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**Supply and Install Modular Skid Mounted Well Head 40m³/Hour brackish Water RO Desalination Plant-
Gaza Industrial Estate**

SPECIFICATION AND PERFORMANCE REQUIREMENTS

TENDER DOCUMENTS



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– GENERAL PROVISIONS

1 DEFINITIONS

In the Contract (as hereinafter defined) the following words and expressions shall have the meanings hereby assigned to them, except where the context otherwise requires:

- A
 - (i) “Employer” - The party named in the Contract as the “FIRST PARTY” who will enter into contract with the Contractor for the execution of the Works covered by the Contract, or any other party authorized by the Employer to exercise the powers and obligations of the First Party, provided that the Contractor will be informed accordingly in writing.
 - (ii) “Contractor” - The person, company or joint venture named as Second Party in the Contract whose Tender has been accepted by the Employer and with whom the Employer has entered into Contract, and includes the Contractor’s personal agents and his legal successors.
 - (iii) “Sub-Contractor” - Any person to whom a part of the Works has been subcontracted by the Contractor with the consent of the Engineer and the legal successors in title to such person.
 - (iv) “Engineer” - The Consulting office, or Engineering office or Engineer or any other technical body appointed from time to time by the Employer to exercise in whole or in part the powers of the Engineer in accordance with the Conditions of the Contract, provided that the Contractor shall be accordingly notified in writing.
 - (v) “Engineer’s Representative” - Any resident Engineer appointed by and be responsible to the Engineer and shall carry out such duties of watching and supervising the execution and workmanship of the Works and to test and examine any materials to be used or workmanship employed in connection with the Works.
- B
 - (i) “Contract” - The documents constituting the Conditions the Specification, the Drawings, the Bill of Quantities, the Tender, the Letter of Acceptance, the Contract Agreement, and such further documents as may be expressly incorporated in the Letter of Acceptance or Contract Agreement (if completed).
 - (ii) “Specifications” - The Technical Specifications of the Works included in the Contract and any modification thereof or addition thereto made or submitted by the Contractor and approved by the Engineer.
 - (iii) “Drawings” - All drawings, calculations and technical information of a like nature provided by the Engineer to the Contractor under the Contract at the time of entering into the Contract or during execution, and all drawings, manuals and other technical information of a like nature submitted by the Contractor and approved by the Engineer.
 - (iv) “Bills of Quantities” - The priced and completed bill of quantities submitted by the tenderer and forming part of the Tender.
 - (v) “Tender” - The Contractor’s priced offer to the Employer for the execution and completion of the Works and the remedying of any defects therein in accordance with the provisions of Contract, as accepted by the Letter of Acceptance.
 - (vi) “Letter of Acceptance” - The formal acceptance by the Employer of the Tender.
- C
 - (i) “Commencement Date” - The date upon which the Contractor receives the notice to commence issued by the Engineer.



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- (ii) “Time for Completion” - The time for completing the execution of and passing the Tests on Completion of the Works or any section or part thereof as stated in the Contract calculated from the Commencement Date.
- D (i) “Tests on Completion” - The tests specified in the Contract which are to be made by the Contractor before the Works or any Section or part thereof are taken over by the Employer.
- E (i) “Works” - The Permanent Works and the Temporary Works to be executed in accordance with the Contract, or either of them as appropriate.
- (ii) “Permanent Works” - The permanent works to be executed (including Plant) in accordance with the Contract.
- (iii) “Temporary Works” - All temporary works of every kind (other than Contractor’s Equipment) required in or about the execution and completion of the Works and the remedying of any defects therein.

2 SPECIFICATIONS

- A These General Technical Specifications should be read in conjunction with the Product Standards which forms part of these Specifications.
- B The General Technical Specifications cover the materials and works of Civil and Hydraulic Engineering, water treatment and storage, and ancillary works.
- C Materials and works not covered by these specifications will be specified either in the Special Conditions of Contract and Specifications or in the Bill of Quantities.

3 WORKS INCLUDED

- A The Scope of the proposed works include the.
 - 1. Rehabilitation of existing concrete water tank of capacity 100 m3 includes all pipes, water levels, ETC...
 - 2. Supply and installation of a complete RO- Brackish Water Desalination Plant
 - 3. Relevant Civil Works,
 - 4. Permeate water connections and piping to connect to the existing desalination plant, and main water network to the tankers filling ports and other GIE main feeding line.
 - 5. Electrical power system supply and installation, both external and internal
 - 6. Construction of a gravity line for brine discharge from the BWDP to the appropriate storm or wastewater drainage point.
 - 7. Supply of lab equipment for the testing of the quality of the permeate.

