipment,
- Borehole drilling, cuttings collection,
- Casing, screens, well head and cap installation,
- Borehole development and testing by alternate and continuous pumping.
- Check borehole alignment, logs and report.

The well should be (a) straight, and (b) vertical: permanent well casing should not deviate more than 2° from the vertical. Straightness should be demonstrated by lowering down the hole a 6-metre length of casing with a diameter about 10 mm less than the inside diameter of the permanent well casing.

5.2 GEOLOGICAL CONDITIONS

5.3 DRILLING EQUIPMENT

The well shall be drilled using an air-hammer ('down-the-hole' or DTH) rotary rig. The drilling equipment must be in good condition and appropriate for the terrain, expected site ground conditions, and soils and rock anticipated.

The drilling equipment must be clean and free from contaminants which would otherwise be introduced into the aquifer. All equipment should be cleaned by means of high-pressure hoses and/or steam, as appropriate.

5.4 DRILLING FLUIDS

Drilling fluids must be free of harmful chemicals. As far as practicable, drilling fluids should be limited to clean water, air, and approved foaming agents.

Water used for mixing drilling fluid must be clean (of potable quality).

Returned drilling fluid which is not re-circulated must be disposed of in a satisfactory manner, i.e. using (a) a sediment trap, and (b) a soakpit.

5.5 WELL LOG AND RECORDS

The Contractor shall keep a log and progress record at the site readily available for inspection during construction of the well and well development, logging, testing and

disinfection and copies of such shall be available to the Supervisor. The Contractor shall keep records providing the following information:

A. A log of the formations drilled from surface to total depth showing each change in formation, sample locations, and rates of penetration.

B. A collection of two (2) sets of samples from borehole from surface to total depth placed in separate bags or containers for each interval, plainly marked with the well name and sample depth. Samples shall be taken each five (2) m and at each change of formation. The method of taking samples shall be approved by the Supervisor. Sieve analyses on up to six (6) samples from the borehole may be requested by the Supervisor and furnished by the Contractor. Duplicate samples will be taken to retain one at well site and other for submittal to lab.

A specific sample will be taken of bottom material after clearing/circulating drilling fluid. Cuttings will discharge to a shaker screen.

C. An electric log and Gamma-Ray log shall be provided upon completion of the well. The E-log shall consist of one spontaneous potential curve and three (3) resistivity curves, and be of the same depth scale as the Gamma ray log and the final caliper log. Two (2) copies of each to be delivered to the Supervisor.

D. A dissolved mineral quality analysis of a composite water sample shall be provided upon completion of the borehole when required in by the Supervisor.

F. A final well log shall show: formation log; diameter, wall thickness, depths and quantities of casings and screens installed; type and aperture size, and pattern of perforations; final borehole diameter; cemented conductor casing; sealed zones; gradation of gravel envelope; quantity of gravel initially installed; quantity of gravel added during development operations; static water level; drawdown after time with constant pump rate; and all other pertinent details.

Development and test records shall be dated and time noted showing production rate, static water level, pumping level, drawdown, production of sand, and all other pertinent information concerning the method of development and test pumping.

G. Two plots of casing plumbness and alignment in planes oriented at 90 degrees with respect to each other.

H. Caliper survey of finished borehole.

I. Calculation of annulus volume between casing and final bore.

J. The final developed and completed well shall have water quality and bacteriological analyses as required by the Supervisor and as specified herein.

5.6 SUBMITTALS

All records shall be available to the Supervisor at all times at the job site. Five (5) copies (each) of all records shall be typed and submitted to the District on A4 paper or as necessary to convey information adequately. They shall include:

- A. Driller's lithologic log
- B. E-log (to be of same depth scale as Gamma and caliper logs)
- C. Gamma-Ray log (to be of same depth scale as E-log and caliper log)
- D. Penetration rate of drilling fluid additives
- E. Drilling fluid additives (Type and Quantity)
- F. All construction entities and information necessary to complete a State and Riverside County Driller's Log. (Log will be reviewed and approved by the Supervisor prior to submittals).
- G. Drill hole caliper log (to be same depth scale as E-logs and Gamma log)
- H. Alignment/Plumb log
- I. Swabbing and surging/air lift pumping records
- J. Development pumping records
- K. Step Test pumping records including specific capacities, drawdowns, pumping rates
- L. Sand production records
- M. Constant pumping rate, drawdown, times, and specific capacity
- N. Sieve analyses results
- O. Gravel pack sieve analyses
- P Water Quality/bacteria test
- R. Submittals on:
 - 1. casing
 - 2. screen
 - 3. gravel pack pipes
 - 4. sounder tubes
 - 5. cement slurry grout
 - 6. concrete

5.7 GUARANTEE

For a period of one year defects Liability period after acceptance of the well by the Supervisor, the Contractor shall make the following guarantees and accept the following responsibilities concerning his work;

1. Sand production shall be less than 5 ppm within 15 minutes after start of pumping at the constant pump test rate of the well.
2. Sand production shall be less than 1 ppm within two (2) hours after start of pumping at the constant pump test rate of the well.
3. The well casing and screen shall remain intact throughout its entire length.
4. Plumbness and alignment shall remain within tolerances set forth in specifications.

To demonstrate compliance with the above, the Contractor shall perform after six (6) months of operation, and again, after eleven (11) months of operation, a test of the well. These tests shall be witnessed by representatives of the Supervisor and certified copies of the test results shall be furnished to Contracting Authority. The tests shall consist of a Rossum sand test of the well and of plumbness and alignment of casing.

5.8 DRILLING PROGRAM SUBMISSION

The contractor shall submit for the Supervisor approval a schedule of tasks to be completed in the process of completing the well including personnel, schedule of tasks (drilling, casing, screen gravel installation (if required), development), and details of the drilling fluid makeup (additives)

5.9 MATERIALS

5.9.1 *Gravel Pack.*

The gravel to be installed shall be composed of sound, durable, well-rounded particles, containing no silt, clay, organic matter, gypsum, iron, manganese or other deleterious materials. It shall be selected by the Contractor with the District's approval based on the Test Hole log, E-log, and Gamma-Ray log, and formation analysis. Material shall have an average specific gravity of not less than 2.5 and a uniformity coefficient no greater than 2.0. Gradation shall conform to that required to retain the 50th percentile of the finest aquifer material encountered in the zone(s) where screens are to be placed. Under no circumstances shall crushed rock be installed in the well. A certificate of quality and gradation of the gravel from an approved testing laboratory shall be submitted to the District prior to gravel being delivered to the site. The Supervisor may elect to have a certified testing laboratory perform an independent sieve analysis to verify conformance with submitted sample. Failure of the submitted sample to meet gradation requirements shall be grounds for rejection.

5.9.2 *Cement slurry grout.*

The annular space around the conductor casing shall be filled with a cement slurry grout mixed in the following proportions by volume: 1 - part cement; 1-1/2 parts sharp, clean sand; and 6/10 - part water. The addition of any additives to prevent shrinkage shall be approved by the Supervisor. The water shall be potable and the sand free of clay, silt, organics, or other deleterious matter. The grout shall be left undisturbed for a period of not less than 48 hours.

5.9.3 **Conductor casing**

Conductor casing shall be in steel of prime quality, hot rolled steel plate, conforming to ASTM A283, Grade B, containing not less than 0.20% copper. The casing shall be factory-assembled in sections not less than 6m long and shall contain not more than one longitudinal seam parallel to the axis of the casing and not more than one circumferential seam in 3m. The inside diameter and minimum thickness are set forth in Bill of quantities. For field assembly by welding, ends of sections shall be as defined in well casing clause below.

5.9.4 **well casing**

The well casing shall be in steel manufactured in accordance with ASTM Standard A139 Grade B with the following additions:

1. The steel from which the casing is manufactured shall be mild steel and contain not less than 0.20% copper by ladle analysis.
2. The inside diameter and minimum wall thickness are set in the bill of quantities.
3. The casing shall be factory assembled in not less than six meters sections. Casing shall be spiral welded in accordance with ASTM-139. There shall be no burrs or protrusions into the casing I.D.
4. For field assembly welding, ends of sections may be either belled or furnished with collars in accordance with the following standards:

a) Plain Ends Fitted With Collars: Collars shall be of the same thickness and have the same chemical and physical properties as the corresponding casing section, shall be 6-inches in width, shall be rolled to fit the outside diameter, and shall be welded to the casing section. Longitudinal welds on the plain end shall be ground to plate surface a sufficient distance from the end. The inside edge of the collars and the outside edge of the adjacent casing length shall be ground or sufficiently scraped to remove sharp edges or burrs. Section ends shall be machined flat perpendicular to the axis of the casing and shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing. Three 1-inch by 3/8-inch alignment holes shall be provided in each collar to insure proper matching of the sections. The casing gap shall be welded full-double pass within the holes as well as hole edges.

b) Bell Ends

The inside diameter of the bell shall be 1/32 to 3/32 inch greater than the outside diameter of the plain end. The ends of each section shall not vary more than 0.010 inch at any point from a true plane at right angles to the axis of the casing.

c) Butt welded joints shall be per AWWA C-206.

5.9.5 **well screens**

The well screens shall be in steel manufactured in accordance with ASTM Standard A139 Grade B.

The well screen shall be slotted or bridge slotted in order to provide maximum inlet area consistent with strength requirements.

The inside diameter and screen slot size and frequency are set forth in the Bill of Quantities. Actual screen slot size used will be selected upon mechanical sieve analyses of the natural water bearing sediments, the artificially introduced gravel pack material and the sand production guarantee.

The Contractor is responsible for insuring that the materials utilized will be adequate for the actual conditions encountered.

The screen length shall be chosen so that the maximum velocity of the water entering the screen shall not exceed 3cm per second at the desired yield. The screen location and final length shall be selected by the Contractor and submitted with supporting borehole logs and calculations for the Supervisor approval.

The screens shall be assembled by welding as specified for casing.

5.9.6 *Sounder tube and gravel make up tube*

The sounder and gravel make up tubes shall be 1-inch minimum, schedule 80 threaded PVC pipe. The sounder tube shall have a screen section of 6m long at bottom of tube.

5.10 WELL EXECUTION

5.10.1 *Disinfection prior to start of drilling*

The Contractor shall clean and disinfect all equipment prior to moving on to site.

5.10.2 *Drilling and installation of conductor casing*

The conductor casing shall be set plumb and centered in a plumb hole not less than 6-inches in diameter larger than the conductor casing O.D. It shall be securely anchored at the ground surface to prevent falling. It is estimated that the setting will be to a minimum depth of 20m or as set in Bill of Quantities however, the Supervisor may order the setting to a greater depth if found advisable. After the conductor casing has been installed, it shall be sealed by filling the annular space between the reamed bore and the conductor casing to the ground surface or top of the conductor casing, with a cement slurry grout. The placing of the cement slurry grout shall be done in a manner such that the conductor casing is entirely sealed against infiltration of water. After cementing operations are completed, the cement shall be left undisturbed for a period of not less than 48 hours

5.10.3 *Drilling and installing well casing and screen*

The well shall be drilled with diligence and without undue delays. It is recommended to continue the drilling on a 24 hour per day work schedule including weekends and holidays.

All material must be on-site prior to the completion of the reaming operation. The gravel must be at the well site so there will be no waiting on gravel once the casing has been installed.

From the base of the conductor casing, the bore shall be drilled to a diameter as set forth Bill of Quantities

Casing and screen installation shall be by approved methods that will insure no damage.

The casing and screen shall be suspended above the bottom of the hole. The casing and screen shall be fitted with approved centering guides or brackets, installed at points as directed by the Supervisor, but not more than forty (40) m apart, in order to center and hold the casing in the proper position until the gravel is in place. Guide placement shall be made based on the caliper survey to avoid large diameter areas. Guides will be joined by a continuous double pass fillet weld. The sounder and gravel makeup tubes shall be racked or skewed in the upper 12m so the O.D. of the sounder tubes are against the I.D. of the surface conductor. Likewise, the sounder and makeup tubes shall favor the I.D. of the surface conductor to allow clearance between the water box base or right angle drive base during development and test pumping and future pumping. Grout placement in the upper well casing annulus shall be preceded by District approval of tube locations.

Tubes, casing, and surface conductor shall extend above ground surface to heights to accommodate development and test pumping.

5.10.4 ***Sunder and gravel make up tubes***

The sounder tube and the gravel make up tubes shall be placed in the gravel pack zone from two 1m above ground surface to the specified depth below ground surface.

The tubes shall be adequately and securely held in place to preclude disruption or movement during tube installation, gravel placement, and any grout placement.

5.10.5 ***Filter gravel placement***

When the assembled casing and screen are plumbed and centered in the bore hole, tubing or drill pipe with a swab(s) shall be inserted. Clear, domestic, water shall be circulated while installing the gravel.

The gravel shall be placed by pumping through a gravel feed line extending to the bottom of the casing-hole annulus. The feeder line shall gradually be withdrawn as the gravel is placed. Swabbing and circulating shall be continued during placement of gravel until the gravel pack is completely in place. Before the gravel packing operation begins, the Contractor shall treat the select filter gravel with a solution containing 50 ppm free chlorine residual and make adequate preparations to insure that circulation will be continuous. In addition to the chlorine, a solution of sodium hexametaphosphate, not exceeding 1.25 kg per 20 liters of water, should be added to the circulating water to aid in the removal of the drilling mud. After the gravel is in place, circulating and swabbing shall continue in stages opposite the entire screen section until the gravel is consolidated and cleaned. As gravel settles more shall be added.

A careful record shall be kept of the amount of gravel added during placement and consolidation. Care shall be taken to not disturb the sounder tube and gravel make up tubes.

5.10.6 Grout placement

The upper portion of the annular space between the casing and the borehole shall be filled with cement slurry grout within the limits, if & as indicated in the Bill of Quantities. The placing of the grout shall be from the bottom up with a tremie or pipe. Care shall be taken to not disturb the sounder or gravel makeup tubes.

A record shall be kept of the volume of grout placed to compare to the void space as determined from the bore caliper survey.

Grout volume shall equal void volume.

5.11 WELL DEVELOPMENT

5.11.1 Development by air lift pumping/swabbing

Within 3 days after installation of the casing, screens, tubes, gravel pack, and sanitary seal, the Contractor shall commence development of the well by swabbing and air lift pumping as a preliminary step to pumping development. If grout placement was made development shall not commence prior to 48 hrs. after grouting finished.

The development steps and procedures shall be the following:

A. An isolation tool with packer elements 2m apart shall be attached to the bottom of the drill pipe of suitable diameter, with an air-line ejector.

B. Beginning at the top of the screened section, each 2m interval will be developed by surging and air-lift pumping until the produced water is essentially clear and no further movement of the gravel pack is noted.

C. During this process, a suitable sounding device shall be employed to measure the level of the gravel in the annulus. Gravel will be checked and added as needed and volume noted.

D. The procedure shall be repeated for each 2m interval of screen until the bottom of the screened section is reached. An air compressor having sufficient capacity (volume and pressure) for satisfactory development of the lowest screened interval shall be employed. Material drawn into the well shall be removed from time-to-time and disposed of by the Contractor.

Water discharged will be sampled/checked by the Supervisor during surging/pumping and the contractor shall assist in sampling.

Upon completion of air swabbing development, the gravel envelope shall be a continuous column completely surrounding the casing and completely filling the annulus between the well casing and borehole. The quantity of gravel placed in the annulus shall not be less than the computed volume of the annulus. A quantity less than the computed volume will

be judged as an indication of voids and corrective measures shall be undertaken at the Contractor's expense. The contractor shall compute the annulus volume and deliver a copy to the Supervisor.

5.11.2 *Development by pumping*

The Contractor shall furnish, install, operate, and remove a deep-well turbine pump for developing the well. Pump setting to be as directed by the Supervisor. The pump and prime mover shall have a capacity in excess of 175% of the specified flow in the geological report. The prime mover shall be a variable-speed type. The Contractor shall furnish and install discharge piping for the pumping unit of sufficient size and length to conduct water to a point of discharge together with acceptable orifices, meters or other approved devices, which will accurately measure the flow rate in m³/h. An air line, electric wire sounder, or approved equal, complete with properly calibrated gauge and source, shall be provided to measure the elevation of water in the well.

The Contractor shall make adequate provisions for disposal of water pumped from the well during development and production testing. Such provisions shall include, but not be limited to, the furnishing and installing of any necessary piping to carry the water to storm drains, catch basins, drainage channels or other facilities approved by the Supervisor.

No water shall be disposed of in streets or roads or in such a manner as to cause flooding of streets or properties. Contractor shall furnish to the Supervisor written authorization (s) from the appropriate agency (s) and/or property owner (s) to discharge said water onto their properties and/or facilities.

The initial pumping rate shall be restricted and as the water clears, shall be gradually increased until the maximum rate is reached.

The maximum rate will be determined by the Supervisor and the Contractor after consideration of the well's drawdown and discharge characteristics. At proper intervals, the pump shall be stopped and the water in the pump column shall be allowed to surge back through the pump bowls and through the perforated area. While pumping and surging, a continuous stream of clean water shall be added to the top of the gravel envelope.

The Contractor shall continue development until, in the opinion of the Supervisor the following conditions have been properly met:

- A. The quantity of gravel placed in the annulus shall be at least as great as the calculated volume of the annulus.
- B. There shall be no further settlement of the gravel envelope.
- C. Specific capacity shall have reached a constant value: i.e. there shall be no increase in specific capacity during the last 24 hours of continuous pumping and surging.

5.12 DISINFECTION

The Contractor shall provide for disinfection prior to startup of and during construction of the well, and during pumping tests and conduct any cleaning procedures. The Contractor shall carry out adequate cleaning procedures immediately preceding disinfection where evidence indicates that normal well construction and development work have not adequately cleaned the well.

All oil, grease, soil, and other materials, which could harbor and protect bacteria from disinfectants, shall be removed from the well. Unless prior Supervisor approval is obtained for employing chemicals or other unusual cleaning methods, the cleaning operation is to be carried out by pumping and swabbing only. Where test pumping equipment is to be utilized, such equipment shall be disinfected prior to installation and use and be thoroughly hosed, scrubbed or otherwise cleaned of foreign material.

Chlorine shall be used as disinfectants. The disinfectant shall be delivered to the site of the work in the original closed containers bearing the original label indicating the percentage of available chlorine. The disinfectant shall be recently purchased. Chlorine compounds in dry form shall not have been stored for more than one year and storage of liquid compounds shall not have exceeded 30 days. During storage, disinfectants shall not be exposed to the atmosphere or to direct sunlight. The quantity of chlorine compounds used for disinfection shall be sufficient to produce a minimum of 50 mg/l available chlorine or as required by regulation.

Should a delay of three days or more be anticipated between the completion of the well and the regularly scheduled well disinfection an interim disinfection shall be provided by the Contractor. The contractor shall install an approved disinfecting agent in an amount equal to 10% of the amount required for final disinfection. For this purpose, the disinfecting agent shall be furnished or prepared in liquid form and placed in the well through a hose or tremie of sufficient length to extend to the bottom of the well. The disinfecting agent shall be applied through the hose, which is to be raised and lowered, to achieve uniform distribution of the solution throughout the well.

The Contractor shall discuss with the Supervisor the amount of disinfecting agent to be used and its method for use in advance of initiating the work. Chlorine compound dosages and method of utilization shall be satisfactory to the District in their entirety. Unless otherwise modified (due to problems involved with the specific well or conflict with local, municipalities,...), disinfection procedure shall include, but not be limited to the following:

A. Provide reliable means of insuring that the disinfecting agent is uniformly applied throughout the entire water depth of the well without relying on subsequent mechanical or surging action for dispersing the disinfectant; the dispersion of the disinfectant shall be assisted by pouring into the well a volume of water equal to the volume of the screened portion after the disinfectant has been placed. This will cause the disinfectant to flow out of the well into the area adjacent to the screen.

B. All accessible portions of the well above the water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a

period of not less than 20 minutes. The disinfecting agent shall be left in the well for a period of at least 12 hours. After a 12 hour, or longer contact period, the well is to be pumped to clear it of the disinfecting agent. The disposal point for the purged water shall be selected with Supervisor approval so as to minimize potential damage to aquatic life or vegetation, of facilities, or exposure to public.

5.13 WELL TESTING FOR YIELD AND DRAWDOWN

5.13.1 *General*

The Contractor shall furnish all necessary equipment and materials and make complete pumping tests of the well following the development work. The test pumping equipment shall have a capacity of not less than is listed under the Section "Development by Pumping" and shall be capable of delivering water from a level below the ground surface as specified by the District. Water shall be disposed of as approved by the District. During the progress of the test pumping, the Contractor shall provide an approved measuring device for measuring the rate of discharge of the pump and the level of the water within the well casing. Reading and recording of pump discharge shall be made by the Contractor or at intervals directed by the Supervisor.

Drawdown shall be measured by means of an air line, pressure gauge and air pump, electric wire sounder, or both.

At the completion of the test pumping, all sand and debris shall be removed from the bottom of the well.

Measurement of time of start, stop and interval measurements must be made with reasonable accuracy (+6 seconds). Any irregular events (e.g. pump failure and restart occurring during the test cycle must be noted and their times recorded. Should these events occur, the District must be notified and decisions made as to the validity of the test. If the pumping test is interrupted due to Contractor's equipment malfunction, the test shall be rerun at the Contractor's expense. Pumping rate (Q) shall not vary by more than 5% (+).

Prior to test pumping, water-level measurements shall be taken on pumping and non-pumping wells in the nearby area as specified by the District. No pumping of the production well to be tested shall occur for at least 24 hours prior to start of pump test.

The time interval between water-level measurements may vary between acceptable limits.

The following are minimum recommendations of measuring intervals after the start or stop of any discharge step:

Time after start or stop of new discharge step (minutes)	Recommended measuring interval (minutes)
1-10	1
10-20	2
20-30	5
30-60	10
60-120	15
120-300	30
300 to end of test	60

5.13.2 ***Step-Drawdown test***

The Contractor shall conduct a step-drawdown test of the well by pumping at a sufficient number of rates (at least 4) to determine the shape of the drawdown curve to the maximum capacity of the well, as approved and directed by the District and based on the development pumping. Pumping shall continue at each rate for a sufficient length of time (4 hours/rate) to bring about a stable (or predictable) water level trend in the well (i.e. a semi-logarithmic plot of pumping level versus time shows a straight-line trend).

The step-drawdown data shall be sufficient such that the following results may be obtained and submitted to the District:

1. Well efficiency diagram for the range of discharges tested.
2. Specific Capacity diagram showing formation and well loss curves for the range of discharges tested.
3. Recommended production pumping rate and lift based on system characteristics as defined by the Supervisor and furnished to the Contractor.

5.13.3 ***Constant rate pump test***

The contractor shall conduct a constant rate pump test for a minimum period of seventy two (72) hours at a production rate as specified by the Supervisor. The constant rate pump test shall not be concluded until the drawdown has stabilized for at least eight (8) hours and under no circumstances, be less than 24 hours in duration. During the constant rate test, measurements of water levels and rates of production shall be made in the well being tested and in any nearby wells selected by the Supervisor at the time intervals recommended in the preceding section. The Contractor shall also plot the time-drawdown data onto 4 cycle semi-logarithmic graph forms. A Rossum sand test shall be conducted for a period of at least two (2) hours after commencement of pumping. Sand production as a

function of time shall be determined with a graph to be drawn and submitted to the Supervisor as part of the permanent record of the well.

At the end of the constant rate pump test, the Contractor shall shut off the pump unit and record the recovery of the water level in the well at the time intervals recommended in section 4.10.1. Monitoring of the recovery of the water level shall continue until such time as the water level has reached at least 95% of the initial static readings recorded prior to the start of testing. Before shutdown of the pump during the test period, a complete set of water samples shall be taken by the Contractor.

5.14 PLUMBNESS AND ALIGNMENT

The Contractor shall guarantee that the well when completed shall be sufficiently straight and plumb to permit the free installation and operation of a vertical submersible pump regularly built for the casing size and installed with the bowls set at the location specified by the Supervisor.

To demonstrate compliance with this requirement the Contractor shall furnish all labor, tools and equipment and make a caging test to the satisfaction of the Supervisor. Tests for plumbness and alignment shall be made after completion of the well construction and before its acceptance.

The well shall be drilled in such vertical alignment that a line drawn from the center of the well casing at the ground surface to the center of the well casing 10 m above the bottom of the well shall not deviate from the vertical more than 15 cm in 30m of length and that any bends shall be no closer to the inside wall of the casing than 10cm. Contractor shall furnish the original and 2 copies of test to the Supervisor.

If the well is not straight, plumb and free of any obstruction, as specified, the well shall be straightened, plumbed and freed of all obstructions or a new well shall be drilled at no additional cost.

In the event the contractor is unable to complete the well due to faulty materials, workmanship, operations of the contractor or a crooked hole, the Supervisor may require a new well to be drilled immediately and no payment will be made for the depth to which the original well was drilled and abandoned. The new well shall be completed in accordance with all the terms and conditions stated herein. If, however, inability to complete the well was not due to any fault of the Contractor the cost of the new well will be paid for by the Contracting Authority at the respective contract prices and the time for completion shall be extended proportionately; however no additional payment will be made for extended overhead costs to the Contractor. The abandoned hole shall be filled in accordance with the requirements of the Supervisor.

5.15 BACTERIOLOGICAL TESTS

Upon completion of all work in connection with disinfection, development, and test pumping, the Contractor shall perform, or have performed for him, bacteriological tests on the well. The results of such tests shall show that the well meets all bacteriological drinking water standards. In the event the well fails to meet such standards the

disinfection, pumping and retesting shall be repeated until the standards are met or a chlorination system shall be installed at the Contracting Authority Expenses . All costs for bacteriological testing shall be borne by the Contractor.

5.16 WELL CAPPING AND CLEAN UP

Upon completion of all work, in connection with development, drilling, and test pumping, the well shall be capped by welding a minimum 1/4 inch steel plate over the top of the casing and a minimum 1/4-inch plate full welded over the top of the conductor casing. The sounding tubes and gravel tubes shall be capped with threaded caps.

The site shall be returned to its original or better condition.

6. PIPEWORK

6.1 GENERAL REQUIREMENTS

The requirements of this section shall apply to the construction of potable water pipelines and pipework.

All equipment specified in this section shall be suitable for waterworks purposes for the conveyance of potable water in the climatic conditions prevailing in Lebanon and in particular at the location of the Works.

The Contractor shall not submit any materials for approval if not compatible with the required specifications of this section. All material procured under this section shall be compliant with project technical specifications, project drawings and Supervisor's requirements. It is the contractor's responsibility to make good any departure from the above.

All material supplied shall be factory new and contractor must submit certificate of origin if asked for by the Supervisor.

All suppliers of equipment under this section shall be approved manufacturer having an ISO 9001-2000 total quality assurance system based on the latest version of the ISO 9001 standard.

All pipes, fittings, valves and accessories shall carry the Kite Mark of the standard to which they are manufactured, clearly indicated at intervals as well as marked for origin, rating and size.

Each and every part of the Works under this section shall be designed, constructed, manufactured, tested and installed in accordance with an internationally recognized Standard, Code of Practice or Regulation.

The Supervisor shall provide details of each pipeline diameter, pressure rating, hydraulic characteristics and the approximate alignment of the pipelines. However this does not relieve the Contractor from the responsibility of checking for himself the correctness of the data being given to him by the Supervisor.

The Contractor shall select the appropriate pipe material and obtain the Supervisors approval. The Contractor shall, in consultation with the Supervisor set out the proposed pipeline alignments, making any changes that the Supervisor may deem necessary, confirming also the exact locations of all manholes, valves, air valves, washouts, hydrants, and the like.

Where instructed by the Supervisor the Contractor shall undertake topographic surveys and / or prepare construction drawings.

Excavation of any part of the project is not allowed until a full supply of pipes and fittings are available on site.

Valve castings shall be clean, close grain metal free from rough projections and porosity.

Screwed valves shall have hexagon reinforcements at threaded joints and ample shoulders to prevent over entry of pipes.

Shut off valves shall be installed upstream and downstream of pressure regulating valves and shall be of same size as the branch pipe work where installed and of same free bore.

Shut off valves with nonmetallic discs shall be used where foreign material in piping system can be expected to prevent tight shut off of metal seated valve.

Non return valves shall be installed whenever reverse flow is to be prevented. Non return valves shall be of same size as the pipe work where installed and flow area should be greater than pipe free bore for silenced operation but should allow valve to remain fully open at minimal flow.

Pressure control valves shall be sized to operate satisfactorily overall system flow range.

6.2 DUCTILE IRON PIPES & FITTINGS

All ductile iron pipes and fittings to be supplied under this Specification shall be obtained from an approved manufacturer having an ISO9001-2000 TOTAL QUALITY ASSURANCE system based on the latest version of the ISO9001 standard.

6.2.1 *Socket and spigot pipes*

Ductile iron socket and spigot pipes shall be centrifugally cast in accordance with the European Standard EN 545-2002.

Each pipe shall be subjected, in accordance with the European Standard EN 545-2002, to a hydrostatic works test at the following pressures:

DN	Hydrostatic pressure
	Bar
60 to 300	50
350 to 600	40
700 to 1000	32
1100 to 2000	25

6.2.2 *Flanged pipes*

Ductile iron flanged pipes shall be manufactured in accordance with the European Standard EN 545-2002. The flanged joint ISO PN 16 or ISO PN 25 whose drilling shall comply with International Standard ISO 7005-2 ISO PN 16 or ISO PN 25 insures the water-tightness.

6.2.3 *Fittings*

The ductile iron fittings shall be sand cast in accordance with the European Standard EN 545-2002.

The water-tightness is insured by the joint, which shall be of the:

- SELF-ANCHORED push in joint where fittings are used with Socket and Spigot pipes.
- FLANGED joint where fittings are used with flanged pipes.

Each fitting shall be subjected, in accordance with the European Standard EN545-2002, to a work leak tightness test carried out under a one bar air pressure.

A certificate shall be carried out from an approved THIRD PART CONTROL ORGANISATION witnessing that the pipes and fittings are supplied from the same manufacturer unit plant. This Certificate must be legalized from the CHAMBER OF COMMERCE AND INDUSTRY of the unit plant locality.

6.2.4 *Laying and jointing*

6.2.4.1 *Laying*

Before Ductile Iron is laid, all dirt and foreign matter shall be removed from inside and all lumps blisters, excess coal tar, oil, grease and moisture shall be eliminated from the surfaces the joints. After the pipe is laid and mounted, care shall be taken to avoid entrance of dirt, water and foreign matter from the trench or from elsewhere by use of tight bulkheads.

6.2.4.2 *Jointing*

Joints of Ductile Iron Pipes and Fittings shall be of the Push in automatic standard type and where there is a need to take up the axial forces, necessary Self Anchored push in joint shall be used which allows concrete anchor blocks to be dispensed with.

For DN80 to DN1200 diameter the SELF-ANCHORED PUSH IN joint shall be as follows:

- The seal is provided by a leak-tightness STANDARD joint gasket
- The axial forces transmission is through a mechanical arrangement, such as:
 - Works applied weld bead on the pipe spigot
 - A one piece or segmented anchoring locking ring (depending on the diameter), with a curved external profile, which abuts against the weld bead.
 - A special gland, which blocks the locking ring.
 - Iron bolts (possibly special steel with baring plates in iron for high pressure and large diameter applications).

For DN1400 to DN1800 diameter the SELF-ANCHORED PUSH IN joint shall be as follows:

- The seal is provided by a leak-tightness STANDARD joint gasket
- The axial forces are transmitted by a mechanical arrangement, independent of the sealing function, comprising:
 - A weld bead, applied at works
 - A locking ring consisting of several segments held together by Elastomer Connectors.
 - A device known as a conformator, which transmits the axial force to the internal socket surface by means of shot filling the annular gap formed by the socket and conformator.
- The shot behaves like a fluid and ensures:
 - Distribution of the axial force on the socket surface and conformator.
 - Automatic stretching of the main on assembly.

Any subsequent movement of the main during testing is consequently restricted to residual shot settlement.

6.2.4.3 *Lubricant Paste*

The lubricant paste shall be a mixing of Vaseline, non soluble in accordance with French standard AFNOR T90 M DOC8. The quantities used in the assembly joints shall be as per manufacturer recommendation. It shall be supplied by the Pipes and fittings manufacturer.

6.2.4.4 *Connecting Pieces*

All connecting pieces i.e. flexible coupling, flange adaptors, dismantling joint shall be made of ductile iron and shall be supplied from the same pipes and fittings manufacturer.

6.2.5 *Linings and coatings*

6.2.5.1 *Pipes Internal Protection (Including Welded Flanged Pipes)*

Pipes shall be internally lined with sulphate resisting blast furnace slag cement applied by a centrifugal process. The cement mortar lining shall be in accordance with the International Standard ISO 4179-1985 with the thickness given in following table:

	Thickness of mortar	
	Nominal mean Value Mm	Tolerance Mm
80 – 300	3.5	- 1.5
350 – 600	5	-2
700 – 1200	6	-2.5
1400 – 2000	9	-3

6.2.5.2 *Pipes external protection (Including welded flanged pipes)*

Pipes shall be externally coated with:

- A metallic zinc coating in accordance with the International Standard ISO 8179 Part 1-1995. The quantity of zinc shall not be less than 200 g/m².
- A bituminous varnish or equivalent anticorrosive paint which shall be applied over the zinc coating in accordance with the International Standard ISO 8179 Part 1-1995, with a minimum thickness of 100 microns.

6.2.5.3 *Fittings internal and external protection*

The fittings shall be internally and externally protected with a bituminous varnish with a minimum thickness of 70 microns or with an epoxy coating applied by a cataphoresis process ensuring an equivalent protection. The type of the coating depends of the diameter of the fittings.

6.2.5.4 *Connecting pieces internal and external protection*

The connecting pieces (Flexible couplings, Flange adaptors, Dismantling joint) shall be internally and externally protected with a powder Epoxy coating having a minimum thickness of 150 microns or with a rilsan nylon coating having a minimum thickness of 200 microns. The type of the coating depends of the diameter and the type of the connecting pieces.

6.3 HIGH DENSITY POLYETHYLENE PIPES AND FITTINGS

Polyethylene pipes up to nominal size 63mm for below ground use shall be coloured blue and comply with the relevant provisions of BS 6572.

Polyethylene pipes for use in nominal diameters greater than 63mm shall be HDPE suitable for a working pressure of 16 bar.

The pipes shall be clearly and indelibly marked to show the name of the manufacturer, diameter, pressure class and date of manufacture.

Pipes with OD up to 110 mm shall be supplied in coils where the inside diameter of the coil is 30 times OD

PE Pipes shall be permanently color-coded with stripes for instant identification as potable water service pipes. Stripes shall be provided by co-extruding four (or more) equally spaced blue color stripes into the pipe outside surface. The striping material shall be the same material as the pipe material except for color. Stripes printed on the pipe outside surface shall not be acceptable.

Pipe surface shall be smooth, free from scoring, pinholes, and other surface defects. Pipe ends must be cut clean and perpendicular to the axis of the pipe. End caps at pipe extremities are required in order to prevent unwanted matter entering the pipe during storage.

Unless otherwise specified or approved by the Supervisor Polyethylene pipes joints shall be butt fusion welded. Fusion welding of polyethylene pipes shall only be undertaken by skilled operatives using appropriate specialized tooling. Pipes to be jointed shall be free from contamination and care shall be taken to ensure correct joint preparation. Suitable shelters shall be used to protect fusion jointing operations from wind and against the effects of inclement weather. Mechanical jigs or other approved methods shall be used to ensure correct alignment of the pipe when making butt fusion joints. Details of fusion welding procedures including details of tools, operatives, materials and method statements shall be submitted to the Supervisor for approval prior to any jointing..

PE fittings shall be of the butt fusion type with Nominal pressure rating of 16 bar.

It is strictly forbidden to procure pipes, fittings and electro fusion machine from different suppliers.

6.4 ACCESSORIES

6.4.1 *Flanges adaptors*

Install flanged adaptors or dismantling joints where necessary to ensure easy equipment maintenance. A flanged adaptor should be installed at one side of each valve in valve chambers.

Flanged adaptors and mechanical couplings shall have a RILSAN nylon coating applied by the manufacturer.

Flanged adaptors shall be of the Dresser, Viking Johnson type without a center register.

Adaptor rings used shall be of ethylene propylene rubber (EPDM) or other material approved by the Supervisor and suitable for potable water application..

All mechanical couplings and flange adapters including nuts, bolts and washers shall be supplied with 'Rilsan' nylon thermoplastic polyamide coating applied by fluidized bed dipping.

6.4.2 *Gate valves*

Gate valves ND 50 and below shall have bronze body and trim and shall be non-rising stem, screwed bonnet and solid wedge disc. Valves connections shall be threaded NPT or BS 21

Gate valves ND 80 and above shall be inside screw non rising stem hand wheel operated, bolted bonnet, resilient seated wedge type, straight passage, flanged PN 16 to ISO 7005-2 (DIN 2501). Valve body and bonnet shall be ductile iron GGG-50 to DIN 1693 electrostatically applied epoxy resin to DIN 30677 internally and externally. Bonnet bolts shall be of stainless steel sealed with hot melt. Bonnet gasket shall be EPDM rubber. Stem shall be stainless steel DIN X Cr 13 with NBR wiper ring and NBR O-rings stem seal.

Valve wedge shall be ductile iron GGG-50 core fully vulcanized with EPDM rubber with integral wedge nut of dezincification resistant brass CZ 132 to BS 2874. Thrust collar shall be of dezincification free resistant brass CZ 132 to BS 2872.

Valve hand wheel shall be cast iron GG-25 to DIN 1691 with electrostatically applied epoxy resin to DIN 30677 with “open” “close” indication arrow. Valve opening shall be anticlockwise.

Gate valves for underground applications shall be as stated above except that they shall be equipped with a cast iron stem cap with set screws and operating key tube consisting of a vertical bar at least 1.5 m long and a horizontal bar 0.5 m long.

6.4.3 **Globe valves**

Globe valves ND 50 and below shall be screwed NPT or BS 21, integral seat, revolving disc, inside screw, rising stem and screwed bonnet, bronze body and trim,

Globe valves ND 80 and above shall be flanged PN 16, renewable seat and trim, outside screw, rising stem and bolted bonnet, cast iron body and bronze trim.

Valve hand wheel shall be cast iron GG-25 to DIN 1691 with electrostatically applied epoxy resin to DIN 30677 with “open” “close” indication arrow. Valve opening shall be anticlockwise.

6.4.4 **Check valves**

Check valves ND 50 and below shall have bronze body and trim, screwed bonnet and renewable composition disc. Silent check valves ND 50 and below shall be non slam spring loaded, screwed with bronze body, seat and disc, 18-8 stainless steel spring with body having PN 16 minimal working pressure. Valves shall have threaded connections NPT or BS 21.

Check valves ND 80 and above shall be silent type, non slam, non shock axial spring loaded, renewable bronze seat and disc, flanged PN 16 minimum, ductile iron body GGG-40 with electrostatically applied epoxy resin internally and externally. Valve disc shall be vulcanized EPDM coated or of convenient resilient construction. Disc spring shall be 18-8 stainless steel.

Alternatively, check valve can be swing type, non slam, non shock flanged PN 16 minimum, Ductile iron body and bonnet GGG-40 with electrostatically applied epoxy resin internally and externally, stainless steel shaft to BS 431S29, EPDM rubber bonnet gasket, stainless steel washer and pin, gun metal seat ring, EPDM rubber coated metal insert disc.

6.4.5 **Strainers**

Strainers ND 50 and below shall be bronze body, PN 16 minimal rating, Y type with 20 mesh removable stainless steel screen, screwed end-cleaning cap with ND 15 drain tap, threaded connection to NPT or BS 21.

Strainers ND 80 and above shall be Y type with 20 mesh removable stainless steel screen, bolted end-cleaning cap with ND 20 drain tap at bottom with blow down valve piped to drain. Strainer body shall be cast iron GG - 25 flanged to PN 16 minimum.

6.4.6 ***Butterfly valves***

Shall be wafer type, EPDM seat, flanged PN 16 minimum, ductile iron body GGG-40 with electrostatically applied epoxy resin internally and externally. Valve disc shall be bronze, shaft shall be 18-8 stainless steel.

Valves shall be fitted with handwheel actuators not exceeding 500mm diameter incorporating gearing to allow opening and closing by manual operation at the pressure stated using an effort no greater than 26 kg on the handwheel supplied.

In all cases, the gearing shall be designed to close the valve, from fully open to fully closed in a period of not less than ten minutes with this effort. Actuators shall be designed so as to close the valves when the handwheel is turned in a clockwise direction; the direction of closing shall be clearly cast on the handwheel. Position indicators shall be fitted to all actuators.

6.4.7 ***Flow control valves***

The function of this valve is to maintain a minimum flow in the circuit and shut off in case flow exceeds a pre-determined value in order to avoid operation at run out conditions.

The main valve shall be a hydraulically-operated pilot controlled, diaphragm type globe valve. The valve stem shall be guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. The main valve shall have a single removable seat and a renewable resilient disc. No external packing glands are permitted and the diaphragm must not be used as a seating surface and there shall be no pistons operating the main valve or any pilot control. The pilot control shall be a direct acting adjustable spring loaded diaphragm valve designed to permit flow when controlling pressure exceeds the spring setting. The valve shall be equipped with a strainer in its pilot circuit.

Valve body and cover shall be cast iron ASTM A48, main valve trim shall be bronze ASTM B61 and pilot control system cast bronze ASTM B62 with 303 stainless steel trim.

6.4.8 ***Air relief valves***

Air relief valves shall be cast iron body GGG-40 with bronze trim. Ball inside valve shall be 316 stainless steel. Valves ND 63 and above shall be flanged PN16 minimum.

Double air valves shall be used for the pumping and transmission lines and single air valves shall be used for the distribution networks.

Double air relief valves shall be double orifice valves consisting of a large orifice and a small orifice. These shall permit the bulk discharge of air from the main during filling and air inflow when emptying in addition to the discharge of small quantities of air during normal operating conditions.

Air valves shall have an isolating valve for servicing without affecting the pipeline operation.

At the connection between the air valve and its isolating valve a BSP tapping shall be made suitable for fitting of a pressure gauge. All tappings shall be sealed by a brass plug and copper compression ring gasket.

Air valves shall operate automatically and be constructed so that the operating mechanism will not jam in either the open or closed positions.

6.4.9 **Ball float valves**

Ball float valves ND 62 and above shall have cast iron body and bronze trim. Float shall be brass or stainless steel.

Valve shall automatically control the rate of filling of the reservoir and shut off when a predetermined level is reached.

Valves shall be of a double seat balanced design with direct float and lever action. Valves shall be supplied with a long actuating lever to provide a long float travel for slow valve closure.

Valves shall be of the right angle pattern with flanged inlet and outlet PN16 minimum and have a resilient synthetic rubber disc, which forms a drop tight seal against a bronze removable seat insert.

Valves shall be sized to pass flows up to the maximum continuous flows stated in the Contract at the working pressure. The pressure rating of the valve shall be cast into the body of the valve.

6.4.10 **Mechanical flow meters**

Mechanical flow meters shall be of the in-line helical vane (Woltmann) type to Standards ISO4064BS 5728 EEC Specification. Meters shall be designed for minimum maintenance and shall incorporate best quality rotor bearings to ensure long working life.

Meter bodies shall be cast in spheroidal graphite iron to BS 2789. All internal parts shall be manufactured from non-corrodible materials.

Meters are for the measurement of potable water flow with a normal working temperature up to 30°C.

Measurement mechanisms shall be removable from the meter body without the necessity to remove the meter from the main. Meters shall be equipped with a register indicating flow in metric units using a sweep hand and six figure counter. Dummy cover plates to seal the meter after mechanism removal shall be provided.

Meters ND 63 and below shall be screwed to BS or NPT, meters above ND 63 shall be flanged PN 16 minimum.

6.4.11 **Water meters**

Water meters shall be volumetric turbine single jet liquid filled type, magnetically driven or with mechanical-transmission. Meters body shall be bronze rated PN16 minimum.

Accuracy at normal flow rates shall be better than $\pm 2\%$. Meters shall be calibrated in cubic meters. Minimum reading shall be 0.1 liter with head loss lower than 0.1 bar at nominal flow.

Water meters shall be equipped with following accessories:

- Tamper proof counter,
- Five (or more) reading rolls totally immersed in a hermetically sealed casing and filled with a lubricating fluid
- Cumulative reading shall be 100.000 m³ or higher
- Index wiper,

The meter must be Class C (BS 5728/1, ISO 4064, EEC 75/33, OIML N049) for horizontal position and class B in any other position, and must have an tamper proof. External adjusting screw

6.4.12 **Fire hydrants**

Fire hydrants shall be Pillar type with triple delivery (2 x 65mm + 1 x 100mm) and visible outlets made of cast iron or ductile iron. The inlet flanges to fire hydrant shall be ND 100mm

Hydrostatic test pressure shall be in accordance with BS 750. The pressure rating shall be cast into the body of the hydrant.

Fire hydrants shall be capable of passing a minimum flow of 17 L/sec at a constant working pressure of 1.7 bar.

Fire hydrants shall conform fully with BS 750 Type 2. with 'captive' internal valve.

6.4.13 **Surface boxes**

Surface boxes shall be either cast iron or ductile iron and coated with a black bituminous solution.

Surface boxes over gate valves shall be hinged and chained and shall generally comply with BS 5334.

For roads and tracks, boxes shall be Heavy duty with 150 x 150mm nominal clear opening.

For fields and areas subjected to light wheeled or pedestrian traffic boxes shall be medium duty with 150 x 150mm nominal clear opening.

Covers shall be suitable for the following maximum safe center static loads:

- Light duty - 250kg
- Medium duty - 1500kg
- Heavy duty - 5000kg

Where applicable, covers shall comply with BS 497 or other appropriate Standard.

Lifting keys shall be provided for each type of surface box or cover supplied. One set of keys shall be provided for every ten surface boxes or covers subject to a minimum of ten sets of keys or the actual number of covers if less than ten. The word "WATER" in both English and Arabic shall be integrally cast into the covers.

6.5 HANDLING AND TRANSPORT

The loading transporting, unloading and handling of pipes and fittings shall be carried out such that no damage is caused. All in accordance with the recommendations of the manufacturer and to the approval of the Supervisor. The use of lifting hooks is not permitted. Pillows shall be provided between lashing (ropes, wires or chains) and the pipes. All cradles and lashings shall be of such widths as to prevent damage to the coating of the pipe, or distortion of the pipes.

valves and fittings shall be transported on timber packing and where possible in the manufacturer's original packing.

Protective cover, discs, and other protective materials provided by the manufacturer shall not be permanently removed until immediately prior to installation.

In the event of any damage being caused, the Supervisor shall determine whether damaged piece shall be replaced or repaired and if it is to be repaired, the manner of such repair,

Pipes shall be placed on suitable pillows or other approved supports. End caps shall not be removed until such time as the pipe is to be inspected and laid.

Where the pipeline crosses roads, tracks or any other access or where directed by the Supervisor, the Contractor shall place the pipes so that access to the public is not in any way prohibited.

Shortly before laying or fixing any valve, pipe or fitting, the Contractor shall examine each valve, pipe and fitting to ascertain that there is no damage or defect. The Contractor shall give the Supervisor not less than 48 hours' notice of his intention to undertake such examination. The Contractor shall not lay such pipes and fittings until he has received approval from the Supervisor.

Linings shall be inspected prior to laying and any defect made good.

Any defect or crack in cement mortar lining exceeding 0.8 mm shall be made good using epoxy mortar.

6.6 INSTALLATION

- a) All pipework installation shall be carried out by experienced labor.
- b) All equipment and tools used for pipe work installation like cranes, slings, shackles, chain blocks, grinders and the like shall be of suitable rating and in good working conditions. In case the Supervisor judges that any equipment or tool is not fit to be used for piping installation, the Contractor shall replace it or carry out the necessary repairs to make it suitable for use.
- c) Pipe sections, fittings and valves shall be carefully checked inside and outside for any defects (breaks, hair cracks, bends, bumps, corrosion, etc....) before installation. Any defects found shall be reported to the Supervisor and the piece put aside.
- e) For Bell & Spigot joints, it is essential to chamfer the edge of the pipe to a proper slope after cutting and before assembly. The protective coating on the pipe areas affected by the cutting operations should be restored if required by the Supervisor.
- f) Install pipes to the invert / crown level indicated on the longitudinal profile using proper survey tools.
- g) Pipes shall not be dragged along the trench bottom.
- h) Use pieces of soft wood when levelling the pipes in the trench. Do not use stones, bricks, etc... this may damage the coating.
- i) All pipes shall be fully and firmly bedded over the entire length of each pipe and shall be laid true to line, level and grade, commencing at the downstream end unless otherwise approved. Inverts shall be matched to form a continuous line free of appreciable irregularities.
- k) Do not leave ends of pipes opened if installations stopped. Use tight lids supplied by manufacture.
- l) Long radius curves in buried pipelines shall be negotiated by deflections taken up in one or more pipe joint. The deflection in pipeline shall not exceed the limits specified by the manufacturer.
- m) Each section of pipe shall be a full pipe span.
- n) Push on and mechanical joints shall be made in compliance with the manufacturer's instructions and as approved by the Supervisor. Care shall be taken to ensure the absolute cleanliness of the pipe ends and joint components (gasket). Only the recommended approved gaskets and lubricants shall be used.
- o) Whenever part or section of pipes, not exceeding 500 meters, is installed in the trench. Submit a written request for pressure testing before backfilling and compacting the pipe trenches.
- p) Pipes and fittings laid in trenches shall have at least the minimum cover stated on the Drawings.

- q) The Contractor shall ensure that no dirty water or other extraneous matter is allowed to enter the pipes during or after laying. In the event of dirty water or extraneous matter entering the pipes the Contractor shall immediately carry out cleaning and disinfection as directed by the Supervisor.
- r) Except when necessary for jointing, the end of the last pipe laid shall be plugged to the satisfaction of the Supervisor.
- s) The Contractor shall be liable for any damage caused to the Contracting Authority's Plant and apparatus or other equipment as a result of foreign matter of any kind not having been cleared out of pipelines before Taking Over.
- t) Pipe trenches shall not be backfilled until approved by the Supervisor. Once approved trenches shall be backfilled without delay to at least the minimum extent required for pressure testing.
- u) Installed pipe, fitting or valve that is subsequently found to be damaged, misaligned, disturbed or displaced due to errors in installation, construction traffic, or any other cause at any stage prior to completion of the Works, shall be repaired (if possible), realigned or removed and replaced as directed by the Supervisor at the Contractor's expense.
- v) Encase DCI pipe in polyethylene sheathing and secure with specified adhesive tape before making joint. Ensure sheath is not damaged during installation.
- w) Ensure at least 300 mm of polyethylene sheath overlap at each joint and secure with specified adhesive tape.
- x) Do not lay pipe when trench bottom is muddy or frozen or has standing water.
- y) PE pipes must be unwound in a straight manner without any buckling. Spiral unwinding must be avoided.
- z) When unwinding PE pipes from drums or coils it is essential to pay attention that the pipe end cannot spring outwards when losing the fastening. As considerable forces are released, particularly from the large diameter pipes, take the necessary measures of precaution (danger of accident!). Drums should unwind from the top.

6.7 PIPE CUTTING

Use proper supports to fix the pipe level before any cutting is attempted. Use square edges, tapes and spirit levels to check straightness of cut. Handle the pipe with care in order not to damage its protective coating.

6.7.1 *DI pipes*

Ductile iron pipes shall only be cut with an approved mechanical pipe cutter in conformity with the pipe manufacturer's recommendations. The use of any other device like a grinder shall not be permitted. The edges of the cut pipes shall be clean, true square and properly chamfered to suit the form of joint used. When a "Push on" type joint is used, pipe edge shall be beveled at 30° to pipe axis.

Special care should be taken not to damage pipe coating and lining, however if it is the case, the periphery of the cut edge from which the coating and or lining has been removed shall be given two coats of bituminous paint and the internal lining repaired with special epoxy mortar.

6.7.2 HDPE pipes

HDPE pipes shall be cut with an approved mechanical pipe cutter and in conformity with pipe manufacturer's recommendations. The ends of the pipe shall be accurately beveled by mechanical means to the dimensions specified in the manufacturer's recommendations.

6.8 FLANGED JOINTS

Use flanged joints for connections Ø63 mm and above.

Unless otherwise specified flanges shall be faced and drilled to conform to the dimensions specified in BS 4504. Flanges shall be compatible with the pressure rating of the adjacent pipework but not less than 16 bar. Bolts, nuts and washers shall be to BS 4504 Clause 5. No bolt shall project more than two full threads beyond its nut after tightening. In no circumstances shall the shortening of excessively long bolts by cutting be allowed.

Gaskets shall comply with BS 4865 and BS 2494 Type W.

Flanges shall be painted with two coats of epoxy resin paint.

Always clean flange and gasket faces before making a flanged joint. Discard any gasket that presents cuts, burrs and uneven surface. Tighten bolts using a torque wrench to the required torques recommended by the manufacturer in a staggered manner to achieve uniform gasket compression.

Flanged joints shall be made with two washers per bolt, one under the bolt head and the other under the nut.

Match valve flanged connections with flanges of similar rating, facing, drilling and thickness. Do not force valve flanged connections into alignment with connecting pipework using wrenches or crow bars. Alignment should be achieved by proper installation and not by using force. Flanged joints shall be flush and truly aligned. Properly align joints to maximum 1/16 inch misalignment tolerance before welding or jointing flanges.

Buried flange joints shall be protected externally by painting with an approved bitumen paint and by wrapping using 'Denso' paste, mastic tape and outerwrap or similar approved materials all in accordance with the manufacturer's instructions as approved by the Supervisor.

6.9 THREADED JOINTS

Use threaded joints for pipe sizes 63 mm and below.

Install pipe on a proper stand before proceeding with threading. Cut pipe with a pipe cutter, do not use a hacksaw. Ends of pipes to be threaded shall be cut square, beveled and reamed to remove all burrs and then threaded.

Threaded Joints shall be made without use of burlap strings. Only Teflon with red oxide primer paint or an approved thread paste shall be used. Apply tape and thread compound on male thread only. Cut threads with new dies and remove burrs and chips with a wire brush.

Use proper padding between wrenches or vice jaws and pipes before tightening in order to avoid deep denting the surface of the pipes. Any pipework so damaged shall be removed from site at no extra cost to the Contracting authority.

6.10 THRUST BLOCKS

Concrete thrust and anchor blocks shall be installed whenever there an abrupt change in direction for the pipeline like bends and tees or in case a dismantling joint is used in conjunction with a valve in accordance with the details shown on the Drawings or as directed by the Supervisor.

Excavation shall be made after laying the pipe and the thrust blocks poured immediately after excavation. If instructed accordingly, restraining saddles made of steel rebar shall be sunk into the thrust block to further restrain pipe movement. The thrust blocks shall abut on to solid ground with all loose material being removed before concreting.

No pressure shall be applied in any section of main until the concrete has achieved adequate strength and at least three day's curing.

6.11 SPOOL PIECE WITH PUDDLE FLANGE

Flanged anchoring pipes with puddle flange shall be used in the concrete walls of valve chambers and reservoirs as specified in the drawings or as instructed by the Supervisor. The puddles flange will provide additional fixation to the pipe in the wall in addition to eliminating water leakage.

The flanged anchoring pipe with puddle flange shall be made of ductile iron. Installation in concrete walls shall follow the manufacturer's recommendations.

No pipe entering a below ground or a water retaining structure shall be installed without having a puddle flange.

6.12 MARKER POSTS

Pre-cast concrete marker posts shall be erected at locations of gate valves, air valves, hydrants, washouts and changes in direction and other locations as directed by the Supervisor. Plates shall be fixed to the post annotated as shown on the Drawing.

Posts alongside a roadway shall be set back against the nearest wall, hedge or similar and the appropriate horizontal and vertical distance to the valve or pipeline to the nearest 100 mm shall be shown on the post or marker plate.

6.13 INDICATOR TAPE

Indicator tapes shall be made of pigmented low density polythene in a bright colour or other approved material not less than 100 mm wide and 0.15 mm thick. The tapes shall be continuously and alternatively labeled in Arabic and English.

Indicator tapes used with nonmetallic pipes shall incorporate an aluminum foil to provide a continuous band detectable with a metal detector.

6.14 CONCRETE ENCASEMENT

Where pipelines pass under streams and rivers or where directed by the Supervisor, the pipeline shall be encased in concrete as shown on the Drawings or instructed by the Supervisor.

Concrete encasement shall be broken at all pipe joints to retain flexibility in the pipeline in case of shallow pipes, except for pipes crossing under watercourse, the concrete encasement shall be continuous and rigid. However, no joints shall be concreted in without the prior approval of the Supervisor.

All concrete works shall comply with the appropriate requirements of section 3 concrete works of these specifications.

When pipes intersect with other utilities, the pipe shall be surrounded with concrete, the joints at such crossing shall also be encased.

All concrete encasements shall not be executed without the prior approval of the Supervisor.

After placing pipe, pour concrete in trench to thoroughly flow under the pipe to provide solid and uniform bedding. Pour the balance of concrete on both sides of the pipe simultaneously.

Introduce vertical construction joints in concrete encasements at the face of each pipe joint using compressible board. Fill any gap left in concrete at the construction joint with approved resilient material.

6.15 MANHOLE AND CHAMBER ACCESS COVERS

The manhole and chamber access covers shall comply with BS 497 Part 1 and be obtained from an approved manufacturer and shall be to the internal minimum clear opening as detailed in Contract.

All manhole and chamber access covers in road shall be to an approved Heavy Duty pattern and in footpaths shall be medium/heavy duty unless otherwise specified. The frame and lid shall have key holes formed with sealed pockets underneath to prevent ingress of sand, grit and surface water and shall be of an approved non-rocking pattern. The covers and frames shall have accurate seating faces to prevent rocking and the ingress of sand or water, and shall be tight fitting to resist overflow conditions or

unauthorized removal. The seating faces shall be coated with graphite grease before installation of the cover.

A supply of keys for use with every type of manhole cover and surface box shall be handed over by the Contractor at the completion of the Contract on the basis of one set of keys for each 50 covers or part thereof.

Manhole and chamber cover frames shall be set in cement mortar and secured with Class C30/10 concrete and shall be set to the camber or fall of the finished road surface. It shall be the Contractor's responsibility to establish the finished road surface levels from the appropriate authority and to fix the covers accordingly.

6.16 HOUSE CONNECTIONS

The Contractor shall submit a plan showing the proposed distribution of the water meters (including diameters and types of water meters) over the entire network providing water meters for all the houses / buildings. This plan will be studied by the Supervisor, discussed with the local authorities, modified if necessary and then approved and adopted for execution.

The Contractor shall also submit to the Supervisor for approval a plan showing the installation details of the water meters, water meter reinforced concrete protection box with metallic medium duty cover and all related pipes and accessories. The Contractor shall not begin works prior to the Supervisor's approval.

Houses / buildings shall be counted and divided into groups according to the location of each house / building, the number of residents in each house / building and the distribution of the houses / buildings over the entire network. Afterwards the house connections shall be arranged in a way to provide a house connection for every house / building.

6.17 FLOTATION OF PIPELINE

The Contractor shall ensure that flotation of the pipeline does not occur during construction especially at river crossings if passing under river bed. Backfill or concrete encasement, depending on the application, placed over each pipe after laying and before testing shall prevent flotation.

6.18 PIPEWORK TESTING

All pressure pipelines shall be hydrostatically tested. They shall be tested in sections not longer than 500 m or as may be directed by the Supervisor,

The Contractor shall submit to the Supervisor the hydrostatic test procedures for pipelines and will stick thoroughly to what has been approved. The Contractor cannot start hydrostatic tests before securing the Supervisor's approval for the test procedure. The procedure must mention the test equipment to be used, the testing method and criteria for passing the test successfully, the water quality to be used, the method of flushing and disposing of the test water.

The Contractor shall give the Supervisor not less than 48 hours notice of his intention to carry out a pressure test. Testing shall not commence without the Supervisor's approval.

Before a length of pipeline is tested, each pipe shall be securely anchored. All thrust and anchor blocks shall have been constructed and, the barrel of each pipe shall be backfilled to the extent necessary to prevent flotation or movement of the pipeline and shall be not less than 600mm above pipe crown. Joints shall be left exposed until pressure testing has been satisfactorily completed. Any need to Backfill a pipeline before pressure testing shall not relieve the Contractor of his responsibility to excavate to locate and repair any leaks.

Pressure testing shall be carried out as the work proceeds in such lengths as are convenient but not exceeding 500 m. The ends of the length of pipeline under test shall be closed by means of securely anchored caps or blank flanges. Pipeline valves shall not be used for this purpose. All washout valves shall be fitted with blank flanges and the valves opened before the commencement of any pressure test. At each air valve location, a special air release arrangement shall be provided to allow manual release of air during filling operations. Pressure testing shall not be carried out with permanent air valves in place.

The pipeline to be tested shall be filled slowly with clean water in such a manner that all air is expelled. Air vents shall be checked to ensure that no air is trapped at high points.

As a guideline the following test procedures are described, the Contractor can propose another test procedure if proved equivalent or superior to what follows and is approved by the Supervisor.

Test procedure # 1

(Recommended in case of important variations in ambient temperature or in case nonferrous pipe material is used)

The pressure in the pipeline shall be slowly raised to the working pressure of the line. The test pump shall then be disconnected and the pipeline left under pressure with air valves opened for a period of not less than 24 hours to allow air in the pipeline to be expelled and pipe linings and pipe walls of absorbing materials to become saturated. At the end of this period of time the air valves shall be closed and the test pump shall be reconnected and the pressure in the pipeline raised to the test pressure as stated here below and this pressure maintained for a period of 24 hours or such other period as directed by the Supervisor.

Throughout this period the pressure in the pipeline shall not be allowed to fall or rise more than 6m head of water below or above the test pressure and this shall be accomplished by pumping water into or releasing water from the pipeline as required. The volume of water pumped into or released from the pipeline shall be carefully measured. At the end of the test period the pressure in the pipeline shall be adjusted to the test pressure by pumping water into or releasing water from the pipeline as required.

The apparent leakage from the pipeline shall be ascertained from the net volume of water that has been pumped into the pipeline during the test period.

The permissible loss shall not exceed 2 litres per meter nominal bore per kilometer length per meter head per 24 hours.

Test procedure # 2

The pressure shall be slowly raised by pumping to the required "Test Pressure". Pumping shall then be discontinued, the pump disconnected, and the line kept under pressure for at least 30 minutes. For the line to be accepted, the pressure shall not drop by more than 0.2 kg/cm² during the said 30 minute period and there shall be no visible leaks at joints, fittings, valves, etc. Should the drop of pressure exceed this value, the Contractor shall search for the defects causing such pressure drop, shall make all necessary repairs and repeat the test until the section under test meets the requirements. Provided always that all visible leaks must be repaired whatever the loss of pressure.

Test pressure shall be as follows for both methods:

- 1) Test pressure shall be equal to 1.5 x Rated Working Pressure for pipeline working pressure equal to or less than 10 kg/cm²,
- 2) Test pressure shall be equal to Rated Working Pressure + 5 kg/cm² for pipeline working pressures exceeding 10 kg/cm².

During the pressure test exposed joints shall be inspected and any leaking or seeping joints shall be remedied.

Test pressures shall be measured at the lowest part of the pipeline.

All signs of leakage shall be remedied whether total apparent leakage from the pipeline under test is less than the apparent allowable leakage or not.

Should any length of pipeline fail to pass the pressure test the Contractor shall at his own expense carry out all work necessary to locate and remedy the faults and to retest the pipeline until it satisfactorily passes the test.

A low pressure air test (not exceeding 0.3 bar) may be used as a preliminary joint tightness test prior to backfilling and hydrostatic testing.

Contractor must flush the test water out no later than 24 hour after successful completion of the test.

The Contractor shall at his own cost provide all necessary test pumps, pressure gauges, cocks and other accessories and shall make such temporary connections as may be required for filling and testing the line in the manner herein specified.

The water used for pressure testing shall be provided by the Contractor, Only clean potable water shall be used to test potable water lines.

The Contractor shall be responsible for obtaining the water, transporting it and for its safe disposal on completion.

The Contractor shall submit all pipework test procedures to the Supervisor and receive approval before starting with the tests.

Pipework testing shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

6.19 CLEANING AND DISINFECTION

After completion of pipeline hydrostatic test, Contractor shall carry out line disinfection before system commissioning.

Contractor shall submit the disinfection procedure to the Supervisor clearly stating the type of equipment to be used, the method of flushing and disinfection, the water quality used and how he intends to dispose of the flushing water.

The Pipeline shall be flushed clean prior to disinfection. Pipeline shall be flushed until flushing water is clean. One to two volume of pipe is usually required for such flushing.

After closing all pipeline's outlets, the Contractor shall fill pipelines with clean water mixed with chlorine at a concentration of 20 mg per liter. After a reaction period of 24 hours, the residual chlorine shall be measured and a bacteriological test performed by taking a sample to the lab in the presence of the Supervisor. If residual chlorine is below 0.1 ppm and or bacteriological test shows that water is still unsafe for consumption, the disinfection process must be repeated and another test must be taken until results are acceptable to the Supervisor.

The Contractor can disinfect the water reservoirs after the completion of the construction works in conjunction with the pipelines or separately.

Contractor shall fill the reservoirs with clear water mixed with chlorine at a concentration of 20 mg per liter and carry out the same procedure stated above.

Disinfection shall not be paid for as a measured item, it shall be considered as subsidiary Works the cost of which is included in the prices of pay items of the B.O.Q.

6.20 CONNECTION TO EXISTING PIPEWORK

Where called for, the Contractor shall be responsible for connecting new pipework laid under this Contract to existing pipework, and for blanking-off existing pipework. The connection shall be made in a manner to minimize disruptions of potable water supply. To consumers.

Before blanking-off or making a connection to existing pipework, the Contractor shall submit his detailed method statement and program of work and a schedule of all plant and materials to be used to get the Supervisor's approval no less than 14 days in advance of the date on which he proposes to carry out the work. The Contractor may need to coordinate with the responsible authority before submitting his work plan to the Supervisor. After receiving the Supervisor's approval the Contractor shall obtain from the responsible authority an agreement on the precise date and time when the connection or blanking-off could be made, all subject to the approval of the Supervisor.

The Contractor work program shall allow for the immediate commissioning on completion of the work.

The Contractor shall be responsible for locating the exact line and level of the existing pipework and shall agree with the Supervisor and the responsible Authority about the precise location of the connection or blanking-off.

Before starting the works, the Contractor shall excavate trial pits as necessary and shall check the outside diameter of the existing pipework and ensure that the couplings to be used for making connections to the existing pipework and the materials used for blanking-off existing pipework are dimensionally suitable.

The Contractor shall ensure that all the materials are on site not less than 24 hours before the start of the work.

The Contractor shall ensure that at least one senior member of his field supervisory staff, who is experienced in such operations is on site throughout the duration of the work.

The Contractor shall also ensure that all necessary skilled workers and an adequate number of laborers for the operation are on site throughout the work.

The Contractor shall execute all necessary works ahead of disconnection of the supply including:

- (a) Excavation and supports to the excavation.
- (b) Blinding with concrete the immediate working areas, but not less than the whole of the bottom of the excavation.
- (c) Executing gravity drains and where not possible, digging a sump of adequate size to install a drain pump..
- (d) Casting the floor of any valve or inspection chamber which is later to be constructed at the place where the connection is being carried out.
- (e) Casting the thrust blocks or any other works which may be required.
- (f) Exposing and cleaning pipes in readiness for the work

Once all preparatory works are complete, the Contractor shall empty the section of existing pipework on which work is to be carried out, as agreed with the Authority and approved by the Supervisor.

The Contractor shall take all precautions necessary to prevent dirt and other foreign matter entering the pipelines.

The Contractor shall provide at the Site a sufficient quantity of clean water containing approximately 10 ppm (10 mg/l) of chlorine before proceeding with the cutting of the existing pipeline. Each item of new pipework to be installed including the joints shall be submerged in the solution for a minimum period of 15 minutes immediately prior to installation.

Once the connection or blanking off is completed, the Contractor shall check for any leaks at the joints and in case of satisfactory installation and after receiving the approval of the Supervisor, he will backfill as per the procedures stated in section 2 of the present specifications.

7. MECHANICAL WORKS

7.1 REGULATIONS AND STANDARDS

In the absence of relevant National Acts of Parliament or Lebanese Government legislation, regulations or standards, the Supervisor shall comply with the current relevant International standard (ISO) or other standard described in this SPD. If no relevant ISO or other standard exists, or is referenced in the SPD, then guidance shall be obtained from the Ministry on which standard to use.

Until appropriate legislation is in place within the Republic of Lebanon, matters relating to safe working practices, safety at work, working in confined spaces and other Health and Safety issues shall follow current recognized international guidelines.

7.2 PUMPS

7.2.1 General requirements

7.2.1.1 Materials

Materials of construction of pumps shall be in compliance with the following requirements unless specified otherwise. Other materials of superior quality may be used subject to the approval of the Supervisor.

SERVICE ITEM	RAW WATER	DRINKING WATER	SEWAGE	HYDROCARBON	SUBMERSIBLE SERVICE
CASING	NI-RESIST	ZINC FREE BRONZE (MAX 3% ZINC)	CAST IRON	STEEL	CAST IRON
IMPELLER	NI-RESIST	ZINC FREE BRONZE (MAX 3% ZINC)	CAST IRON	STEEL	CAST IRON
TRIM	NI-RESIST 316 L	ZINC FREE BRONZE (MAX 3% ZINC)	CAST IRON	CAST IRON 13 CR	CAST IRON
MECH.SEAL	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD	MANUFACTURER STANDARD
STUDS	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B7	ASTM A193 GRADE B8M
NUTS	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 2H	ASTM A194 GRADE 8M

7.2.1.2 *Pump Units*

All pump units shall have means of isolation from their associated pipework system.

In dry well installations, the suction valve will normally be left open, unless used for isolation when the pump is out of service.

The delivery side of the pump set shall include a non-return device to prevent back circulation when the set is not running. This shall be a fail-safe device such that in the event of pump failure or loss of external services, the device shall independently close e.g. ball valves, check valves or gate valves closed by gravity or stored energy systems in exceptional circumstances. A gate valve will normally also be installed on the pump delivery side, downstream of the non-return device, for pump isolation.

7.2.1.3 *Pump Unit Control*

The pump unit control panel shall include all control and indication elements for the pump motor, together with any associated valve actuators, lubricating systems and valves, cooling fans, flushing pumps and other ancillary control equipment required by a pump drive, all arranged to operate in a safe and proper sequence.

Where external services are required to open the delivery valve, the control system shall initiate the valve opening procedure as soon as the pump is up to a speed sufficient to overcome any existing delivery pressure.

Normal starting sequence will therefore cause the pump to run-up to operating speed then initiate opening of the delivery valve. Normal stopping sequence will first initiate delivery valve closure, after valve has closed then pump motor will be de-energized.

Failure of the valve to open within the time allowed, or closure occurring whilst running, shall initiate an alarm and shut down the pump set. The maximum running time with the delivery valve closed shall be 3 minutes unless otherwise specified.

7.2.1.4 *Pump Duty*

Pumps shall be of the type specified. They shall be designed to give specified output against all losses including those relating to the pump.

The Contractor shall match his pump characteristics to the pipe system network to achieve high pump efficiency and reliability.

Each set must be capable of running satisfactorily in parallel with other sets in the system without throttling and by itself, without cavitation or overload under all operating conditions within the system characteristics given.

The pump section and arrangement shall be such as to ensure that the head available exceeds the N.P.S.H. requirements of the pump under all operational conditions.

Where the system and pump characteristics are such as to give rise to the possibility of surge in the pipeline with consequential damage, a surge investigation shall be undertaken; if the results of the investigation show that there is a problem, measures shall

be proposed by the contractor to alleviate the problem. These measures shall be agreed with the Supervisor.

Centrifugal pumps shall have a non-overloading characteristic over the complete range of head and quantity delivered and the drive shall be capable of starting the pumps against a closed valve, i.e. maximum pump head conditions.

The whole pumping unit shall be capable of withstanding without detriment, reverse rotation to a speed that would occur if the pump were to stop when the differential head was at a maximum and the delivery and/or non-return valve failed to close.

The design of the pumps shall be such that there will be no tendency to unlock any part due to possible reversal of rotation and shall not pass through or approach a critical speed.

The pumps shall be capable of working for long periods without cleaning or attention.

For sewage pumps the ability to operate with the maximum reliability is of prime importance, with efficiency being a secondary consideration. The pump shall operate without clogging, being designed to pass a sphere as specified where the size of the delivery mains permits. Whilst the pumps shall be designed to meet a specific duty they shall also be capable of operating over the duty range specified for prolonged periods and for standing idle for long periods without attention as in the case of storm pumping.

7.2.1.5 Pump Duty Control

Each of the pump units shall be capable of operating in any combination of duty sequence.

Any starting sequence, including those following restoration after a supply failure shall be time sequenced to prevent excessive load on the supply system. Each duty circuit shall include its own timer, arranged to be initiated in the selected duty sequence by the preceding duty, the delay periods between each re-start being adjustable up to 20 secs.

Pumping sets shall be automatically operated according to water levels in the discharge and suction side reservoirs unless otherwise specified.

Successive levels shall be carefully chosen in order to ensure a smooth and safe operation of the pumping system, taking into consideration the characteristics of the pumps, networks, hydraulic inertia of the installation, as well as the sensitivity of the instrumentation.

Two sets of level measuring devices operating in redundancy shall be installed in each reservoir unless otherwise specified.

Where valves with motorized actuator are installed on pump outlet pipe section, the pump shall be started with a closed valve: each pump shall start when the valve is still closed. The valve begins to open at the starting command of the pump and shall be controlled by the discharge pressure. The time of the total opening of the valve shall be chosen according to the pump manufacturer recommendation. At the pump stop command, the

corresponding valve shall receive a closing signal and shall close fully prior to the shutdown of the pump.

Where more than one pumpset is installed for a water network and unless otherwise specified, pumps shall be operated with a cyclic duty program automatically executed by the supervisor system. However, a selection of pump duty order by the operator shall be possible.

7.2.1.6 Pumps Casings

Pump casings shall be capable of withstanding all pressures which may be produced due to operating pressure surges.

Particular attention shall be paid to the wear characteristics of the pumps. In the case of sewage pumps, due to the presence of grit in the sewage wear, could be appreciable.

The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that all components liable to wear can be replaced.

Components shall be permanently marked with the manufacturer's number and where dowels are not used, permanently marked for correct assembly. The pump casing shall have detachable wear rings.

The casings of the pumps shall have flanges to match the specified pipework.

The waterways through the pumps shall be smooth in finish and free from recesses and obstructions.

Sewage pump casings shall be of substantial construction to give long life under abrasive conditions and suitably stiffened to withstand shock due to solids in suspension. Inspection holes shall be provided in any section bend and in the pump casing above the impeller for access to facilitate the clearance of obstructions. The inspection hole covers shall be shaped to conform to the interior profile of the waterway when in place and shall be fitted with starting screws where necessary.

7.2.1.7 Impellers

Impellers shall be securely fitted to pump shafts in such a manner to prevent them becoming loose or detached when the pump is in operation, or when rotating in the reverse direction, either by liquid flow or motor rotation.

The impellers and guide vanes (if any) shall be accurately machined and smoothly finished to minimize hydraulic losses.

The rotating elements type shall be as specified and shall be statically and dynamically balanced before final assembly.

For sewage pumps the impeller shall be of the open type with the inlet ends of the vanes being of bulbous design and the impeller passages being as large as possible consistent with good performance. The impeller shall be readily withdrawable from the pump casing without the need to disconnect pipework. The inlet ends and surfaces of the vanes shall

be dressed to give a smooth finish to prevent fouling by rags and fibrous matter within the pumps.

Impellers for both sewage and storm water pumps shall be of the non-shrouded type designed to exclude gritty matter from the shaft and gland.

The impellers should have replaceable wear rings. The clearance at the wear rings shall be kept to a minimum, and where it is found necessary to cut back the impeller this is to be done on the vanes only.

7.2.1.8 Pump Shaft

The pump shaft shall be adequately sized, with good fatigue, shock load and corrosion resistance. The duty speed range shall be well below the first critical speed of the shaft. Where a change in diameter of the shaft occurs the shoulder shall be radiussed or undercut to the appropriate BS to reduce stress concentration.

The shaft shall be complete with easily renewable protecting sleeves of suitable material (stainless steel) at glands and bearings.

7.2.1.9 Shaft Seals

Pump shaft sealing arrangement shall be suitable for the water pressures and shaft speeds involved.

Pumps shall be fitted with packing glands seals or a split type mechanical shaft seal arranged such that replacement of wearing components can be carried out without the need to dismantle the pump.

Special care in the selection of materials shall be taken in order to avoid binding and electrolytic action between the shaft sleeve and the mechanical seal components, particularly where long periods of idleness are inherent in the duty cycle as in the case of standby and storm pumping.

Each mechanical seal shall be equipped with leakage collection facilities and separately piped as specified.

Pump glands shall be of the soft packed type with wearing sleeves and shall be designed for grease lubrication and shall be provided with large size grease lubricators with tell-tales. Glands and lantern rings shall be of the split type to facilitate easy packing.

Pumps fitted with soft re-packable or packed gland type seals, shall have stuffing boxes designed to facilitate adjustment or replacement of the packing materials.

7.2.1.10 Bearings

All pumps shall incorporate bearing arrangements which prevent the escape of lubricant into the liquid being pumped. The bearings shall be located in dust/moisture-proof housings.

All bearings shall be liberally rated to ensure cool running and meet the load factors specified.

For vertically mounted pumps, the top bearing shall be a combined thrust and journal type, designed to prevent any thrust loads being transmitted to the drive motor. The pump bottom bearing shall be lubricated by an enclosed water lubricated sleeve bearing for potable water applications but by grease or other approved means for sewage use. Storm pump bearings shall also be suitable for standing idle for periods up to 2 months without attention or movement.

Where grease points are necessary they shall be fitted with removable screwed plugs which shall be accessible without removing guards. All bearings having automatic lubrication shall also have provision for hand lubrication.

7.2.1.11 Baseplates and Stools

For vertical pump units, heavy cast iron or fabricated steel floor plates and motor stools shall be provided for direct mounting on concrete floors or supporting steelwork. Suitable journal and thrust bearings shall be provided in the baseplates to carry the vertical drive shaft.

Where necessary the motor stools shall be designed to accommodate flywheels and bearing housings.

Floor plates shall be recessed and so arranged that the tops and fixing bolts are level with the finished floor.

The pump units shall be accurately aligned and located on the baseplate by set screws and parallel dowels or machined spigots. Approved means of dowel withdrawal shall be provided.

7.2.1.12 Lubrication/Cooling Monitoring

A lubrication system shall be arranged for the lubrication of all grease points on the pumps and shafting from motor room level. Individual bearings within the support tunnel tubes and on the pump sets themselves shall receive separate supplies of grease fed by pressure tubes laid from each bearing to battery plates readily accessible from motor floor level for grease gun operation.

Pressure tubes shall be grouped together where possible and securely attached by brackets, straps etc. to tunnel tubes, with connectors located near to the motor support plate for easy removal of shafting in the event of maintenance work. In exposed positions pressure tubes are protected from damage. Motor grease points will not be included in this lubrication system but shall receive individual attention.

The battery plates shall have sufficient greasing points for all bearings and be located on or adjacent to each pump motor stool.

A notice is to be supplied and fixed on the wall in a prominent position detailing the manufacturer's recommended greasing schedule. The notice shall include a warning of the dangers to bearings from 'over greasing'.

A grease gun shall be supplied for all greasing purposes.

Bearings which require a continuous supply of lubricant shall incorporate a means of monitoring such a supply, either by flow or temperature rise as appropriate for the type of bearing employed; separate monitors being fitted for each bearing feed or housing.

Such monitors shall include all necessary ancillary power or pulse counting devices to enable the operation of any monitor to initiate a volt free contact rated at 240V 0.5A AC.

7.2.1.13 Pump Tundish

Where specified, each pump shall be equipped with a cast aluminum or fabricated steel tundish to accommodate the drain lines from mechanical seals, casing vent and other minor drainage points on the pump. A single drain pipe shall be run from the tundish to the house drainage system.

7.2.1.14 Air Release Cock

The highest point on the pump casing shall be fitted with a manual air release cock having a removable handle or an automatic air release valve with a lockable isolation valve as specified. Air release pipework on sewage pumps shall be not less than 30mm bore and shall discharge back into the wet well at high level and have facilities for rodding. The drain from each air release cock shall discharge via pipework as specified.

7.2.1.15 Couplings

Coupling materials shall be chromium stainless steel.

All couplings shall be of an approved type and the Contractor shall arrange for the provision and fitting of both coupling halves to each respective shaft and shall include for all necessary modifications to any existing shafts to be coupled.

Where specified, the Contractor shall include any equipment required to prevent damage to any part of the drive in the event of reverse rotation of the pumps.

7.2.1.16 Intermediate Shafts

Intermediate shafts between the pump and drive shall include universal couplings at each end allowing free axial movement to avoid end thrust being transmitted. The shaft and coupling shall be fitted with a full length guard manufactured from mild steel mesh on a mild steel framework, easily removable for maintenance purposes.

The frame and mesh shall be hot dip galvanized.

7.2.1.17 Gear Unit

Each unit shall be continuously rated to transmit the full power of the drive either directly in line or through a right angled, helical gear system, having an input/output speed ratio to suit the duty.

The gear case shall be made of substantially ribbed cast iron with machined mounting feet and shall form a totally enclosed, oil tight casing.

The gear unit case and bearings shall be designed to accommodate the total weight of any suspended drive shafting and couplings in addition to any dynamic load imparted

during service, and run for a minimum of 10,000 hours before a major overhaul is required.

Where specified, an electric tachometer shall be fitted to indicate the output shaft speed.

(i) Lubrication:

The gear unit shall be grease or oil lubricated, arranged to provide an adequate supply of lubricant for the duty.

Where oil lubrication is employed, the casing shall include an oil breather, level indicator and drain plug.

Units having a rated output greater than 500kW shall have inspection covers and include a forced lubrication system comprising an oil circulating pump, reservoir tank and full flow 'Duplex' type oil filters having re-usable elements together with associated pipework; the oil being circulated by either (a) an internal mechanically driven gear pump and an external electrically driven pump arranged to prime the gears as pre-set timings as recommended by the unit manufacturer, or (b) duplicate external electrically driven pumps, each of which may be selected to prime at pre-set intervals and run when the gear unit runs.

Such a lubrication system shall include dial gauges and alarm switches to monitor high oil temperature and low oil pressure.

(ii) Reverse rotation:

Where specified, the gear unit shall be capable of withstanding reverse rotation for a limited period with no detriment to the unit. Where a forced lubrication system is used, this shall continue to operate satisfactorily under such conditions.

7.2.2 Submersible Borehole Pump system

7.2.2.1 Submersible pumps

Pumps impellers shall be closed or semi open type.

Pump body shall be treated against corrosion. The bowls shall be joined by flanges or by tie rods.

The shaft main guide bearings located in the suction and delivery end housings of the pump shall utilize a leaded-bronze material, and shall be provided with protection guards to prevent ingress of sand and grit. Pump bowl guide bearings shall utilize either leaded bronze or other approved abrasion resistant material. All pump bearings shall be lubricated by the water to be pumped. The pump delivery end housing shall incorporate a thrust washer of suitable material at the shaft end to absorb up thrusts that occur during pump starting. Unless otherwise specified, the pump shall incorporate a delivery check valve of hydrodynamic shape fitted with a spring to prevent reverse rotation of the shaft from back flow of water through the pump. The pumps shall be provided with a flanged discharge connection suitable for operating against the pump closed valve head or 16 bar

whichever is the greater. The shaft coupling connecting the pump and driving motor shall be accurately machined and keyed to ensure precise shaft engagement and alignment. A strainer of suitable corrosion and abrasion resistant material, designed to guard against entry of foreign matter but permitting unrestricted flow of water into the pump, shall be provided on the pump suction housing.

Protection against the effect of sand shall be provided by renewable wear rings (made from a hard smooth flexible material such as polymethane) mounted at the seating of the impellers and the passages of the shaft.

The pump shall be designed to pump water having a sand content of up to 40g/m³, unless otherwise specified

A centralizer shall be fitted to every pump to ensure central alignment of the pumpset in the borehole casing.

7.2.2.2 Borehole Pumps Rising Column

Borehole rising column shall be seamless steel and provided in section lengths not exceeding 3 meters with flanged joints or screwed couplings according to API5L grade B or equivalent. The rising column shall allow for small deviations in borehole verticality. Cables and water level dip tubing shall be securely fixed to the rising column by straps or bands at approximately 2 meter intervals.

The rising column shall be sufficient to take the stresses generated by the hanging weight of the pump, motor and rising column, the stresses produced by the water pressure together with any dynamic stresses which may occur under any circumstances including valve closure.

The rising column shall be protected internally and externally in factory against corrosion by a non toxic epoxy resin coating (300 µm minimum thickness) suitable for use with potable water.

7.2.2.3 Borehole Pumps Headworks

A fabricated steel discharge head piece shall be provided at the top of the borehole to support the complete rising column and electro-submersible pumpset assembly, and shall be complete with lifting eye bolts. The discharge head piece shall comprise a heavy duty sealing plate arranged for bolting to the borehole outer casing flange, and a 90° discharge bend arranged for flanged connection to both rising column and horizontal surface pipework. Lifting eyes shall be provided in the sealing plate. A flange shall be provided and welded by the Contractor to the top of the borehole outer casing. The flange shall be suitably drilled to accommodate the discharge head piece sealing plate bolts. Holes shall be provided in the sealing plate to accommodate an air vent pipe, motor and control cables, water level dip tubing, etc. and shall include adequate sealing arrangements to protect against borehole contamination.

A 25mm diameter screwed removable plug shall be provided over the dip tubing for water level measurement with electrical contact tape. A stainless steel air vent pipe shall be

fitted to the discharge head sealing plate, terminating in an insect proof screen and arranged to prevent entry of rain or surface water.

7.2.3 **Booster pumps**

Pumps shall be end suction single stage vertical casing, base plate mounted directly coupled to motor through a heavy duty flexible coupling. The pump design shall ensure that alignment is maintained between the various assemblies by recesses, spigots and dowels and shall be such that components liable to wear can be replaced.

Casing shall be end suction volute type top centerline discharge self venting and arranged for back pull out. Disassembly shall not require disturbing either suction or discharge pipework or driver. Suction and discharge connection shall be flanged to DIN 2533 PN 16. Casing shall be foot mounted register fitted to bed plate to provide maximum resistance to misalignment and pipe loads. Tapped bosses shall be provided for suction and discharge pressure gauges connection and casing drain and vent.

Casing shall be high tensile strength close grain JL 1040 grey cast iron with smooth waterways and grey cast Iron GG wear rings. Casing shall be equipped with internally machined cast iron stuffing box to accommodate a minimum of 5 asbestos free packing rings and split removable Teflon lantern ring with cast iron split type gland

Impeller shall be gray cast iron JL 1040 enclosed end suction type free of surface imperfections and has close fit for quiet, smooth, efficient and stable operation without cavitation, pulsation, vibration or internal recirculation. It shall be fitted to shaft with key and locked in place.

Shaft shall be one piece tempering steel type C45 sized to have minimal deflection at face of stuffing box under maximum loading. Shaft sleeve shall be Chrome Nickel Molybdenum steel 1.4571, renewable type and positively driven by a roll pin pressed into shaft. A Teflon O ring shall prevent leakage between impeller and sleeve. Sleeve shall extend from the impeller through the stuffing boxes.

Shaft Bearings shall be mounted in heavy duty cast iron bearing frame with proper interference fit to provide precise alignment with casing. They shall be single row deep groove of robust construction and pressed on shaft. Bearings shall be protected from contamination by labyrinth rings. Grease fittings and grease relief fittings shall be furnished for each bearing.

Base plate shall be one piece heavy duty steel or cast iron construction to provide maximum assembly rigidity. Base plate shall be provided with drip rim, drain tapping, anchor bolt and grouting holes.

Flexible coupling shall be self aligning with EPDM or Neoprene sleeve and alloy flanges.

Coupling guard shall be of heavy gauge sheet metal, properly connected to base plate or bearing housing for maximum sturdiness.

Electric motor shall be squirrel cage induction type 380V/3ø/50Hz, 1500 RPM nominal speed, horizontal foot mounted tropicalized construction, TEFC / IP 55 enclosure, class F insulation and class B temperature rise, rated for 40° C ambient temperature.

Horsepower rating of motor shall allow continuous operation without overloading throughout pump operating range. Motor shall be able to deliver full rated output at voltages deviating up to 5% from rated value and at rated frequency. Only motors of the energy saving type with high operating efficiencies shall be used.

Motor junction box connections shall be properly marked according to international standards and allow star delta starting, it shall be equipped with earth lug terminal connected to motor frame. Motor Bearings shall be greased for life. Motor shall receive an anti corrosion treatment consisting of three coats of epoxy-urethane enamel protection.

Motor winding insulation shall be insensitive to moisture ingress and shall not allow microorganism growth.

7.2.4 Split Casing Pumps

Split casing pumps shall be designed to meet the following requirements:

- a- to give prolonged running at the required output under Site conditions
- b- to have a stable 'head-quantity' characteristic and show sufficient rise from the duty point to closed valve to avoid large changes of output with small changes of head
- c- to be suitable for use with a modified impeller which will give the required output against 110% of the specified head.

Drive motors shall be of sufficient power to suit the above requirements.

Waterways through pumps shall be smooth in finish and free from recesses and obstructions.

The pump casing shall be split in a plane through the shaft axis of the pump, enabling the shaft and impeller to be withdrawn from the pump without the need to disconnect the adjoining pipework and with the minimum disturbance of the drive motor.

The rotating element shall be statically and dynamically balanced before final assembly.

Pump bodies, bearing blocks etc., shall be cast iron.

Pump impellers shall be of gunmetal or cast iron and keyed to the shaft.

Pumps shall be fitted with substantial renewable impeller and/or casing eye rings. Impellers, greater than 200 mm diameter, shall be provided with substantial eyes to permit the future fitting of wear rings.

Pump shafts shall be of steel and fitted with stainless steel or equal renewable sleeves, where they pass through stuffing boxes.

Glands shall be fitted with conventional water lubricated soft packing. The water shall be taken from the pump discharge.

The shaft shall be fitted with grease lubricated ball and roller bearings, no thrust shall be transmitted to the drive unit.

Pumps shall be fitted with air release cocks at the highest point of the casing, and with a drain cock at the lowest point.

Copper or suitable plastic drain pipes shall be provided from the air release cock and the glands to a common tundish.

Horizontal pumps and their drive motors shall be mounted on a common cast iron or fabricated steel baseplate.

Drive couplings shall be of the flexible type.

Suction Compound and Delivery Pressure gauges shall be fitted to each pump. Each gauge shall be at least 150 mm diameter, be fitted with an isolating cock, and be graduated in meters head of water and bars gauge. The gauges shall be mounted on a common gauge board for each pump set.

7.3 VALVES AND ACCESSORIES

Provide labor, materials, equipment and services and perform operations required for the complete installation, testing and commissioning of all valves and accessories in conformance with the following and as described in related drawings.

7.3.1 General

Valve components shall comply with one of the international Standards institute requirements. (ISO, BSS, DIN). Manufacturer must have the ISO 9001 label of quality.

Valve castings shall be clean, close grain metal free from rough projections and porosity.

Screwed valves shall have hexagon reinforcements at threaded joints and ample shoulders to prevent over entry of pipes.

All valves to have the manufacturer Kite mark cast, heavily stamped or rolled on body.

Shut off valves shall be installed in suction and discharge branches of pumps and upstream and downstream of pressure regulating valves and shall be of same size as the branch pipe work where it is installed and of same free bore.

Shut off valves with nonmetallic discs shall be used where foreign material in piping system can be expected to prevent tight shut off of metal seated valve.

Non return valves shall be installed at discharge of each pump and whenever reverse flow is to be prevented. Non return valves shall be of same size as the pipe work where installed and flow area should be greater than pipe free bore for silenced operation but should allow valve to remain fully open at minimal flow.

Pressure control valves shall be sized to operate satisfactorily over all system flow range.

7.3.2 **Materials**

- a) The materials of Gate Valves; Globe Valves; Check Valves; Strainers; Butterfly Valves are described in section 5.4
- b) Solenoid valves

Shall be bronze body PN 16 minimal rating, bronze trim, silent coil fail close type, bronze bolted cap for easy maintenance, stainless steel stem, threaded NPT or BS 21.

- c) Pressure sustaining valve

The function of this valve is to maintain a minimum pressure in the pumps circuit when pumps are not operating in order to avoid operation at run out conditions.

The main valve shall be a hydraulically-operated pilot controlled, diaphragm type globe valve. The valve stem shall be guided at both ends by a bearing in the valve cover and an integral bearing in the valve seat. The main valve shall have a single removable seat and a renewable resilient disc. No external packing glands are permitted and the diaphragm must not be used as a seating surface and there shall be no pistons operating the main valve or any pilot control. The pilot control shall be a direct acting adjustable spring loaded diaphragm valve designed to permit flow when controlling pressure exceeds the spring setting. The valve shall be equipped with a strainer in its pilot circuit.

Valve body and cover shall be cast iron ATM A48, main valve trim shall be bronze ASTM B61 and pilot control system cast bronze ASTM B62 with 303 stainless steel trim.

- d) Pressure relief valve:

The function of this valve is to relieve excess pressure from the pump circuit when pressure level reaches a preset value as specified in the drawings. Valve construction shall be as standard norms and practice.

7.3.2.1 *Installation*

Do not use gate valves for throttling purposes. Use instead globe valves. Provide isolating valves in all branches whether shown on the drawings or not.

Install drain valves at all low points of water piping systems whether shown on drawings or not.

Whenever possible gate valves shall be installed upright and with enough room to easily operate the handwheel. Valves shall be installed in accessible locations to facilitate easy operation and maintenance.

Valve flanges should not be used to bring misaligned pipework into alignment or as supports.

Exercise care in installing threaded valves to avoid straining valve bodies. When threading a pipe to a valve, use a pipe stand or a second wrench to hold valve whilst pipe is being tightened. To avoid damage to seat never screw pipe too far into valve.

Use proper padding between wrench jaws and valve body before tightening in order to avoid deep denting the metal surface of the valve.

7.3.2.2 Submittals

Before placing orders, Contractor shall submit to the Supervisor for his approval complete hydraulic calculations where applicable for the selection of valves, complete technical data including but not limited to construction material, dimensions, manufacturer catalogues, mode of operation with installation details and time schedule for valves supply, installation, testing and commissioning.

7.4 PIPES & ACCESSORIES

Provide labor, materials, equipment and services and perform operations required for the complete installation, testing and commissioning of all pipes and accessories in conformance with the following and as described in related drawings.

7.4.1 General

Pipes and accessories supplied under this section shall comply with the requirements of section "PIPEWORK" where applicable.

All pipes shall carry the Kite Mark of the standard to which they are manufactured, clearly indicated at intervals as well as marked for origin, rating and size.

Only brand new pipes and fittings shall be supplied to site, pipes shall be free from rust, and without any signs of scaling, pitting or weathering to the satisfaction of the Supervisor.

Pipes shall have smooth surfaces free of dents, burrs and other imperfections with concentric bores. Threaded fittings shall have smooth surfaces free of porosity and undamaged clean rust free threads.

All pipework shall be supplied with varnished finish and each length must have at least one colored identification band when delivered.

Pipe fittings (Tees, elbows, crosses, reducers, union, flanges,.....) shall be of the same weight, type and quality as the pipes.

7.4.2 Materials

7.4.2.1 Black steel pipes and fittings

Black steel pipes shall be seamless steel suitable for butt welded connection, medium weight conforming to DIN 2440, BS 1387 medium class or equivalent international standard for steel pipes.

Flanges for black steel pipes DN 80 and above shall be cast iron weld neck type PN 16 minimum to DIN 2532 or cast steel weld neck type PN 16 minimum to DIN 2543 depending on mating equipment flanged connection.

Pipes DN 50 and above shall have black steel butt welded fittings to BS 1965. Elbows shall be long radius type except where instructed otherwise by the Supervisor or indicated on the drawings.

Pipes DN 50 and below shall have threaded connections with banded black malleable iron threaded fittings to BS 143 rated PN 16 minimum and shall bear the manufacturer name or identification.

7.4.2.2 Galvanized steel pipes and fittings

Galvanized steel pipes shall be ERW, medium weight conforming to DIN 2440, BS 1387 medium class or equivalent international standard for steel pipes.

Pipes DN 80 and below shall have threaded connections with banded galvanized malleable iron threaded fittings to BS 143 rated PN 16.

7.4.2.3 Ductile Iron Pipes and fittings

Ductile iron pipes and fittings shall comply with BS 4772 or European standard EN545. Pipes shall be class K9. Fittings shall be class K 12 or K 14.

Pipes and fittings shall have flanged connections to DIN 2533 PN16 unless otherwise specified or shown on the Drawings.

Contractor shall submit his design lay out for the installation for approval before ordering the flanged spools.

Pipes and fittings shall be given an external coating of zinc in accordance with BS 4772 and a finishing coat of either cold applied bitumen complying with the performance requirements of BS 3416 Type II material, or hot applied bitumen to BS 4147 Type I Grade C.

All pipes and fittings shall be lined internally with sulfate resistant cement mortar and shall comply with BS 4772.

7.4.2.4 Gaskets

Gaskets for flat face flanges shall be full face ring type with factory punched holes, 1.5 mm thickness, asbestos composition or rubber to DIN 2690.

Gaskets for raised face flanges shall be ring type to match raised face, 1.5 mm thickness, asbestos composition or rubber to DIN 2690.

7.4.2.5 Flexible Connectors

Shall be flanged PN 16 minimum with EPDM rubber bellows and mild steel zinc coated flanges.

7.4.2.6 Flanged adaptors

Please refer to sub-section 5.4

7.4.3 ***Installation***

Install dismantling joints like flanges and unions where necessary to ensure easy equipment maintenance. Install flexible connectors at suction and discharge of each pump.

Reduce sizes using reducing fittings. Change pipe directions by use of proper fittings like standard radius elbows or appropriate tees. Field fabricated or miter elbows, reducers and Tees are not allowed.

Galvanized steel sleeves shall be installed wherever pipes cross slabs, walls and floors.

No pipe entering a below ground or a water retaining structure shall be installed without having a puddle flange. Puddle flanges shall be an integral part of the spool piece crossing the wall.

Run pipes vertically or horizontally, avoid diagonal runs. Orient pipe runs to be parallel with walls, ceilings and columns. Always pitch piping to drain.

Do not install pipework in a way to obstruct equipment access, operation or maintenance.

Before installing any pipe, it shall be internally cleaned from dirt, debris and other foreign material by passing through a cleaning cloth or jetting with water.

Match equipment and valve flanged connections with flanges of similar rating, facing, drilling and thickness. Do not force equipment and valve flanged connections into alignment with connecting pipework using wrenches or crow bars. Alignment should be achieved by proper installation and not by using force. Flanged joints shall be flush and truly aligned. Properly align joints to maximum 1/16 inch misalignment tolerance before welding or jointing flanges.

Always clean flange and gasket faces before making a flanged joint. Discard any gasket that presents cuts, burrs and uneven surface. Tighten bolts in a staggered manner to achieve uniform gasket compression.

Bolts & nuts for flanged connections shall be Black steel to BS 4190. Length of bolts should be such that bolt tip protrudes 2 threads from face of nut. All bolts shall be tightened to the required torques in a sequential manner to ensure equal compression on gasket face.

All ends of pipes to be welded shall be cut square and uniformly beveled. Ends of pipes to be threaded shall be cut square, beveled and reamed to remove all burrs and then threaded.

All screwed joints shall be NPT or BSPT, use only one joint standard for all threaded fittings. Threaded Joints shall be made without use of burlap strings. Only Teflon with red oxide primer paint or an approved thread paste shall be used. Apply tape and thread compound on male thread only. Cut threads with new dies and remove burrs and chips with a wire brush.

When making threaded connections, use proper padding between wrench or vice jaws and pipes before tightening in order to avoid deep denting the metal surface of the pipes. Any pipework so damaged shall be removed from site at no extra cost to the Contracting authority.

All PVC fittings for drainage application shall be long sweep type. Straight TEES are not allowed. Only WYE and sanitary TEE are allowed for branch outs.

7.4.4 Submittals

Before placing orders, Contractor shall submit to the Supervisor for his approval complete hydraulic calculations for the selection of pipe sizes with the maximum operating pressures, pipes and accessories material and physical data, manufacturer literature, surface protection schedule, installation details and time schedule for pumps supply, installation, testing and commissioning.

7.5 SURGE SUPPRESSION EQUIPMENT

Provide labor, materials, equipment and services and perform operations required for the complete installation, testing and commissioning of surge suppression equipment in conformance with the following and as described in related drawings.

7.5.1 General

Surge analysis shall be undertaken by the Contractor if such analysis is considered necessary by the Supervisor who will instruct the Contractor to proceed once details of the Contractor's proposals have been submitted to the Supervisor. The analysis shall be carried out by a specialized sub-contractor in the field of hydraulic transient analysis and simulation.

The analysis shall show the transient pressures at the pumping station and at intervals of approximately 100m along the pipeline on pre-agreed time intervals showing minimum and maximum pressures with and without surge suppression devices. The analysis shall include the effects of a power failure occurring at any time during any sequence of operation.

Proposed surge suppression measures shall limit maximum pressures to permitted values and shall ensure that minimum pressures do not fall below atmospheric pressure plus 5.0m head. The Contractor shall, on completion of the analysis, submit his findings to the Supervisor for agreement on the protective measures, if any, to be taken. Charts and/or graphs shall be used to illustrate the conditions.

If possible, prevention of harmful pressures shall be by means of non-return valves with appropriate closing characteristics, bypasses or by other mechanical means.

If such simple measures are not effective in dampening the surges, surge vessels shall be used as specified below. Vessels may be either air water interface type with compressors to maintain the air volume or bladder type. For small installations a vessel with a flexible membrane and hand air pump may be used.

7.5.2 **Materials**

7.5.2.1 *Air water interface vessel*

A) Vessel

Vessel shall be designed and constructed to BS 5500, category 1, 2 or 3, post weld heat treated with a corrosion allowance of 1 mm. The vessel shall be cylindrical, Hot dip galvanized carbon steel to BS 729 with a median thickness of 85 microns (0.0034"), ERW welded with dished ends and mounted vertically on integral steel legs. The vessel shall be provided complete including the following:

- a) Access manhole with opening not less than 450 mm x 410 mm with EPDM rubber gasket or other material suitable for potable water application.
- b) Two way water connection flanged to DIN 2543 PN16.
- c) Drainage connection flanged to DIN 2543 PN16.
- d) Spring loaded safety valve;
- e) Ø 150 mm pressure gauge complete with isolating cock;
- f) Water level sight glass complete with metal protective shroud and isolating / blowout prevention valves;
- g) Air inlet fitting incorporating an air release valve, isolating and non-return valves;
- h) Level sensing devices complete with accessories.
- i) Access ladder if deemed necessary by the Supervisor
- j) Lifting lugs
- k) Nameplate

Surge vessel shall be designed to sustain the maximum surge pressures in the system with suitable safety factor.

B) Air Compressor

The air compressor shall be capable of filling the surge vessel to the design pressure within 30 minutes when vessel is only quarter full with water.

Air compressor shall be duplex (one duty one standby) belt driven oil free reciprocating type, cast iron construction, air cooled, mounted with motor on an air receiver via a base plate with slide rails for belt tension adjustment. A sheet steel guard shall be bolted to the base plate.

The Compressor shall deliver oil free air but may be of the oil lubricated type with oil trap / filter installed on the delivery side of the receiver. Each air compressor shall be fitted with a pressure relief/offloading valve for a no-load start under all conditions, fusible plug, check valve, isolating valve and a discharge side pressure gauge

Compressor air filter/silencer shall be of the dry media washable type enclosed in rugged filter housing.

Compressor shall be fitted with an air receiver of such volume to limit compressor starts to no more than 10 per hour. Receiver shall be of welded steel construction with a corrosion allowance of 2 mm and shall have integral supporting feet to allow housekeeping.

Receiver fittings shall include a pressure gauge, pressure safety valve and manual drain valve. Pressure switches shall be installed on the receiver to control the compressor start/stop sequence

Receiver shall be piped to the pressure vessels through independent galvanized steel pipework of suitable dimension fitted with a solenoid valve. The solenoid valve shall control air delivery to the pressure vessel through the signals sent by the level control sensors installed on the vessel.

7.5.2.2 Bladder type vessel

Vessel shall be constructed of mild steel generally in accordance with BS 4814 and BS 5169 and as per ASME section VII Div. 1. Tank shall have enamel or epoxy coating for long term corrosion protection. It shall be horizontally mounted on integral steel legs

Vessel shall be provided with following:

- a) Access manhole with opening not less than Ø 450 mm with EPDM rubber gasket or other material suitable for potable water application.
- b) Removable heavy duty Butyl rubber bladder.
- c) Flanged inlet / outlet assembly consisting of check valve, by-pass throttling plate and isolating valve. Flanges shall be to DIN 2543 PN16.
- d) Ø 150 mm pressure gauge complete with isolating cock;
- e) Spring loaded safety valve;
- f) Air fill valve
- g) Access ladder if deemed necessary by the Supervisor
- h) Lifting lugs
- i) Nameplate

Surge vessel shall be designed to sustain the maximum surge pressures in the system with suitable safety factor.

7.5.3 **Installation**

Where space is available the surge tank and associated equipment shall be installed within the pumping station building. Where space is not available the tank shall be located on a concrete plinth outside the building. All associated equipment shall be indoors. Suitable measures shall be taken against the possibility of damage due to freezing where tanks and pipework are located outside the pumping station.

Make sure compressor air intakes are unobstructed and are away from exhaust fans intakes. Install compressor receiver on a housekeeping pad with rubber isolators to cut on vibration and noise transmission.

Galvanized pipework at outlet of receiver shall be equipped with flexible connector. Install compressor to allow easy maintenance and accessibility to all parts.

7.5.3.1 **Submittals**

Before placing orders, Contractor shall submit to the Supervisor for his approval complete surge simulation for the selection of appropriate surge protection devices, equipment operating and physical data, manufacturer literature, surface protection schedule, installation details and time schedule for surge prevention equipment supply, installation, testing and commissioning.

7.6 **EQUIPMENT AND PIPEWORK SUPPORTS**

Provide labor, materials, equipment and services and perform operations required for the complete installation of all pipework and equipment supports in conformance with the following and as described in related drawings.

7.6.1 **General**

All floor mounted equipment shall have adequate concrete housekeeping bases equipped with anchor bolts and other accessories as per manufacturer recommendations and the Supervisor's instructions. Bases to extend a minimum of 100 mm beyond equipment in any one direction and 100 mm above finished floor.

Provide structural steel stands to support equipment not floor mounted or hung from structure

Support piping and associated valves independently of equipment to prevent piping weight or stresses from bearing on equipment connections.

7.6.2 **Material**

a) Structural supports

Structural support shall be of concrete or steel material.

b) Fasteners and anchor bolts

Anchor bolts for supports shall be heavy duty steel rawl bolts of an approved design and compliant with international standards.

All steel bolts, nuts, screws, washers and other fixings for anchoring equipment and pipe supports to walls, floors and ceilings, that may come in contact with water or are installed in damp locations or externally fixed shall be of stainless steel, cadmium plated mild steel or other corrosion resistant material or shall have a protective surface treatment subject to the approval of the Supervisor.

All bolts in inaccessible positions shall be secured by either self-locking nuts, spring washers and nuts, or castle nuts with split pins. Fasteners associated with items requiring removal during routine maintenance shall be of stainless steel. All other items shall be sheradized or hot dip galvanized in matched condition.

All holding-down or foundation bolts shall be supplied and shall be complete with hexagon nuts and washers. Bolts of steel round bar formed into a loop at one end are not acceptable.

Anchor bolts for the fixing of small items shall be of the torque-expanded type of approved make, installed strictly in accordance with the manufacturer's instructions. The size of hole required in the civil work shall not exceed 38mm.

Where the bearing structure (concrete or masonry) will not withstand the expansion stresses imposed by the torque-expanded type or where the highest degree of resistance to vibration is required an approved type of chemically bonded anchor bolt may be used.

The minimum distance from any concrete edge shall be 100mm for expanding type fixings and 75mm for embedded bolts.

7.6.3 Installation

Fix supports to structure with expansion bolts of proper size and at suitable intervals without causing overstress to the structure. Follow manufacturer instructions as to proper drill bit size to use, expansion bolt spacing and size.

Bolted flanges may be used to secure pipework to supports on condition of using properly contoured connection plates and bolts of convenient size.

Main line branch out connecting to the surge tank shall be properly anchored to prevent horizontal and vertical movement.

After fixing supports or equipment with anchor bolts, the minimum engagement of the anchor bolt thread shall equal the thickness of the nut. The projection of the thread beyond the outer face of the nut shall not exceed one quarter of the outside diameter of the thread. In no circumstance shall galvanized or coated bolts be shortened by cutting.

Washers shall be provided for all nut and bolt fasteners.

7.6.4 **Submittals**

All supports must be submitted for approval with necessary calculations and drawings when requested by the Supervisor. Contractor shall submit for approval support material, loading scheme, supports location, welding and surface treatment methods

7.7 **PAINTWORK**

This work shall consist of painting equipment and civil works as per requirements below and the Supervisor's instructions.

7.7.1 **General**

All coatings applied to any part of the plant in contact with water to be used for drinking, washing or cooking shall be non-toxic, non carcinogenic, shall not impart taste, odor or turbidity to the water or foster microbial growth.

Paint all components, parts, members and surfaces as shown on the drawings, as required by the specs and following the Supervisor's instructions.

The whole preparation and paint system shall be suitable for the operating environment specified and a painting schedule giving details of preparatory treatment, types of paint, number of coats and method of application shall be submitted with the Tender. (See Particulars of Plant.)

Proprietary items may be used in their standard finish subject to the approval of the Supervisor. For specified applications, adequate supervision shall be provided for all stages of preparation, application and testing.

All steelwork shall be protected in accordance with BS 5493 and based on a 'long' time to first maintenance.

7.7.2 **Materials**

a) Primer paint

Corrosion prevention primer paint for ferrous surfaces shall be zinc chromate of first quality.

b) Finish paint

Finish paint for ferrous surfaces shall be oil based paint. Paint color shall be as shown on the drawings or per Supervisor's instruction.

Protective epoxy paint shall be solvent-free heavy abrasion resistant applied after epoxy primer. Solid content shall be minimum 57% by volume and total DFT not less than 140 micron.

The above shall not relieve the Contractor to supply specific paint types other than those mentioned and which may be necessary to be used for specific applications

7.7.3 **Execution**

Follow manufacturer recommendations for surface preparation and application procedures for paints and finishes.

Thoroughly clean surfaces requiring primer painting of rust, loose scale, oil, grease and dirt by the use of wire brushes, solvent and other required means. Obtain The Supervisor's approval before starting base coats. Do not paint on damp surfaces or during wet and cold weather. Spread and brush paint evenly to eliminate drips, runs or sagging.

Fill voids, open or hollow places and irregularities with compound whenever working on wooden or masonry surfaces. Dressing equipment surfaces is not allowed without prior approval of The Supervisor.

Always apply 2 coats of primer paint unless instructed otherwise by the Supervisor.

Always apply 3 coats of finish paint or more till satisfactory surface finish is reached unless instructed otherwise by the Supervisor.

Wait for previous coat to dry before applying second coat.

Unless instructed otherwise the Contractor shall keep all paintwork till the end of construction activities. The finishing coat of paint shall be applied after completion of all electrical, mechanical and sanitary installations.

Thoroughly clean and retouch damaged or dirtied shop coat surfaces. Do not paint controls, nameplates, labels, wires, cables and electrical fixtures. Do not prime coat galvanized piping and metal parts.

Upon completion of paintwork clean windows glass, handles, floors, electrical accessories and all other paint spattered surfaces.

Color coding of surfaces inside pumping station shall be as follows

- Factory painted equipment: Keep original color
- Equipment not factory painted: Grey
- Structural frames and supports: Black
- Water Piping: Navy blue

7.7.4 **Submittals**

Contractor shall prepare for the Supervisor's approval a submittal including a schedule of colors to be applied, samples of the paint showing the brand, quality and color in closed original container cans, manufacturer technical literature and methods of paint application.

7.8 CONCRETE BASES

Works under this sub-section shall comply with the requirements of section "Concrete works".

The Contractor shall furnish the necessary materials and construct suitable concrete or other foundations for all equipment installed by him even though such foundations may not be indicated on the drawings.

The tops of foundations shall be at such elevations as will permit the installation of approved neoprene pads or grouting in accordance with the recommendations of the equipment manufacturer and to the satisfaction of the Supervisor.

All such equipment shall be installed by skilled mechanics and in accordance with the instructions of the manufacturer.

In case pumps concrete bases are to be poured, the Contractor shall prepare a template to the exact dimensions of the bedplate complete with the approved anchor bolts and rigidly fix it to the concrete reinforcement at the required depth before pouring concrete.

In case the Supervisor requires pocket holes only to fix the anchor bolts at a later stage with epoxy mortar, the Contractor shall fix properly sized wood box outs to the template at the exact location of the anchor bolts, all to the Supervisor's requirements and manufacturer recommendations.

In setting pumps, motors, and other items of equipment to be grouted, the Contractor shall use approved non-shrinking grout under the equipment bases unless otherwise approved. Shims used to level and adjust the bases shall be preferably galvanized steel. Shims may be left embedded in the grout in which case they shall be installed neatly and so as to be as inconspicuous as possible in the completed work.

Grout shall be mixed and placed in accordance with the recommendations of the manufacturer. Where practical, the grout shall be placed through the grout holes in the bases and worked outward and under the edges of the base and across the rough top of the finished foundation.

Where such a procedure is impracticable, the method of placing grout shall be as approved. After the grout has hardened sufficiently, all forms, hoppers, and excess grout shall be removed and all exposed grout surfaces shall be patched in an approved manner and, if necessary, given a burlap-rubbed finish, and painted with three coats (300 microns minimum) of an approved paint.

7.9 NOISE AND VIBRATION

All rotating parts of the machinery shall be statically and dynamically balanced unless otherwise agreed in writing by the Supervisor. The complete rotating assembly shall be designed such that equipment rotational critical speeds are outside the duty running speed range of the machine.

Equipment shall run without undue vibration and with the least practicable amount of noise.

Vibration levels shall not exceed those set out in ISO 2372 for the particular type of equipment and application.

The noise level generated at the site boundary by any new equipment shall not exceed that generated by any existing equipment of the same nature and service.

7.10 TAGGING AND LABELING

Contractor shall supply a framed P&ID diagram for the pump station to be permanently fixed in a prominent location in the pump station as per the Supervisor instructions. This diagram shall have the prior approval of the Supervisor.

All pipework, equipment, valves and electric panels shall be properly identified using directional arrows and color coding for pipes, engraved bakelite or brass tags for equipment and valves. Tagging should conform with drawing markings and tagging system shall be submitted to the Supervisor for approval.

Instruction plates, nameplates and labels shall be provided for all items of the plant giving particulars of duty, size, serial number and full information for identification and operation. Their construction and engraving shall be to the Supervisor's approval.

Any components requiring manual lubrication shall be provided with greasing nipples of an approved type mounted on a panel and identified.

The Contractor shall make provision for all grease and oil required for testing the Works.

The first filling after tests shall be provided by the Contractor who shall submit for approval details of his recommended lubricants available from any of the major oil companies.

7.11 LUBRICATION

Any components requiring manual lubrication shall be provided with greasing nipples of an approved type mounted on a panel and identified.

The Contractor shall make provision for all grease and oil required for testing the Works.

The first filling after tests shall be provided by the Contractor who shall submit for approval details of his recommended lubricants available from any of the major oil companies.

Contractor shall submit in the O&M manuals a lubrication schedule stating the different types of greases applicable and the lubrication intervals required for each installed equipment.

7.12 FIRE EXTINGUISHERS

Shall be carbon dioxide 9 KG capacity made of hard drawn steel cylinder with hard scratch resistant enamel finish with color as per international fire regulations color code for CO2.

Pull pin squeeze handle discharge valve with full vision pressure gauge, high strength braided hose and non-conducting discharge cone.

7.13 SPARE PARTS

All following equipment shall be supplied with 3 years spare parts as recommended by the manufacturer.

- Pumps
- Valves
- Surge prevention equipment
- Electric panels

Contractor shall submit to the Supervisor for approval the spare parts list together with the equipment.

8. ELECTRICAL, INSTRUMENTATION AND CONTROL WORKS

8.1 GENERAL

The Electricity Supply Authority of Lebanon (EDL) will be requested to provide reliable secure and adequate power supply to the site. This supply may not be made during the period of the Contract and the availability of electrical power supplies cannot be guaranteed. The Contractor shall provide all necessary temporary power supplies, by use of mobile generators or otherwise, for the purposes of construction, connection, installation, testing and commissioning of the works.

The Contractor shall be deemed to have included in his tender for the provision of all necessary temporary electrical power supplies.

The electricity supply in Lebanon is nominal 380 V/3 Ø/50 Hz. The voltage may vary $\pm 15\%$ and equipment shall be rated to withstand this variation.

Power will be brought to the site by EDL either at 15 kV or 380 V, where the supply is at 15 kV a transformer will be installed by EDL. The Contractor shall provide all cabling and wiring from the transformer or from the EDL cut outs at the metering location. Buried cables within the station shall be routed in underground ducts.

Electrical installations and equipments shall be conforming to I.E.C. standards or equivalent.

8.2 POWER DISTRIBUTION BOARD

A power distribution board shall be provided for the equipment to be installed in the pump station in case the existing one does not have allowance for extra distribution feeds. The board shall have, as applicable, feeds to the Motor Control Center and other building services as needed or requested by the Supervisor.

The primary distribution panel shall be located as much as possible near the existing one. It shall be either wall mounted or free standing as appropriate to its rating and size. The board shall incorporate door mounted ammeter and voltmeter, with a voltmeter phase-phase and phase-neutral selector switch.

Where the EDL transformer is not in a building or where the incoming EDL supply to the site is at 380 Volts, an earth fault relay shall be incorporated in the main distribution board to trip out the incoming supply under earth fault conditions.

The primary distribution board shall include an incoming section with facilities for connection of a standby generator. When a generator is provided it will be a mobile unit brought to site as required with a flying lead to the distribution panel. An opening 200 x 200mm with a hinged steel door shall be provided at low level in the external wall of the room of the building housing the power distribution board. The incoming section shall incorporate an interlocked mains/standby supply, manually and automatically operated, changeover switch. "Mains supply available" and "standby supply on" indicator lights shall be provided on the panel face.

8.3 MOTOR CONTROL CENTER (MCC)

8.3.1 **General**

The manufacturer of the MCC shall be responsible for the design, manufacture and factory testing of the panel detailed in this sub-section of the Specifications.

The manufacturer shall supply all drawings showing the construction and wiring diagrams as per the operation description set out in these specifications.

The MCC shall house the starters and controls necessary for the satisfactory operation of the pumps as well as the auxiliary power necessary for the electrical services inside the pump station if required.

Branch circuit breakers and other earth fault protection devices shall be coordinated with MCC main breaker.

Motor Control Center shall be installed on a level concrete pad that will provide full stability.

MCC shall be installed such that all door compartments can be freely opened and access to the compartments unhindered.

8.3.2 **Materials & installation**

8.3.2.1 *Enclosure*

The MCC shall be of the multi-cubicle floor standing type made from folded and welded mild steel sheet not less than 2mm thick. Alternatively of welded angle iron framework supporting mild steel panels of not less than 1.2 mm thick or of a proprietary sectional modular system construction to similar standards.

Removable lifting eyes shall be provided for each section. MCC shall be designed to comply with BS 5486/1990 – Form 4 BS EN 60947 and shall have damp and dust protection to BS 5420 IP 54.

Welding were required shall be continuous and ground flush for net appearance. Surface treatment shall be hot dip galvanized finished with one coat primer and one coat stove enamel internally and externally.

MCC shall be arranged for front access only with top entry. Manufacturer shall provide sufficient space and a removable gland plate for all incoming and outgoing power and control cables.

Enclosure shall consist of six cubicles each with an individual lockable door to be interlocked to the cubicle circuit breaker which must be in the OFF position before door can be opened.

All external fittings such as door hinges and handles and cover fixing screws shall have a non corrodible finish of a matching type to give a neat overall appearance.

All enclosure doors shall be properly earthed with coiled earth wires solidly connected to a screw welded to the door.

8.3.2.2 *Busbar*

Shall be 98% pure electrolytic copper based on a maximum temperature rise of 40° C over an ambient of 50° C. Busbar shall be enclosed in a separate fully shrouded compartment not accessible from inside the cubicles and rigidly braced to withstand a symmetrical rms short circuit current equal to main breaker interrupting capacity. Busbar shall withstand the stated fault current for a period of 1 second and shall carry 125% of the rated full load current of the main breaker continuously without damage or overheating. Current density shall not exceed approved standards.

Branch copper Busbars of adequate capacity shall distribute power to each starter circuit breaker served. Connections to Busbar are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance. Contact surfaces are to be electro-silver plated.

Neutral and Earth copper Bus bars shall be rated at half capacity of main Busbar and distributed throughout whole MCC. Neutral bus shall be connected to earth bus with removable links.

Power supply shall be 380V/3ø/50Hz.

8.3.2.3 Wiring and terminations

All control wires connecting to electrical components shall be terminated with indent compression type lugs, pin, spade or bootlace eyelets as appropriate. Bare undressed ends are not allowed.

Control wires connecting to components located on cubicle doors shall be properly bundled, strapped and enclosed in a flexible plastic sheath. Each bundle shall not exceed 20 wires. Connecting control wire shall be of the flexible type.

Plastic trunking inside the cubicles shall not be filled to more than 50% of their volume. All cable entries and terminations shall be accessible and clearly marked to correspond with the panel wiring and external connection diagram.

Adequate space shall be provided between the main isolator terminals and the gland plate to enable the cables to be correctly positioned and terminated.

All cubicles shall be equipped with suitable terminal lugs on DIN rails. Sizes of terminal

Lugs shall be no smaller than 2.5 mm². All wires and cables entering a compartment whether from a device external to the MCC or from an adjoining compartment shall be terminated at interposing terminal lugs.

Control wires shall be 1.5 mm² PVC sheathed and black color. Control wiring shall be separated from power wiring.

Control circuits shall operate at no more than 110V.

8.3.2.4 Labeling and tagging

All control wiring and power conductors inside the panel shall be tagged at each end using numbered ferrules according to the submitted wiring diagrams.

All electrical components like breakers, contactors, relays, shall be properly labeled as per wiring diagram.

All outside mounted components as push buttons, pilot lights, selector switches etc... shall be tagged with incised letters on black bakelite with white laminated core. Labels are to be permanently fixed under each component and for identification of MCC and each cubicle. Tagging schedule and samples of each kind shall be submitted to The Supervisor for approval.

MCC shall have an inner pouch for keeping the wiring diagrams.

8.3.2.5 MCC description

1) Compartment: Incoming section consisting of:

- MCCB with door interlock mechanism.
- Manual transfer switch contactor type.
- Auxiliary power MCCB.
- Electrical power Meter.
- Earth leakage relay.
- Under / Overvoltage relay.
- Phase failure relay.
- Current transformers.
- Enclosure light.
- Anti-condensation heater with thermostat.
- Fan with filter.

The front door of the compartment shall include the following:

- Interlock padlockable power shut off handles (2)
- Voltmeters (3)
- Ammeter with selector switch (1)
- Frequency meter (1)
- Power factor meter (1)
- Grid power transfer push button
- Emergency power transfer pushbutton
- Fault reset pushbutton
- Grid power ON pilot light
- Emergency power ON power light
- Power supply Fault pilot light

2) Compartments for Pumps each consisting of:

- MCCB with door interlock mechanism
- Star Delta starter closed transition type
- Phase sequence relay
- Phase failure relay
- Undercurrent relay
- Current transformers
- Anti condensation heater with thermostat

The front door of each compartment shall include the following:

- Interlock padlockable power shut off handle
- Voltmeter with selector switch
- Ammeter with selector switch
- Run hour meter
- H.O.A selector switch
- Start push button
- Stop push button
- Fault reset pushbutton
- Pump ON pilot light
- Pump OFF pilot light
- Fault pilot light

3) Compartment: spare.

4) Compartment for controls circuits consisting of:

- MCB
- Control transformer
- Sequence control relays and timers (see section II.1.A.1 for operation description)
- Alarm horn
- Anti condensation heater with thermostat

The front door of the compartment shall include the following

- Duty sequence selector switch
- Pumping cycle start pushbutton
- Pumping cycle stop pushbutton
- Emergency shut off push button
- Low water level pilot light
- Low pressure pilot light
- Fault pilot light
- Reset pushbutton
- Test pushbutton

The size of all power components (MCCBs, contactors) shall be determined by the Contractor depending on the design and the final pump motor ratings.

The control section shall house all relays, timers and other necessary devices to provide the required sequence of operations and interfaces.

The above description of the MCC components content is only for indication purposes. MCC shall incorporate all necessary breakers, starters, contactors, push buttons, selector switches, relays, timers, pilot lights, interlocks, wiring, and other devices for an automatic and manual operation as per requirements of the specifications and the Supervisor.

8.3.2.6 *Circuit breakers*

Shall comply with IEC 60947-2 and shall be Molded Case Air Brake fixed type utilization category B, with magnetic/thermal or electronic adjustable protection for each pole, manually operated for normal switching and automatically operated under short circuit and overload conditions. Overload protection shall be inverse time delay ambient compensated. Breaker short circuit interrupting capacity to be greater than system bolted short circuit capacity.

Breakers shall have quick make quick break non welding silver alloy contacts with effective arc quenching cooling plates. Breakers above 225A rating shall have interchangeable and adjustable electronic trip units.

Main Breaker shall be suitably equipped to provide earth fault protection through a built in device or through an earth leakage relay.

Ratings of circuit breakers serving electric motors are nominal design values and must be checked and readjusted, if needed, by contractor to conform to the motor actual power and rating as recommended by pumps manufacturer.

Circuit breakers shall be equipped with padlockable door interlock mechanism.

8.3.2.7 Manual transfer switch

It shall consist of two mechanically and electrically interlocked AC3 category contactors mechanically held on both line and generator side. Interlock mechanism shall positively prevent the load from being simultaneously energized by normal and emergency power.

The MTS shall be operated manually through push buttons located on the MCC.

8.3.2.8 Contactors

Contactors shall be indoor triple pole double air break pattern, non welding silver alloy contacts with arc quenching devices, silent replaceable coils. Contactors shall comply with IEC 61095, IEC 60947-4-1, IEC 60445.

All contactors shall be rated for uninterrupted duty and intermittent duty class 12 with on-load factor of 60%. Utilization category shall be no less than AC3.

Rated operational voltage shall be no less than 440V AC and rated insulation voltage shall be no less than 660 V AC. All contactors shall be of the block type with built in silver alloy NO / NC auxiliary contacts and shall be capable to receive additional modular auxiliary contact blocks as required by wiring diagram.

Contactors shall be suitable for DIN rail installation.

8.3.2.9 Overload relays

Each motor starter shall be complete with an adjustable triple pole indirectly heated differential type thermal overload relay type 3c as defined in clause 4.7.2 of IEC 60947-4-1 with ambient temperature compensation and manual reset. Motor overloads for reduced voltage starters shall measure phase current and not line current and shall be in circuit during run up and normal operation.

Overload relays shall have silver alloy auxiliary NO / NC contacts as required by wiring diagram.

8.3.2.10 Control Relays

To be multi-pole with NO / NC contacts, replaceable magnetically held silent electric coils operated. Contacts to be double break silvered tip, interchangeable from normally open to normally closed without additional parts, rated at 10 A, 600V.

Relays are equipped to take additional auxiliary blocks as required by wiring diagram.

Relays shall be suitable for DIN rail installation.

8.3.2.11 Push Buttons

Shall comply with IEC 60947-5-1, one unit momentary contact with NO / NC contacts as required by wiring diagram and with lockout attachments. They shall be of \varnothing 22 mm with colors of buttons complying with IEC 60073.

Emergency stop pushbuttons shall be of the latched type and shall have a mushroom type pushbutton. They shall be connected in control circuits so they are effective under all plant operating conditions. Resetting of the pushbutton shall not automatically re-energize the equipment.

8.3.2.12 Pilot lights

Shall be comply with IEC 60947-5. Lens color shall comply with IEC 60073 unless otherwise specified. Pilot Lights be of \varnothing 22 mm and their lenses shall be easily removable. Bulbs shall be of the incandescent type to operate at no more than 90% of their rated voltage.

8.3.2.13 Analogue indicating instruments

Shall be of the moving iron or moving coil and fixed magnet type suitable for 50Hz power supply. They shall have an accuracy of class 1.5 except for frequency instruments where it shall be 0.5 at 40°C ambient temperature. The maximum rated voltage shall be 500V. Instrument range shall be 1.4 times the rated value being measured. Ammeters shall have red pointers or markers to indicate rated motor current.

Case shall be made of magnetic sheet metal and other parts shall be termite and fungus resistant and shall be self-extinguishing and shock resistant. Enclosure protection shall be IP 52. Case size shall be 96x96 mm.

Fixing to the panel shall be through two brackets located at opposite case corners.

Indicating instruments shall comply to IEC 60051 and IEC 61010.

8.3.2.14 Control transformer

Shall be of the double wound type with 110 volts secondary. The transformer rated output shall not be less than 20 percent greater than the total standing load. The combination of the inrush VA of the largest contactor plus the total hold-in VA of all devices shall not result in the transformer secondary voltage falling below 80 percent of its rated value.

Control transformers shall be provided with primary and secondary winding protection devices.

Float switches should be connected to a 110 V control circuit. It is not allowed to use a 220 V supply.

8.3.2.15 *Current transformers*

Shall comply with IEC 60044-1 and shall be of the wound primary or bar-primary type according to the ratio required. CT shall have a short time current rating of no less than that of the switchgear in which they are installed.

CTs shall be class 1 accuracy for use with measuring instruments and class 5P for use with protective relays.

The secondary winding of each CT shall be earthed at one point only via a bolted link. Separate CTs shall be used for metering and protection.

8.3.2.16 *Anti condensation heaters*

Individual compartments shall be provided with anti-condensation heaters. Heaters shall be rated to ensure that condensation does not occur under all conditions of ambient temperature and relative humidity. Heaters shall be provided with thermostat and individual protection.

Anti condensation heaters shall be mounted as low as possible in enclosures and shall be located to ensure free air flow over the heating element and to have no detrimental effect on temperature sensitive devices or adjacent cabling.

8.3.3 **Submittals**

Design and installation drawings for MCC are to be submitted for approval prior to ordering materials and equipment. Drawings and material submittals to include:

- Design drawings and load calculations.
- Complete technical data including catalogue cuts for circuit breakers, contactors, motor starters, protection relays, timers, voltmeters, ammeters and all other components installed in the MCC.
- Power and control wiring and termination diagrams for MCC.

The Supervisor shall witness the factory test before shipping MCC to site.

8.4 **LOW VOLTAGE A.C. MOTOR STARTERS**

8.4.1 **General**

Motor starters shall be combination type as defined in and complying with IEC 60947-4.

Motor starters shall be of the electromagnetic non latching type.

Unless otherwise specified, motor starters shall be suitable for uninterrupted duty.

Motor starters shall comprise contactor and fused switch or molded case circuit assemblies providing Type 2 short-circuit coordination. The protective device, contactor and overload relay combination shall have undergone and passed all the tests specified for full Type 2 coordination in accordance with IEC 60947-4-1.

Coordination with the short circuit protective device (SCPD) shall be Type 2 as defined in Clause 7.2.5 of IEC 60947-4-1 for the prospective short-circuit current. For this purpose the SCPD shall be fitted with the maximum rating of motor circuit fuse.

Thermal overload relays shall be Type 3c as defined in Clause 4.7.2 of IEC 60947-4-1. Time current characteristics shall be supplied by the Manufacturer on 28 mm x 56 mm logarithmic decades. These curves shall have a tolerance not exceeding $\pm 10\%$.

8.4.2 ***Standard Facilities For Motor Starters***

Each motor starter protection, control and indicating facilities shall include but not be limited to the following.

Each motor starter shall be housed in a separate compartment and be completely isolated by means of an isolating switch interlocked with the door or cover to allow access only when the switch is open. The isolating switch shall be operated by means of an external handle and shall have provision for padlocking in the "OFF" position. When in the "ON" position, interlocks shall prevent the unit door being opened. Any components still live after this switch has been opened shall be adequately shrouded and have warning labels attached thereto.

All motors rated up to 30kW shall be protected by adjustable triple pole direct acting thermal relays providing overload and single phase protection. The relays shall be hand reset and ambient temperature compensated.

Motors in excess of 30kW and up to 100kW shall be protected by electronic relays providing ambient temperature compensated thermal overload, stalling, and single phasing, and earth fault protection.

For motors rated in excess of 100kW, electronic overload/earth fault relays shall be provided, which shall be programmable to provide:

- Thermal overcurrent protection, providing protection against overload, repeated starting, and stalling.
- Phase unbalance/single phase protection.
- Earth fault protection.
- Undercurrent protection.

All protection relays shall be hand reset and ambient temperature compensated.

Short circuit protection shall be provided by the fully coordinated operation of the starter integral HBC fuses or molded case circuit breaker.

All fault conditions relevant to each mode of operation shall stop the drive and prevent it re-starting until the particular fault is cleared and individually reset; lock-out relays and a reset button being provided for any self-resetting devices such as excess torque switches etc.

Motor starters shall be equipped with the following controls and indications:

- Start and stop push-buttons.
- Running, stopped and fault indicator lights.
- Control selector switches providing HAND/OFF/AUTO or LOCAL/REMOTE to suit the drive control requirements.
- Indicating ammeter and hours-run meter for motors in excess of 10kW or as otherwise specified.
- Emergency stop push button.

Hours-run meters shall be of the non-resettable cyclometer type indicator having a flush fascia and driven by a synchronous motor connected to show the hours (up to 99,999.9) run by the main motor. They shall incorporate visible indication of operation but need not necessarily be of the same bezel size as the instruments.

Motor starters shall be provided with the following voltage-free changeover contacts wired to terminals:

- Run.
- Stop.
- Fault.

Additional contacts shall be provided as specified.

Provision shall be made to enable control circuits to be tested with the main circuit supply isolated.

Where control and interlock circuits are broken via plugs and sockets on withdrawable type starters, one interconnecting lead shall be provided for each size and type to facilitate testing in the withdrawn position.

Where the starter is to be remotely controlled by a remote terminal unit (RTU), interposing relays with 24 volt DC coils complete with back EMF suppression diodes shall be provided in each starter unit to facilitate remote control and watchdog capability.

8.4.3 **Control Circuit**

All control circuits shall operate at not more than 110V and be derived from a double wound, screen earthed isolation transformer with one side of the secondary winding connected to neutral/earth. The primary supply shall normally be from one phase to neutral if available.

Individual transformers shall be provided for each starter but sequenced groups of starters having a common isolator shall use a common control transformer.

Fuses shall be provided on each primary and secondary supply and be clearly labeled and segregated. A link shall be fitted in the neutral/earth connection.

The control circuit and the main supply must be isolated before opening the cubicle door but provision shall be made to re-energize the control circuit when the main supply to the cubicle

is isolated, so that the operation of the control gear may be inspected without energizing the motor. The necessary control circuit Normal/Test switch shall be mounted within the cubicle and so arranged that it is not possible to close the door with this switch in the 'Test' position.

The motors in some applications will be required to operate in a predetermined sequence and starters should include suitable auxiliary relays and contacts.

Each plant control panel shall contain a multiple cam contact timer housed in a separate clearly labeled compartment. The timer shall have sufficient contacts to provide as minimum one per starter plus 25 percent spare.

The timer shall allow drives to restart in a predetermined staggered sequence under both automatic and manual (hand) control following a failure of power supply and its restoration.

Each contact shall be fully adjustable between 0 and 30 minutes.

8.4.4 Direct-On-Line Starters

Direct-on-line (full voltage) ac starters shall be air-break electromagnetic switching devices complying with the recommendations of IEC 60947-4-1.

Direct-on-line starters shall be rated for uninterrupted duty and intermittent duty class 12 with on-load factor of 60% and utilization category AC-3.

The rated operational voltage (U_e) shall be not less than 440 V ac and the rated insulation voltage (U_i) shall be not less than 660 V ac.

The rated operational current (I_e) shall be not less than the full-load current of the motor. The rated operational power shall be entered in the Technical Schedule.

Thermal overload relays shall be Type 3c as defined in Clause 4.7.2 of IEC 60947-4-1. Time current characteristics shall be supplied by the Manufacturer on 28 mm x 56 mm logarithmic decades. These curves shall have a tolerance not exceeding $\pm 10\%$.

Starters shall be suitable for both automatic and non-automatic methods of control. When opening by overload relay involves energizing an auxiliary relay from the control supply, the pick-up voltage of this auxiliary relay shall be below the drop-out voltage of the contactor.

The rated control supply voltage (U_s) shall be equal to the nominal voltage of the ac system. The rated control circuit voltage (U_c), and frequency if ac, shall be entered in the Technical Schedule.

Test certificates shall be supplied for the following type and special tests to IEC 60947-4-1:

- Temperature - rise limits
- Dielectric properties
- Operation and operating limits
- Rated making and breaking capacities

- Performance under short-circuit conditions
- Conventional operational performance
- Ability of contactors to withstand overload current
- Special test to verify discrimination between the SCPD and overload relay in accordance with Clause B4 of Appendix B of IEC 60947-4-1.

Short-circuit tests shall be certified by ASTA, KEMA or PEHLA or other approved authorities.

The following routine tests shall be carried out on all starters to IEC 60947-4-1 and test certificates shall be supplied:

- Operation test
- Dielectric tests

8.4.5 **Star-Delta Starters**

Reduced voltage (star-delta) ac starters shall be air-break electro-magnetic switching devices complying with the recommendations of IEC 60947-4-1.

Star-delta starters shall be closed transition incorporating automatic change-over with adjustable time delay.

Star-delta starters shall be rated for uninterrupted duty and intermittent duty class 12 with on-load factor of 60%.

The rated operational voltage (U_e) shall be not less than 440V ac and the rated insulation voltage (U_i) shall be not less than 660 V ac.

The rated operational current (I_e) shall be not less than the full load current of the motor. The rated operational power shall be entered in the Technical Schedule. The transition current shall be not less than the motor current attained at the end of the starting period.

Thermal overload relays shall be Type 3c as defined in Clause 4.7.2 of IEC 60947-4-1. Time current characteristics shall be supplied by the manufacturer on 28 mm x 56 mm logarithmic decades. These curves shall have a tolerance not exceeding + 10%.

Starters shall be suitable for both automatic and non-automatic methods of control. When opening by overload relay involves energizing an auxiliary relay from the control supply, the pick-up voltage of this auxiliary relay shall be below the drop-out voltage of the main contactor.

The rated control supply voltage (U_s) shall be equal to the nominal voltage of the ac system. The rated control circuit voltage (U_c), and frequency if ac, shall be entered in the Technical Schedule.

Test certificates shall be supplied for the following type and special tests to IEC 60947-4-1.

- Temperature - rise limits

- Dielectric properties
- Rated making and breaking capacities
- Change-over ability
- Operation and operating limits
- Performance motor short-circuit conditions
- Conventional operational performance
- Ability of contactors to withstand overload current
- Special test to verify that closed transition resistor will withstand the starting current for the transition time.
- Special test to verify discrimination between the SCPD and overload relay in accordance with Clause B4 of Appendix B of IEC 947-4-1.

Short circuit tests shall be certified by ASTA, KEMA or PEHLA or other approved authorities.

The following routine tests shall be carried out on all star-delta starters to IEC 60947-4-1 and test certificates shall be supplied:

- Operation tests
- Dielectric Tests
- Phase sequence at Motor terminals

8.4.6 ***Auto-Transformer Starters***

Reduced voltage (two-step auto-transformers) AC starters shall be air-break electromagnetic switching devices complying with the recommendations of IEC 60947-4-1.

Auto-transformer starters shall be series closed transition incorporating automatic change-over with adjustable time delay. A three-phase air cooled autotransformer with tappings at 65%, 75% and 85% shall be built-in to each starter.

Auto-transformer starters shall be rated for uninterrupted duty and intermittent duty class 12 with on-load factor of 60%. The rated operational voltage (U_e) shall be not less than 440V ac and the rated insulation voltage (U_i) shall be not less than 660V ac.

The rated operational current (I_e) shall be not less than the full load current of the motor. The rated operational power shall be entered in the Technical Schedule. The transition current shall be not less than the motor current attained at the end of the starting period.

Thermal overload relays shall be Type 3c as defined in Clause 4.7.2 of IEC 60947-4-1. Time current characteristics shall be supplied by the manufacturer on 28 mm x 56 mm logarithmic decades. These curves shall have a tolerance not exceeding $\pm 10\%$.

Starters shall be suitable for both automatic and non-automatic methods of control. When opening by overload relay involves energizing an auxiliary relay from the control supply, the

pick-up voltage of this auxiliary relay shall be below the drop-out voltage of the main contactor.

The rated control supply voltage (U_s) shall be equal to the nominal voltage of the ac system. The rated control circuit voltage (U_c), and frequency if ac, shall be entered in the Technical Schedule.

Test certificates shall be supplied for the following type and special tests to IEC 60947-4-1:

- Temperature - rise limits
- Dielectric properties
- Rated making and breaking capacities
- Change-over ability
- Operation and operating limits
- Performance under short-circuit conditions
- Conventional operational performance
- Ability of contactors to withstand overload current
- Special test to verify that auto-transformer will withstand starting current for the starting time (T_s)
- Special test to verify discrimination between the SCPD and overload relay in accordance with Clause B4 of Appendix B of IEC 60947-4-1.

The following routine tests shall be carried out on all auto-transformer starters to IEC 60947-4-1 and test certificates shall be supplied:

- Operation tests
- Dielectric tests
- Voltage of tapplings
- Phase sequence at motor terminals.

Short-circuit tests shall be certified by ASTA, KEMA or PEHLA, or other approved authorities.

8.4.7 **Stator/Rotor Starters**

Where separate stator and rotor cubicles are provided, a key interlock shall be fitted to prevent access to the rotor cubicle unless the stator isolating switch is in the Open or Earth position.

Rotor resistances shall have suitable interlocking facilities to prevent operation of the starter switch until all sections of rotor resistance are in the starting condition.

The resistor enclosure shall be ventilated to IP41 and a thermostat shall be incorporated to trip the starter if the resistance overheats due to excessive use or mal-operation.

Rotor resistances may be metal or liquid material as specified to suit the drive characteristics. Metal resistors shall consist of rustless unbreakable resistor grids which may be readily replaced. Where tiered banks of resistors are provided, it must be possible to readily remove from the front any section without disturbing any other section of the resistance bank.

Liquid or derived vapor resistors shall have the electrolyte contained in leak-proof containers and incorporate means of restricting evaporation and detecting loss of electrolyte.

8.4.8 ***Electronic Assisted Starting***

Starters for specified squirrel-cage induction motors shall incorporate a solid state device designed to provide a smooth acceleration up to the motor's rated speed.

The acceleration time shall be adjustable by means of control settings provided to enable optimum maximum starting current and torque as well as initial threshold starting current and torque to be selected.

The starting current of the largest motor shall be limited as specified.

Where specified to reduce system shocks, provision shall also be made for motor stopping under controlled deceleration.

a- Protection:

The thyristors shall be protected by high speed semi-conductor fuses and heat sink thermal cut-outs.

The device shall shut down in the event of single phase loss or open circuited thyristors.

In the event of short circuited thyristors, the drive shall continue to run at full voltage by automatically transferring to an override condition.

b- Indications:

Alarm indications shall be provided for each of the above faults.

An auxiliary relay shall be used to control the function of the main contactor.

c- Energy Saving Facility:

For continuous running drives, an energy saving control shall be provided where the voltage applied to the motor is automatically matched to the actual power demand. The control shall be effective after run-up and a dwell time at full voltage has been allowed to enable the motor load to stabilize.

The device shall respond immediately to any sudden load changes to prevent a potential stall condition.

8.4.9 ***Frequency Converters***

The motor speed control shall be a frequency converter of an approved type and manufacture, providing a variable frequency output of adequate capacity to drive the specified motor over the specified speed range and suitably matched to the starting torque and the speed torque characteristics of the driven plant. (Details to be determined by the Contractor from the driven plant/motor manufacturer during the Contract.)

The converter unit with the associated control electronics shall be housed in a steel, free standing, drip protected (IP21) panel, mounted in the position specified. The unit shall be suitably air-cooled by means of an integral fan and all the components within the unit shall be readily accessible for easy servicing and removal without disturbing other components. Chassis units shall be suitable for rack mounting.

The incoming supply shall be via an isolator interlocked with the panel door and have suitable fuse protection.

The drive unit shall be capable of operating with the motor disconnected for test purposes.

A current limiting circuit shall be incorporated to give short circuit and overcurrent protection in the output circuit, and undervoltage detection shall be incorporated to protect the drive against fan failure. A thermostat shall be fitted for protection against fan failure and overheating.

a- Harmonics:

The unit shall be protected from any harmonic distortion or switching surges in the power supply system and incorporate contactors to automatically isolate the input and output and to protect the unit from component damage arising from a power supply interruption which shall, if necessary, include automatic shutdown. If the converter will not perform correctly when running from a specified Standby generator an interlock shall be provided to prevent such operation.

To prevent distortion of the supply system wave form (and dependent instrumentation), harmonic voltage and current distortion introduced into the mains supply by the drive unit shall be within the limits specified in Electricity Council Supervising Recommendation G5/3. The point of common coupling shall be regarded as the output connections of the first upstream transformer.

The supplier shall list with the offer the expected harmonics generated by the drive under running conditions (worst case).

Where an input filter is used to limit the harmonic currents, the design shall minimize the possibility of resonance with any power factor correction capacitors fitted.

The supplier shall include any shielding necessary in accordance with BS 800, to prevent any interference that may affect other surrounding instruments.

b- Monitoring and Control:

The control of each variable drive unit shall normally be from a PLC outstation which will provide a start/stop facility and a 4-20mA speed control signal. Where the distance between the drive unit and PLC exceeds 20m, special care shall be taken to ensure radio frequency interference and distortion are kept to a minimum.

The following signals will be required from the drive unit and wired to clearly marked terminals:

- Common fault (motor overload, emergency stop operated etc)
- Control status indicating Hand/Off/Auto
- Control 'on'
- Motor available
- Motor running
- RS 232 Serial Interface (where required by the specification).

The following items shall be included along with other control devices and instrumentation:

- Control potentiometer for speed setting on hand control, (scaled with linear graduations over the range and arrows indicating clockwise rotation to 'INCREASE SPEED' and anti-clockwise rotation to 'DECREASE SPEED');
- Output ammeter;
- Frequency/speed meter;
- Test and fault diagnostic card for circuit checking, having a front of panel display and facility for serial link remote indication.
- Isolated inputs for 0-10/4-20mA auto control, start/stop, external reset, etc.
- Adjustments for ramp up/down, duration, frequency range, base/maximum speed, current limiting facility and economy mode.

The following items shall be monitored for fault conditions:

- Phase failure
- Earth fault
- Overcurrent
- Over voltage
- High temperature/fan failure
- DC link fuse failure

8.5 CABLES & WIRES

Power supply connections to vibrating or rotating machinery shall be made through adequate metallic flexible conduits or tubing through which cables and wires shall be drawn.

At least 200 mm of free conductor is to be left at each outlet, switch point and pull box for making up joints, connections. Wires shall be continuous from one outlet to another and no splice shall be made except within outlet and junction box.

Directly burying cables in concrete or screed below floor tiles is prohibited. Joints or splices shall not be accepted on main and sub feeders.

Single cables and bunched wires are to be drawn in galvanized or rigid plastic conduits. where two or more cables are run in parallel, they are to be fixed on covered cable trays or on approved special cable supporting and protecting arrangement.

All cables and wires entering junction or connection boxes shall use properly sized glands.

All cable terminations shall be done using appropriate termination lugs. All cable splices shall be done using appropriate splicing tools.

It is forbidden to reduce a conductor cross section by cutting strands to make it fit into lugs.

All cables running outside conduits shall be clearly tagged every ten meters.

8.6 ELECTRIC ACTUATORS

8.6.1 *General*

Electric actuators shall be suitable for outside installation and all components shall be housed in waterproof enclosures to IP67 or better, which shall incorporate an anti-condensation heater.

The whole actuator shall be of easily maintained, robust construction and shall be sized to guarantee the penstock or valve opening or closing at the maximum differential pressure specified herein. The operating speed shall be approximately 300mm/minute unless otherwise specified.

All actuator component items shall be coupled via flanged mating faces secured by stainless steel bolts, except valve mounting fixings subject to thrust forces which shall be by means of suitably sized, high tensile steel bolts.

The gearbox shall be of the worm gear totally enclosed, oil bath lubricated type, having a cast iron enclosure suitable for operating at any angle and provided with the appropriate filling and drain plugs. The actuator drive bushing shall be easily detachable for machining to suit the valve stem or gearbox input shaft and the length of the drive nut shall not be less than 1.25 x the spindle diameter.

The drive shall incorporate a lost motion feature to provide the additional torque required to unseat the valve from the "Open" or "Closed" position in the event of the valve being in either position for an extended period. This movement shall give a hammer blow of sufficient force to free the valve.

The output shaft shall be hollow to accept a rising spindle where appropriate, and incorporate thrust bearings of the ball or roller type. The design shall preferably permit the gear case to be opened for inspection without releasing the spindle thrust or taking the penstock/valve out of service.

8.6.2 Motors

All motors fitted to actuators shall be specially designed for the application and of the squirrel cage induction type for operation from the Power supply system of 220 VAC \pm 5%, 50 Hz.

The rated output of the motors shall be determined by the tenderer in relation to the requirements of the mechanical plant described elsewhere in this specification, and starting torque shall be at least 10% in excess of maximum service requirements. The intermittent running load factor shall be 25% in accordance with VDE 530.

The motors shall preferably be 4 pole 1440 revs/minute machines designed with adequate thermal capacity to ensure that the actuator and starter can adequately perform, without overheating, the number of successive opening and closing operations, in no case shall this number be less than three.

Each motor shall be fitted with a thermostat or thermistor per phase arranged to stop the motor in the event of dangerously high temperature in the motor windings due to overcurrent or an abnormally high number of starts per hour.

8.6.3 Manual Operation Interlock

The actuator shall have a handwheel for manual operation which will be at standstill during motor operation. A lever shall be provided for engaging the handwheel drive, and this shall be interlocked so that when starting the motor the handwheel is automatically uncoupled without danger to the operator. Provision shall be made for the lever to be padlocked in either position to prevent hand or motor operation as required.

8.6.4 Position Monitoring

A mechanical position indicator, showing the open, closed or intermediate positions of the valve on a visible dial, shall be incorporated in the actuator housing. Alternatively, where specified, a continuous position indicator shall be provided.

Remote position indicators, where specified, shall be controlled from a suitable potentiometric drive arranged to provide a continuous proportional signal from "Open" to "Closed" positions.

8.6.5 Position Control

Where specified for control purposes, a current position transmitter shall be provided to give a positive 4-20mA signal proportional to the valve position, and shall incorporate zero and span adjustments to suit the actual valve travel.

8.6.6 Torque and Limit Switches

All switches shall be accommodated within the actuator housing and all contacts and mechanism shall be of sealed, rustproof and robust construction and have a self-cleaning

wiping action. Adjustable torque limiting devices and switches shall be provided to trip the starter in the event of mechanism overload due to obstructions or jamming etc. They shall be mechanically latched to prevent torque tripping during unseating.

Adjustable limit switches shall be arranged to trip the starters when the 'fully open' or 'fully closed' positions are reached. Should the manufacturer consider it desirable (to ensure proper seating) the travel may be stopped in the "fully closed" position by the torque limit switches, but in this case the 'fully closed' limit switches shall still be provided, although they will be adjusted to be inoperative.

The actuator shall be equipped with two independent torque limit switches operating in both rotational directions.

8.6.7 Auxiliary Switches

Two adjustable auxiliary switches shall be provided. They may be used for remote controls or indications monitoring the "Open" and "Closed" positions.

8.6.8 Terminal Facilities

All electrical components shall be wired out to terminal blocks in a common terminal chamber incorporated in the actuator housing but separated from all actuator components by means of a watertight seal.

Each terminal shall be labeled to correspond with the diagram of connections and shall be capable of accommodating not less than 2.5mm² copper conductors. AC and DC terminals shall be clearly segregated.

Terminal blocks shall comprise shrouded anti-tracking moldings of melamine phenolic or comparable material with provision for securing conductors by screw clamp connectors or other approved vibration-proof devices.

The terminal chamber shall be provided with three tapped conduit entries, 1 x 32mm ET and 2 x 25mm ET or as otherwise specified. These holes shall be plugged with suitable plugs during transit and storage to prevent ingress of moisture or foreign matter.

Any conduit entries not used after cabling is completed shall be plugged with threaded aluminum blanks and the threaded joints made watertight by using suitable tape or jointing compound.

8.6.9 Starters and Control Gear

Where motorized valves are installed far from pumping stations or reservoirs and the provision of a control panel is impractical, the actuator motor shall be controlled through integrally mounted electrically and mechanically interlocked contactors, rated for switching the motor direct-on-line, adequate for the duty requirements and complete with all necessary auxiliary contacts for the functions specified herein.

The control circuit shall operate at 24V DC derived from a suitably rated transformer/rectifier with one side of the secondary winding connected to earth or as otherwise specified. Primary and secondary windings shall be protected by cartridge type fuses.

The method of control and operation shall be as called for in the PS and the actuator shall be provided with any facilities called for therein to suit the method of control, whether this be automatic or by hand. Local controls integrally mounted on the actuator shall consist of push buttons for 'Open', 'Close' and 'Stop' functions, together with a Remote/Off/Local selector, lockable in all positions. The "Stop" button shall be effective in both local and remote settings and operate directly in the contactor control circuit.

Local and remote status indications (ON, OFF, FAULT, CLOSE, OPEN) shall also be provided.

Facilities by means of volt-free contacts shall be provided for remotely monitoring:

- i) motor running
- ii) actuator is available for remote operation
- iii) actuator opened and actuator closed.

Wherever motorized penstocks and valves are specified, they shall be provided with adequately rated starters. The starter shall be integrally housed within the actuator in a robustly constructed, totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.

The starter housing shall be fitted with contacts and terminals for power supply, remote control and positional indication, and shall also be fitted with internal heaters to provide protection against damage due to condensation. Heaters shall be suitable for single phase operation. The heaters shall be switched to "ON" when the starters are "OFF" and shall be switched "OFF" when the starters are "ON".

Starters for motorized actuators shall be equipped with a thermal overload relay and unless otherwise specified, starters shall include an integrated controller (PLC) with an RS 422/485 output allowing remote operation and data acquisition through a twisted pair bus.

8.6.10 ***Paint Finish***

The finish color shall be full gloss, Crimson, Color No. 540 to BS 381C (or 04 D 45 to BS 4800).

8.6.11 ***Actuator Isolators***

Unless otherwise specified, motorized actuators shall have an isolator switch. The switch shall have a slow make and break mechanism of the two position rotary pattern arranged to isolate the 3 phase supply and all other control circuit supplies to the actuator. The isolator rating shall be based on the actuator average load current being switched normally off-load, but emergency on-load.

Each switch shall be incorporated in a heavy duty, hose-proof, cast aluminum enclosure to IP65, having external fixing lugs and adequate seals and drip shields on the operating shaft and cover. Austinlite rotary type EXO 190 or equal.

Switch positions shall be 90° apart, clearly and permanently inscribed or embossed as 'OFF' and 'ON' on the cover, and the switch handle shall incorporate provision for the switch to be padlocked in both the 'OFF' and 'ON' position. The 'OFF' position to be to the left of center or vertical, the 'ON' position to the right or horizontal.

It shall be possible to remove the switch cover for access to the terminal without disturbing the switch or its mounting base. The enclosure shall be suitable for mounting on, or adjacent to, the penstock pedestal. If mounted on the penstock pedestal, cabling between the isolator and the actuator above may be arranged through conduit connections, suitable for disconnection should it be necessary to remove the actuator assembly complete.

(This item preferably to be provided by the contractor who is responsible for the cabling.)

8.7 STANDBY GENERATING SET

8.7.1 General

The Contractor shall supply, install and connect a standby emergency diesel generating set with all necessary switchgear, controls and accessories for the supply of electric power.

Generating set shall be a complete package unit mounted on a rigid base suitable for skidding with the radiator mounted integrally with the set.

The Contractor shall indicate the nearest locations from which service facilities and spare parts may be obtained.

8.7.2 Operation of generator set

This section describes the operation of generator set.

The generating set shall start automatically if the voltage of one or more phases of the normal supply to the changeover switch remains below an adjustable level (setting 60-90% from rated) for an adjustable period of time (setting 1 to 60 seconds). An adjustable time delay control (setting 5 to 50 sec.) shall be provided controlling changeover contactors after rated voltage and frequency are available on the generator.

It shall be possible to operate the set manually for testing and normal operation purposes.

8.7.3 Engine

The engine shall be diesel; water cooled, of the naturally aspirated, turbo-charged or charged cooled version, four strokes, direct injection

Lubrication shall be full pressure by gear type pump with full flow filters with replaceable elements. An oil temperature stabilizer, strainer and a relief valve shall be fitted.

Fuel injection shall be enclosed in-line fuel injection pump or pumps with diaphragm type fuel lift pump. Full flow filters with replaceable elements shall be fitted.

Engine equipment shall include mainly the following:

- a) An engine governor of the electronic speed sensing type.

- b) An electric starting motor for operation on DC volt.
- c) Cooling-engine shall be radiator-cooled with belt driven pusher fan, coolant pump, thermostat temperature control, liquid-cooled exhaust manifold, engine mounted inter cooler cooling system.
- d) Positive displacement, mechanical lubrication oil pump, lubricating oil cooler, full flow relubricating oil filters and dipstick oil level indicator.
- e) Primary water separators and secondary fuel filters with replaceable elements, and an engine driven, mechanical, positive displacement fuel pump, all mounted on the engine, replaceable dry element air cleaner.

A length of flexible exhaust pipe shall be supplied connected to the exhaust manifold. Exhaust system shall be included in the installation cost.

8.7.4 Engine control panel and protective devices

The engine control panel shall incorporate an oil pressure gauge, coolant temperature gauge, battery charge rate ammeter, RUN-STOP-REMOTE selector switch, level gauge for the bulk fuel tank and engine monitoring system.

The engine monitoring system shall be provided, shutdown for high Coolant Temperature and Low Oil Pressure; shutdown for over speed, shutdown for overcrank, lamps test switch.

8.7.5 Coupling system

Coupling shall be a system of Unit Construction which forms the Engine and generator into one unit of exceptional strength and ensure perfect alignment.

The generator end shield and the engine flywheel housing faces shall be fully machined with spigots concentric to their shafts. The machined flange mounted alternator shall be connected to the flywheel housing by steel bolts.

A flexible rubber block coupling shall be fitted between the engine-generator to provide the drive and absorb the transmission of shock loads.

8.7.6 Alternator

Shall be brushless, salient pole, revolving field self regulating alternator.

The alternator shall be of fabricated steel construction throughout with ball and roller bearings, a dynamically balanced rotating field, salient pole construction with heavy damper windings. The machine shall have an A.C. exciter and liberally rated silicon diode assembly with a self-contained excitation system with transistorized automatic voltage regulator (A.V.R.) and an efficient cooling system using a centrifugal fan. It shall be screen protected and drip proof with a large terminal box for outgoing cable connections.

The alternator shall be provided with a main moulded case circuit breaker of rating as recommended by the manufacturer.

8.7.7 Engine-Generator control

Engine-generator control shall include the following components and devices for each unit:

1. Indicating lights for the following alarms:
 - a. Overcrank lockout - red.
 - b. Low oil pressure prealarm and shutdown - red.
 - c. Overspeed shutdown - red.
 - d. High water temperature alarm lamp only - red.
2. Alarm to sound whenever an alarm light is lit, and an acknowledge switch to silence alarm
3. LCD digital read out for engine oil pressure, coolant temperature RPM, system DC volts, running time meter.
4. All devices indicated for use with automatic transfer switch shall be wired to terminal blocks.
5. Engine control switch, "Remote-Off-Run" for automatic start-stop from the transfer switch, mutual engine startup and shutdown.
6. Control relays, sensing equipment, switchgear protective relays and devices and start, stop and shutdown controls are to be provided as necessary for operation specified. Generating set, instruments, protection and controls are to be mounted preferably in one control cubicle.
7. Instruments and controls are to include at least the following:

Voltmeter and 7-position selector switch, ammeter and 4-position selector switch, frequency meter, off/test/manual/auto duty switch, manual start and stop push-buttons, kilowatt-hour meter, power factor meter, service-hour running counter, cool-down time setting controls.

Illuminated indicator panel with LEDs at least for low oil pressure, high water temperature, over-speed, fail-to-start, generator overload, generator on load, lamp test push-button, indicating gauge and low level fuel alarm, alarm sounder and reset controls, anti-condensation heaters.
8. Generator instrument and/or control cubicles are to be set mounted, preventing transmission of vibration to the components. Cubicles are to be sheet steel construction, ventilated indoor type, vermin and dust-proof, (IP 42 to IEC 144), with lockable hinged doors and instrument panels, separate compartments for control devices, protective relays, circuit breaker(s) and neutral earthing device. Wiring is to be modular, with connections made at front terminal blocks with no live conductors exposed.
9. Instruments are to be housed in enamelled metal cases for switchboard flush installation, with scales and markings protected and sealed. Indicating meters are to

be digital type. KWh meter are to be 3-element type for unbalanced 3-phase, 4-wire loads, fitted with 6-digit cyclometer.

8.7.8 ***Diesel-generator set***

- a) Set is to basically consist of diesel engine, brushless synchronous generator with direct flexible coupling to engine. Governing is to be electronic type.
- b) In the automatic mode the set is to start and stop automatically by a signal sensed through an auxiliary contact in the automatic transfer switch. The set is to stop, after an adjustable cool- down period (2 - 30 minutes).
- c) Should engine fail to start following a start impulse, the system is to come to rest for few seconds. Two further starting attempts are to be automatically made with intermediate 20 seconds maximum period of rest. Should the set fail to start after three attempts, an alarm is to sound and a 'start failure' signal illuminate. Hand operation is to be possible for testing or normal operation through a test/manual/off/auto selector switch.
- d) Engine is to be compression-ignition type with direct solid-injection, turbo-charged, water cooled, with air-cooled radiator, 2 or 4-stroke cycle, 1500 rpm, operating on No. 2 diesel oil, suitable for direct coupling to driven machine. Flywheel is to be suitably sized for type of service and constraints specified, and capable of being rotated at 125% of rated speed without failure.
- e) Engine is to be water cooled with gear- driven water pumps. System is to be pressurized, with heavy duty tropical radiator cooled by reverse flow fan. Fan cowl and hand protection guard are to be fitted. Coolant temperature is to be controlled by one or more thermostats. Set mounted instruments are to include, at least, water temperature gauge, lubricating oil temperature gauge and pressure gauge, tachometer and running time meter.
- f) Any obstructions in path of cooling air flow (louvers, mesh, ducts, etc.) are not to reduce air flow below that needed at full rated output. Fan and radiator characteristics are to be selected accordingly. Advise and provide at no extra cost, additional booster fans as required with necessary control gear for automatic operation.
- g) Lubricating oil system is to be pressurized circulating type with full flow filters and replaceable elements and lubricating oil heat exchanger.
- h) Fuel system is to have injection pump and injectors. Engine is to have integral, gear type, engine driven transfer pump to lift fuel and supply it through filters to injection pump at constant pressure. Fuel filter elements are to be easily replaceable.
- i) Exhaust system shall include flexible exhaust fitting, properly sized and installed according to the manufacturer's recommendation. Exhaust pipe shall have sufficient size to ensure that exhaust back pressure does not exceed the maximum limitations specified by the generator set manufacturer.

A clearance hole shall be allowed where exhaust pipe passes through to avoid overheating of the surrounding wall.

- a) Engine starting is to be manual by push-button or automatic through control system at control panel. System is to consist of heavy duty d.c. starter motor, heavy duty battery and battery charger. Cranking motor and battery are to be rated for cranking the engine when cold and at lowest temperature recorded. Starting pinion is to automatically disengage when engine fires. Batteries are to be lead-acid, sealed-in-plastic type.
- b) Battery charger is to be 25% over-rated, solid state, full-wave rectifier type, adequate to fully recharge depleted battery in not more than 8 hours and to automatically control rate of charge. Ammeter is to be provided to indicate charging rate, which is to be adjustable.
- c) Protective system is to comprise automatic engine shut- down and generator trip with visual and audible alarm in event of over speed, low lubricating oil pressure, high cooling water temperature and over cranking. Governor over speed trip is to automatically close fuel pump racks in event of engine over speed. Device is to be separate and independent from governing mechanism.
- d) Generator is to be synchronous, low reactance, high efficiency, revolving field type, with brushless exciter and flexible coupling, sized to pick up effective load without exceeding transient and steady-state voltage deviation limits specified up to its full nominal rating. Phase leads are to be brought out fully insulated to a terminal cable box of heavy gauge sheet steel, protection IP 43.
- e) Basic set characteristics are as follows:

Number of phases	: 3
Rated voltage, frequency	: As per drawings at 0.8 P.F, with 10% overload for one hour every 12 hours.
Winding connection	: reconnectable
Unbalanced load current	: 30% minimum
Voltage regulator	: automatic, with readily accessible controls for voltage level
Insulation	: class F for stator, class F for rotor and exciter
Enclosure	: drip proof (IP 23 to IEC144)
Cooling	: built-in centrifugal fans

- f) Overall voltage deviation within normal speed variations is to be within limits specified from no-load to full-load, from hot to cold and with load power factor from 0.8 lagging to unity. Total harmonic content is not to exceed 5% and that of one harmonic not to exceed 2%. Voltage regulator is to be solid state utilizing silicon semi-conductor devices in control and power stages, with built-in electro-magnetic interference suppression and designed for single or parallel operation.

- g) Armature is to be 3-phase, directly mounted to generator shaft and connected to generator field windings through six solid state, hermetically sealed, silicon rectifiers, accessible for maintenance or repair.

8.7.9 ***Automatic transfer switches***

Automatic Transfer switch shall be remotely actuated with the possibility of operating as automatic or manual transfer switch if the user wishes to.

Transfer switch shall be contactor type (AC-3) and shall be rated to carry 100% of rated current continuously in the enclosure.

The complete transfer shall be enclosed in a nonventilated IP40 enclosure for installation indoors. The enclosure shall contain a swingout service panel and a key operated door lock.

The transfer switch shall be mechanically held on the line side and mechanically and electrically interlocked to positively prevent the load from being simultaneously energized by normal power and emergency power.

Colored indicating lights shall be provided on the enclosure door and labeled to indicate transfer switch position (green: normal source; red: emergency).

Push-Button switch shall be provided which, when operated, retransfer load to line. The switch shall override time delay on retransfer, if used, and stop engine unless time delay on stop is employed.

Voltmeter - alternator side, ammeter - alternator side, frequency meter - alternator side. Running time meter - alternator side shall be provided.

8.7.10 ***Base frame construction***

The combined engine-generator unit shall be bolted to a separate sub-frame which will be attached to a main frame through RESILIENT MOUNTINGS so providing complete protection from engine vibration for the control gear, radiator and other set mounted components. Mountings under the set will not be considered.

Base frame shall have four lifting points.

8.7.11 ***Storage, daily fuel tanks and fuel lift pump***

Bulk fuel storage tanks shall be located as indicated by the Supervisor.

The tanks shall be manufactured in accordance with BS 799: Part 5 and fabricated from mild steel plate of 5 mm minimum thickness with ends dished and flanged, electrically welded throughout and spatter removed. Galvanized materials shall not be used.

Each tank shall be provided with the following features:

- a) A 480 mm dia. raised manhole with a gasketed 8 mm thick bolt on cover;
- b) Fuel contents gauge;

- c) BSP threaded male bosses for filling, venting, outlet, drainage and overflow connections;
- d) Provision for cleaning out the tank;
- e) Tank full warning alarm float and suitable boss.

The fuel outlet shall be at least 90 mm above the drainage cock and preferably at the opposite end of the tank. The fuel supply line shall incorporate a mesh type filter, not coarser than 120 mesh, together with a weight operated, automatic fire shut-off valve located within the bund wall. The tank shall be positioned with a fall to the drainage cock.

Isolating valves shall be fitted within the bund wall to the outlet and drainage connections.

A daily fuel tank with sufficient fuel capacity for at least 8 hours operation on full load shall be provided, in a suitable location in the room or under the engine. A dial type fuel gage, fuel filter inlet and outlet connections, drain plug and all feed and return fuel pipe will be fitted to the tank complete with hose for filling purposes.

An electrical and manual fuel lift pump shall be supplied and installed near the daily fuel tank to lift fuel automatically or manually from the bulk storage tank to the daily storage tank. Necessary float switches to operate lift pump shall be provided.

8.7.12 **Generator earthing**

Generator frame shall be connected to the equipment earthing system through a separate equipment earthing conductor. In addition a local electrode might be required if generator is appreciably remote from the main electrical room. Neutral and frame of generator shall not be bonded except in the case of local neutral grounding as mentioned above.

8.7.13 **Miscellaneous requirements**

- a) Day tank construction is to be closed steel, inclined at least 3 degrees from horizontal and fitted with drain plug, inlet and outlet pipe connectors and breather pipe. Day tank instruments are to include float switch, solenoid valve and dial-type level indicator to give alarm on over-fill and low-level.
- b) Day tank filling pumps is to be provided and connected to the underground fuel tank. Pump is to be electrically and manually operated, automatically started and stopped, installed on piping system between storage tank and day tank. Starter with thermal overload protection and circuit breaker for short-circuit protection are to be provided. Operation is to be interlocked with float switches in day tank. All necessary check valves, by-pass valves, float valves and maintenance valves are to be provided.
- c) Fuel line is to be heavy gauge, black steel. Size of fuel return line from day tank to storage fuel tank is to be to manufacturer's recommendations. Filling line of fuel tank is to be as recommended by manufacturer, entering tank at opposite end to drain plug.

8.7.14 **Testing**

- a) Fully assembled plant or equipment is to be tested at the factory. Complete performance tests are to be carried out under site simulated conditions, in accordance with the relevant Standards
- b) Load tests are to be carried out at low loads to overload conditions, at various power factors. Measurements are to include voltage and frequency deviations and regulating time under various step loading conditions. Tests are to include:
 - Full load test for 8 hours continuous, immediately followed by
 - 10% overload test, without interruption,
 - Insulation measurement,
 - Functional tests for voltage sensing, automatic start, transfer of load,
 - Operation of engine shut-down and alarm signaling and indication, under simulated fault conditions.

8.7.15 **Submittals**

- a) General description and characteristics of engine- generating sets, standards with which components comply, site rating and overload capability, overall efficiency, and fuel and lubricant consumption at 100%, 75%, 50% and 25% of rated load.
- b) Description of engine; type, model, manufacturer, fuel and lubricating oil types, starting conditions and starting periods from cold to full-load pick-up, governor and response characteristics due to sudden load changes.
- c) Dimensions, weights and forces, mounting methods, vibration protection etc.
- d) Battery type, make, charge/discharge characteristics, capacity, Battery charger
- e) Fuel tanks, pipes and accessories
- f) Control instruments, protection, alarms, cut-outs, indicating lamps, instruments

8.7.16 **Spare parts**

The Contractor shall provide spare parts for one year of operation.

8.7.17 **Guarantee**

Provide one year warranty for equipment specified in this Section. Provide an annual maintenance contract, available after substantial completion of the work, covering routine service and emergency service by trained employees, and to ensure supply of necessary standard spare parts.

8.8 INSTRUMENTATION

8.8.1 *Pressure Measurement*

8.8.1.1 *Pressure Gauge*

Pressure gauge shall be of the Bourdon tube or diaphragm type. Each gauge shall incorporate a surge-damping device and be fitted with its own stainless steel isolating cock.

Pressure gauge shall be constructed with stainless steel case and bezel.

Case shall be equipped with rear blowout plates to protect the operator in the event of the Bourdon tube rupturing due to overpressure.

The case shall be liquid (glycerin 99.7%) filled, and its diameter shall be as specified in particular requirements. It shall be scaled in metric units according to EN 837-1/5 and normally ranged over a 240° arc from zero to 20% - 40% above the system designed operating value for full load conditions.

The gauge shall have a degree of protection equivalent to IP65 according to IEC 60529, and shall be able to operate safely for temperature values ranging from -20°C up to +60°C with the same accuracy.

The accuracy class shall be according to EN 837-1/6.

Labels shall be securely attached on or adjacent to each gauge; and groups of any such instruments shall be of matching appearance and approved layout.

Pumping station water pressure gauges shall have a dial diameter of not less than 100mm. Pump delivery and station delivery pressure gauges shall be mounted at a convenient height for reading. Suction and delivery gauges and their isolating cocks may be mounted direct on the tapping bosses and shall be adequately supported.

Pressure gauges incorporating transducers for remote monitoring shall be damped to provide a steady output. The pressure at the tapping point shall give a direct indication on the gauge as well as driving the transducer. Any alarm contact settings shall be independent of the transducer function and neither shall interfere with the direct gauge indication.

8.8.1.2 *Differential Pressure Switch*

It consists mainly of an electro-mechanical switch which is generally used as a protective device for high discharge pressure but also for low-pressure protection.

Pressure switches shall be selected for optimum performance and operation considering basic functional and environmental parameters such as: working range, setpoint, deadband, tolerance, sensitivity, switch setting, corrosion protection, and safety considerations.

Location of these devices should be that no turbulence shall interfere with the measurement of pressure either side of the device.

Differential pressure switches shall have the following characteristics:

- Two adjustable micro-switches, SPDT type, hermetically sealed.

- High repeatability of the switch points.
- Differential pressure range nominal settings, adjustable over the whole range of the instrument.
- Setpoint value indicated by means of a scale and pointer.
- Overload pressure protection up to 1.5 times the maximum line pressure.
- Stainless steel, cast zinc or aluminum alloy casing.
- IP54 for indoor installations, IP65 for outdoor installations and IP67 in locations liable to flooding.
- Operating temperature: -10 °C to +70 °C.
- Adjustment of switchpoint is made by setpoint screws accessible from the front.
- Switching point repeatability accuracy: < 1.6 %.

8.8.1.3 Pressure Transducer

Pressure monitoring shall be by a transducer/transmitter suitable for the medium and pressure/level range specified herein.

Each transducer shall be ranged to provide adequate sensitivity over the working range and be capable of sustaining a 400% overpressure (burst pressure) without damage.

They shall be rugged and waterproof design, employing a pressure sensitive element within a stainless steel enclosure having an isolation diaphragm, suitable for either free wire suspension in the medium or fitted with a BSP thread for external connection to the relevant pipe tapping.

Suspended sensors shall be mounted in accordance with the manufacturer's instructions within a UPVC 'stilling tube' of sufficient nominal bore to enable easy withdrawal of the sensor.

Sensors shall be enclosed to IP67, offer a long life and shall be supplied complete with a suitable signal cable of enough length to reach the approved point of termination indicator – control system without intermediate joints.

The position of the equipment shall be such that withdrawal and installation can be achieved easily.

Cable entry shall be by integral sealed assembly.

The pressure transmitter shall be integrated in the same casing of the transducer, and shall be suitable for operation from a DC source not greater than 30V dc; and converting the signals received from the transducer to an analogue 4-20mA signal proportional to the range specified.

The pressure sensor shall be internally compensated for zero and thermal drifts, and shall be able for safe operation under temperature conditions ranging from -30°C to +80°C.

For use in hazardous areas as specified, the units shall be certified intrinsically safe Ex.

8.8.2 Level detection and measurement

8.8.2.1 Level Electrode

It shall be of the single pole electrode type, comprising mainly an AISI 304 stainless steel probe, a noryl holder and a cable gland.

Special arrangements of seal rings and cable glands shall be available to prevent water from entering the cable terminal connector.

The maximum operating temperature of the fluid shall not be less than 75°C.

Electrode Holder:

This device shall be installed whenever a standard multi-probe arrangement is foreseen.

It consists mainly of a thermo-set resin or ceramic holder suitable for three electrodes. The electrode holder mounting is either flanged or on a threaded coupling.

For each set of three electrodes, or less, a holder shall be supplied and shall be of the same brand of the electrodes.

8.8.2.2 Level Control Relay

Level control relays shall be installed to convert the relative impedance of level electrodes into dry contacts suitable for automatic control sequences.

They shall comply with IEC/EN 60255-6 and have the following technical data:

- Modular DIN (43880) housing.
- Relay – electrode cable length not less than 500 meters when using single core, double insulated cables.
- 'Power On' indicator LED.
- 'Relay State' indicator LED.
- One changeover output contact.
- Adjustable sensitivity from 2 to 12 kOhms.
- Automatic reset.
- Dual supply voltage, one of which shall be 220 V a.c.
- Wiring terminals for three probes.

8.8.2.3 Float-Type Level Switch

The float type level switch is a standard tank level switch used to provide alarms on low or high levels and to initiate automatic control sequences or alarm conditions.

When the fluid level reaches the float mechanism, it lifts the float and operating shaft. The operating shaft is pivoted inside the level switch and its movement operates an integrated dry contact switch that shall be rated 10 A @ 220 V a.c.

8.8.2.4 Magnetic Level Indicator

It shall be made of a vertical mounted stainless steel tube, suitable for measuring fluid levels up to 6 meters.

This device shall be used where it is unadvisable rather difficult to install level sensors inside the fluid itself, or where indicated specifically.

The operating principle of this level indicator, called also bypass tube, is based on the vertical movement, inside the measuring tube, of a floating device with integrated magnet, which follows the liquid level and transmit it, without physical contact with the fluid, for local display and remote signaling.

The local display shall be through bi-stable magnetic blind plates having different high contrast colors on opposite sides.

The blind plates shall toggle face (color) according to upward or downward movement of floating device.

The fluid level shall be permanently indicated in case of power failure.

The level indicator shall have an integrated transmitter drawing a standard output analogue signal 4-20 mA with an overall precision better than 0.3 %.

The level indicator shall have provision for the installation of two dry contacts for triggering alarm conditions.

The level indicator shall operate safely for fluid temperatures ranging up to 100°C and its overall degree of protection, including the transmitter and contact blocs, shall be equal or better than IP65.

8.8.2.5 Ultrasonic Level Sensor

Level monitoring by non-contact ultrasonic measuring devices shall incorporate ambient temperature compensation and adjustable datum setting facilities.

Transducer:

The sensor head shall be protected to IP67, mounted to provide an unhindered beam path, prevent unwanted reflections, within easy reach of maintenance personnel and, where possible, be clear of flood conditions. For sewer or foul pumping sumps, the units shall be certified intrinsically safe Ex(i) for use in hazardous areas.

Transmitter:

The transmitter shall be suitable for operation from the specified power supply and convert the signals received from the sensor head to a 4-20 mA signal proportional to the range specified, to be used as indicated in the particular requirements.

The transmitter shall comprise a base unit and a programming device, all in a weatherproof enclosure to IP65, in case it is mounted separate from the transducer, and to same IP value of transducer in case of compact version.

A minimum of 4 digit LCD shall be used to indicate key programming features, settings and output conditions.

Accuracy of transmitter shall be better than $\pm 0.25\%$ of reading and shall have the following programmable outputs:

- Analogue signal 4-20 mA proportional to user defined Supervising units.
- SPDT relay contact output closing upon failure of the signal transmitter, lost echo or multiple echoes.

8.8.2.6 Gauge Glass Level Indicator

Gauge glass level measuring systems shall be provided with a protective housing, borosilicate glass tubes and isolating valves. The range of any gauge glass shall be the same as that of any other level meter installed on the same vessel, including any high and low level sensor. Multi-section gauges shall have an overlap of at least 25 mm between sections.

Where necessary the level indicator shall be provided with flushing and drain points with valves and hose connections.

8.8.3 Flow detection and measurement

8.8.3.1 Flow Switch

This flow control device shall be mounted on the process piping, and shall be supplied with 'T' connection to fit the required pipe size.

It shall have the following characteristics:

- Stainless steel body 316L.
- IP65 class of protection.
- 85°C maximum ambient temperature and 120°C maximum fluid temperature.
- Adjustable stainless steel paddle sensing element.
- Two switch contacts, 8A @ 240 Vac.
- Mounting in all directions.

8.8.3.2 Flowmeters

All liquid flow measurements shall be performed in accordance with accepted practices defined by International standards.

Reliable and accurate flow measurement is of paramount importance and requires special attention in the following implementation phases that shall be strictly followed by the contractor:

- Selection of the flow measuring element and its associated instrumentation.
- Accurate calibration and operational checkout of the flow measuring system before installation.
- Precise and accurate installation and checkout in the field.
- Correct operational procedures applied to ensure that accurate metering data is generated in accordance with the design capabilities of the metering system.

8.8.3.3 Mechanical Flowmeters

Mechanical flowmeters shall be of the helix type and incorporated into a flanged section of pipe.

Tapers shall be provided, or non-standard bearings and propellers, if required, to obtain the specified degree of accuracy at the specified flow rates.

The meters shall be suitable for working pressures up to 16 bar unless otherwise stated.

An extension drive and extended head shall be fitted to meters as required. The drive shaft bearings and gears shall be designed for long life under continuous operation, and normal wear shall not significantly affect the accuracy of the meter.

Mechanical flowmeters shall not require any constraints on the piping downstream and upstream the meter, nor any additional flow stabilizing sections.

Meters shall have a circular dial and rate of flow indicator registering flow in units as specified in particular requirements. A flow totalizer having at least six digits shall be incorporated in the head. The totalizer shall have a capacity of at least one year's flow at maximum flow rate. A multiplying factor in multiples of ten may be used in conjunction with the totalizer if required, however if this is the case, the factor shall be clearly marked alongside the register.

The meter bodies shall be in cast iron with a high quality epoxy coatings minimum 150 microns, inside and outside.

Meters shall be individually flow calibrated at the manufacturer's works and shall be guaranteed to within $\pm 2\%$ of true flow within the rated range of the meter. Each meter shall be supplied with a calibration certificate.

The coupling between the wet and dry part (totalizer mechanism) shall be magnetic, fully tamperproof against any external non-destructive actions. The totalizer mechanism shall be located in a non-plastic housing, preferably copper, and with a solid glass window. It shall be totally condensation free and waterproof if submerged under 2 meters of water.

It shall be possible to remove all moving parts from the meter without the necessity to remove the meter body from the pipeline. A blanking plate shall be provided for each meter, if necessary, to allow flow to pass through the meter body when the operating mechanism has been removed.

The spare parts shall include as a minimum spare gearing and bearings for each size of flowmeter used.

Where specified, meters shall incorporate a pulsed output unit and data logger connection to enable flow rates to be monitored and logged at a remote data center. However, the totalizer mechanism of all meters shall be pre-equipped to receive a pulse output unit in the future which can be added on site without destroying the seal and without removing the meter or the measuring mechanism. The pulse unit and data module shall be self-supporting using dry cell batteries.

8.8.3.4 Ultrasonic In-line Flowmeters

The flowmeters shall have flanged steel bodies and be without probes or pressure tapplings which can foul or create a disturbance to the flow. The meter performance shall not be affected by emptying the pipeline, and servicing shall be possible without the need to remove the meter from the pipeline.

Ultrasonic flowmeters measuring the fluid level upstream of a flume or weir shall employ a microprocessor-based system to compute flow in accordance with BS 3680 against a range of user programmable primary device characteristics. Combined system accuracy shall be within 1% of span over 5-100% flow. Displays of flow, programming details and operating parameters shall be provided by LCD device. For outdoor use the whole system shall be in an IP65 enclosure.

The sensor tube and associated equipment shall be capable of withstanding occasional submergence in the flow metering chambers. The contract shall include for the provision of a 230V, 50Hz power supply from the nearest distribution panel, and a power pack unit if required for flowmeter operation.

The transmitter unit and the power pack unit shall be housed in a G.R.P. lockable cabinet which may be either pedestal or wall mounted as appropriate to the meter location. The cabinets shall have heaters and thermostats if required to prevent condensation.

The contract shall include for all internal wiring, and for cabling between the flowmeter and cabinet. Where necessary, cabling shall be screened to prevent interference.

The transmitter shall give an output signal of 4-20mA.

The span of the instrument shall be adjustable and the range of each instrument shall be chosen to suit the particular flow range. Means shall be provided for check calibrating the meter on site.

The outputs signals from the flowmeters shall be wired back for display and control, with provision for wiring to a telemetry outstation.

Meters on gravity lines will normally have flow, and although this could be low at some times of the day, in practice flow is unlikely to drop below approximately 20% of maximum.

The meters on the pumping mains will have flow dependent on the operation of the pumps.

8.8.3.5 Electromagnetic Flowmeters

The flow meter shall be of the electro-magnetic inductive type having a DC pulsed field with automatic zero error averaging and low power consumption. It shall have no moving or protruding parts nor cause any restriction in the flow path and be capable of setting adjustments without the need to stop the flow.

Each metering system shall be in accordance with ISO 4064/1 and comply with EN29104 and comprise a flow sensor mounted in pipe work line and a transmitter which degree of protection is equal or better than IP65, either integrally mounted or remotely located; preferably within the main control panel.

The flowmeter shall be approved and certified for hygienic and sterile requirements when used for potable water, and it shall be capable of accurate reading for a fluid conductivity equal or higher than 5 $\mu\text{S}/\text{cm}$; and a fluid temperature range between -20°C and 130°C .

The system accuracy shall be independent of the range which has been selected for the analogue signal and shall be better than 0.25% of the actual measurement, for a fluid velocity equal or higher than 0.5m/sec.

For a velocity $< 0.5\text{m/s}$, the accuracy shall be better than $\pm 1.25\text{ mm/s}$ of actual flow.

The repeatability of the system shall be better than 0.1% for flow ranges from 0.03 up to 10m/s.

Flow Sensors:

These shall comprise electrodes located in a meter tube which shall be of watertight construction, suitable for operation without loss of accuracy when totally submerged to a depth of three meters or even buried into the ground together with the water pipe. Its degree of protection shall be IP68. They will not contain any active components such as amplifiers or memory modules.

The meter tubes shall be made from a non-magnetic material lined with an inert material suitable for the medium. The flowmeter may be flanged or welded ends type. On flanged type the lining shall cover the external parts of both flanges.

The measuring electrodes shall be continuously cleaned by means which do not interrupt the process flow or the measurement.

The flowmeter shall have an automatic pipe detection feature.

The flowmeter body shall be effectively bonded by non-corrodible, tinned copper braid links at each end, to the adjacent pipework to ensure a good connection between the body and the metered liquid, an earthing flange being inserted where non-conducting pipework is employed.

Transmitter:

The transmitter shall provide the following minimum functions:

- Conversion of its supply voltage (85 to 240VAC or 11 to 40 VDC) in a pulsed signal which feeds the coils in the flow sensor. This method allows the transmitter to

compensate for a zero drift of the flowmeter and shall give the flowmeter a perfect zero stability.

- Supervision of the flow sensor: The transmitter shall be able to generate an alarm signal when the following conditions occur:
 - Flowmeter empty.
 - Reverse flow direction.
- Output signals to inform the control/display equipment. Thus, the transmitter shall have as a minimum the following independent output signals:
 - Standard analogue current signal 4-20mA, where the zero and full-scale mA values are configurable as well as the measuring range. The range adjustment shall be continuous, and the units shall be configurable in flow Supervising units.
 - This analogue signal shall represent forward flow, reverse flow or both depending on the configuration.
 - In case the analogue signal represents both flows, then an output digital signal shall be provided to indicate flow direction.
 - A serial port for downloading data.
 - Two pulse signals, fully configurable in volume and length. The pulse signals shall be open collector transistors or voltage free contacts.
 - Two alarm signals, fully configurable and representing the following fault signals (each fault signal can be assigned through configuration to the first, the second or none of the two alarm contacts):
 - Empty pipe.
 - No signal from electrodes.
 - Coils broken (open circuit).
 - Flow above or below selected alarm level.
 - Reverse flow direction.
 - Output pulse frequency above maximum selected rate.

The alarm signals shall be open collector transistors or voltage free contacts.

- Local, user-friendly indicator, used to inform the operator about the measurement. The indicator shall provide at least the following information and functions:
 - Actual flow with direction, in selected units.
 - Alarm indication with full description.
 - Selection of total positive, negative and net flow as well as velocity in the pipe and actual flow in percentage of full scale.

- Configuration tool: It consists of a password protected menu from which the operator shall be able to access and set all configurable parameters grouped by function: measuring range, totalizers, alarms... A test function shall be available as well to test the wiring and the complete configurations.

Flowmeter Cabling:

Where remote mounted converters are specified, cables shall be provided, installed and terminated between the sensor and converter unit for the following purposes:

- Flow signal.
- Reference signal.
- Coil supply.

Such cables and sealing glands shall be suitable for submersible operation (IP68) of the sensor to the depth specified. The length of each cable shall be as specified.

Spool Piece:

A flanged steel pipe spool piece shall be provided of the same diameter and length as the respective flowmeter and flanged for insertion in the pipe; should it be necessary to remove the flowmeter.

Isolating gate valves shall be provided on either side of the flowmeter.

Calibration Certificate:

The flowmeter shall be supplied with a calibration certificate mentioning also the pressure at which the meter has been factory tested. The flow test shall be made on a recognized test bench which is traceable to international standards.

8.8.3.6 Differential Pressure Flowmeters

Flowmeters of the differential pressure type shall be designed and installed in compliance with BS 1042 or equivalent. Primary devices shall be a stainless steel carrier-ring type orifice assembly with a stainless steel orifice plate, a dall or a Venturi tube, and which shall include two sets of gaskets, fixing bolts and isolating valves for each primary device. All materials shall be appropriate to the metered fluid and service conditions. Full details of the calculations of the differential pressure flowmeter shall be supplied to the Supervisor.

Orifices shall be square-edged and concentric. The upstream edges of orifices shall be sufficiently sharp that the reflection of a beam of light from the edge cannot be seen without magnification. Drain holes shall be provided. The diameter ratio shall be between 0.20 and 0.70. Orifice assemblies shall have identification tags showing the direction of flow, orifice diameter and position of drain hole.

Differential pressure transmitters shall have over-range protection up to 1.5 times the maximum line pressure.

Interconnecting pipework between the primary isolating element valves and the transmitter shall be supplied and installed with a suitable 3-valve manifold and blowdown legs.

Provision shall be made for easy connection of a U-tube manometer or portable instrument for the purpose of calibration.

The differential pressure produced by each primary element shall be converted to a dc current by an output signal transmitter mounted adjacent to the primary element. Power supply units for transmitters, if required, shall be mounted close to the transmitter in a weatherproof housing unless they are mounted in a control panel.

Square root extraction shall be provided to give a linear 4 to 20 mA dc output signal proportional to flow.

After installation the calibration of each flowmeter system shall be proved to the satisfaction of the Supervisor by applying fixed measured differential pressures to the input of the converters.

8.8.3.7 Variable Area Flowmeters

Variable area flowmeters shall have a float moving vertically in a tapered tube, the position of the float being proportional to the flow. The meter tube shall be provided with a scale calibrated for the specific fluid in volumetric flow units. The calibration conditions shall be engraved on the tube.

The flowmeter shall have glass or metallic tubes according to the particular application.

Metering tubes shall be removable for range change or cleaning without disassembling the meter or removing it from the line. Metering tubes shall have ends of equal cross-sectional area and if O-ring seals are used, tube retainer springs shall be outside the fluid stream. End fittings shall be rotatable to any angle. Connections shall be horizontal and plugged vertical openings shall be provided for cleaning purposes.

Glass metering tubes shall be of borosilicate glass and shall be adequately shielded with safety glass on the reading side and amply vented on sides, back and bottom. Meters with glass metering tubes shall not be used at working pressures over the relevant values given in Recommended Practice RP 16.1.2.3 issued by the Instrument Society of America.

Variable area flowmeters shall be installed in locations free from vibration and with sufficient clearance for the removal of the float. If used in conjunction with a flow-regulating valve, the valve and meter shall be close together, with the valve downstream of the meter. There shall be a minimum of five diameters of straight pipework upstream of the meter. Pipework shall be supported, having regard to the weight of the meter. The outlet connection shall be at the top of the meter.

8.8.4 Temperature measurement

8.8.4.1 Bi-metallic Thermometers

Bi-metallic thermometers are used basically for local temperature read-outs on the pipeline or a specified process.

They shall be of rugged design, direct acting, with a good accuracy for temperature measurement within 1% of the full-scale range.

Bi-metal thermometers shall be mainly constituted of the lamination at a high temperature welding process of two metals of different thermal expansion coefficient. This bi metal strip will bend when heated or cooled. This bending force is then translated into mechanical movement which is amplified by a helix coil, over a calibrated temperature scale.

The instrument shall withstand safely a 50% temperature range over and/or under the specified range, without affecting the thermometer accuracy.

Where specified, thermometers shall be installed in a thermowell to provide protection against corrosion effects.

8.8.4.2 Resistance Temperature Detectors (RTD)

RTD's are temperature measurement devices which utilize the concept of resistance change with temperature change.

Unless otherwise specified, Platinum RTD's of 100 ohms resistance at 0°C shall be used, and shall have an improved linearity, long term stability and a high resistance to corrosion.

The platinum RTD shall be built around a sensor element composed of highly pure (99.99%) platinum wire coils and leads, housed in a ceramic body. The sensor element shall be protected by a stainless steel sheath which constitutes the immersion length of the instrument. The sensor element and lead wires shall be totally encapsulated for vibration protection and to provide faster time response.

The wiring method for RTD to relevant electronic transmitter shall be three-wire type to provide lead resistance compensation.

The electronic transmitter shall be housed in the sensor head and shall deliver a standard analogue output signal 4-20mA configurable to the selected range.

The sensor length shall be optimized for the selected application to ensure maximum performance and it shall be vibration and impact resistant, though allowing to be bent flexibly around small diameters.

The sensor shall be suitable for direct contact with the medium without additional protection. Furthermore it shall be used, where specified, for insertion in thermowells.

Where installed inside a pipe, the typical immersion length shall be the two third of the inside pipe diameter.

The temperature limits for RTD sensors shall be: -40°C to +600°C.

The sensor tolerance shall be class B according to EN 60 751: +/- 0.30°C at 0°C.

8.9 PROGRAMMABLE LOGIC CONTROLLERS (PLC)

They shall be microprocessor based controllers designed to suit various application needs such as controlling, regulating, monitoring, etc.

They shall be of a proven technology, shall have robust enclosures and shall provide reliable functioning even in locations near sources of electromagnetic interferences.

PLC units shall be compliant with the latest editions of IEC 61131 standards.

The PLC units could be of an expandable compact or a modular type. They shall cater for analog and digital inputs/outputs and have serial ports for communication with computer equipment. They shall be capable to accommodate special modules such as intelligent peripherals cards or functional units that operate autonomously.

PLC units shall be capable of processing complex data at high speed. For large programs, CPUs shall be added to maintain a high processing speed.

PLC shall support hierarchical configurations of control system networks with central operator station.

8.9.1 *Power supplies*

Instrument signals shall operate at 24 Vdc, derived from a suitably rated power supply to each PLC or instrument panel section and connected to the I/O terminals as necessary. The power supply units shall be sized such that the total demand does not exceed 75% of the power supply's maximum rating.

The power supply functions inside the PLC shall provide for conversion and isolation of the PLC system

8.9.2 *Cpu*

The CPU function consists of the application program storage, the data storage, the operating system, and the execution of the application program functions.

The CPU shall process signals obtained from sensors as well as internal data storage and generates signals to actuators as well as internal data storage in accordance with the application program.

The interface function to sensors and actuators shall convert:

- The input signals and/or data obtained from the machine/process to appropriate signal levels for processing;
- The output signals and/or data from the signal processing function to appropriate signal levels for commands and/or display.

8.9.3 *Input/Output Modules*

The I/O modules shall accept standard analog and digital signals. These modules shall accept also signals coming from special modules which pre-process external sensor signals according to the defined functions contained in the special modules themselves. Examples of such special modules include PID controllers, fuzzy control module, motion modules and others.

The number of I/O points shall be determined according to the relevant control scheme. Spare I/O points shall be provided to allow for system expansion or enhancement. Unless otherwise specified, 30% overall spare I/O points shall be provided at least, while ensuring a minimum of 20% spare of each type of I/O points.

8.9.4 **PLC Programming Languages**

The PLC programming language shall comply with IEC 61131-3 which specifies the syntax and semantics of a unified suite of programming languages for PLCs. These consist of two textual languages:

- IL (Instruction List).
- ST (Structured Text).

And two graphical languages:

- LD (Ladder Diagram).
- FBD (Function Block Diagram).

The programming language shall include for programming, debugging, and testing and documentation functions. These functions shall provide for application program generation and loading, monitoring, testing and debugging as well as for application program documentation and archiving.

The programming language shall be user-friendly, open and manufacturer – independent.

8.9.5 **Communication Ports**

PLC shall have a communication function which provides the data exchange with other systems such as other PLC-systems, controllers, computers, etc.

PLC's shall have as many communication ports as necessary to achieve the specified control scheme.

Unless otherwise specified, each PLC shall have as a minimum one RS485 communication port.

8.9.6 **Watchdog**

All PLC's shall be self-monitoring and any system failure, whether hardware or software derived, shall cause the watchdog relay(s) to de-energize / fail-safe and un-inhibit back-up control operation and/or carry out any function as detailed in the functional design specification.

Watchdog status shall be indicated visually on the panel sections and the SSU mimics.

Failure of PLC's shall not leave the associated plant in an unsafe condition or allow a process failure.

8.9.7 **Physical Installation**

The installation of PLC based units shall be as per relevant standards and manufacturer recommendations.

PLC equipment shall be mounted in secure lockable panels, which may be housed within an instrument panel.

PLC cabling shall be separately routed and segregated from other cabling services.