The Scope of the proposed Works shall be as delineated on the Drawings, schematic Diagram and set-out in the Specifications together with any Drawings which may be issued by the Engineer during the currency of the Contract.

- B The Contractor shall, unless otherwise specified herein, supply all materials, equipment, temporary works, plant and labor, supervision and technical services necessary to install, complete and maintain the works required under the



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contract, according to the drawings, specifications and technical clauses of relevant standards and code of practices, and upon approval of the engineer in charge.

C The Works shall include but not be limited to:

Earthworks: trenching and backfilling work, including the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property; pipe embedment; surfacing and grading; and other related works; cleaning up and maintaining the working site so that it may be handed over to the Employer in good condition and working order and in full compliance with the requirements of these documents.

Concrete and Reinforced concrete: furnishing all plant, equipment, appliances and materials and in performing all operations necessary to cast concrete and reinforced concrete in accordance with the Specifications, Drawings and Engineer's instructions and subject to the terms of the Conditions of Contract; cleaning up and maintaining the working site so that it may be handed over to the Employer in good condition and working order and in full compliance with the requirements of these documents.

Pipe laying: preparing the pipeline route including all setting out, etc.; excavation for pipes and valve chambers to the required dimensions for the transmission pipelines, distribution systems and house connections, including extra excavation at joints and all working space for planking and strutting, etc.; all works and temporary works necessary for maintaining the flow of traffic, provision of alternate detours barricades, guards and warning lights; supply, lay and test of the pipes, fittings, valves and coupling; construction of all valve chambers and boxes, ducts, thrust blocks, anchors, etc.; backfilling and consolidation of trenches; pumping and dewatering, make temporary connections; reinstatement of surfaces, surplus material removal and dispose; cleaning up and maintaining the working site so that it may be handed over to the Employer in good condition and working order and in full compliance with the requirements of these documents.

Civil Works: carrying out block work, plastering, painting and decorating, and tiling in accordance with the Drawings and BoQ, and as set-out in the relevant Technical Specifications together with any Drawings which may be issued by the Engineer during the currency of the Contract; cleaning up and maintaining the working site so that it may be handed over to the Employer in good condition and working order and in full compliance with the requirements of these documents.

Brackish Water Desalination Unit: Supplying and installation of a skid-mounted packaged Reverse Osmosis Brackish Water Treatment Plant. Feed water is provided by existing two wells.
The mechanical and electromechanical equipment of the reversed osmosis unit itself will be designed and manufactory checked for a max. Capacity of 40 m³/h.
The desalinated water (about 500 m³/d) is to be pumped through the existing water tank, to supply drinking water and domestic water to Gaza Industrial Estate (less than 100 PPM Chlorides and nitrate concentration less than 30 PPM).

Electric Power Supply: Supplying and placing in service of the electrical power and control systems, both external and internal for the successful operation of the water scheme



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- A The works have been designed to incorporate and utilize economically high quality product standards and workmanship to various specifications which are detailed herein.
- B Preference shall be given to ISO Standards (International Standards Organization) as described in the attached list of Products Standards.
- C Second priority shall be given to JSS (Jordan Standard Specifications) and IS (Israeli Standards). These shall be followed where described in this Technical Specifications and in the attached list of Product Standards.
- D Other standards such as EN (European Committee for Standardization /CEN), BS (British Standards Institution / BSI), AFNOR (Association Francaise de normalisation), DIN (Duetsches Standards fur Normung), ASTM (American Testing and Material Standards), ANSI (American National Standards Institute), ACI (American Concrete Institute), AWWA (American Water Works Association) can only be used either if they are compatible and better than the relevant ISO Standards or when an ISO Standard is not covering the product. Documentation for this is to be attached to tender.
- E All standards and references shall in every case be deemed to include the latest edition or issue of such standards.
- F All units of weight and measurements shall be based on the Metric System of Weights and Measurements.

5 **CONTRACT DOCUMENTS**

5.1 **Contract Drawings and schematic Diagram**

- A The Contract Drawings and schematic Diagram shall be as delineated on the Drawings and set-out in the Particular Conditions and Specifications together with any other drawings which may be issued by the Engineer during the currency of the Contract.
- B All lines, elevations and measurements shown on the Drawings are approximate and are intended to be used for tendering only. It shall be the Contractor's responsibility to verify and determine the exact lines, grades and elevations to the approval of the Engineer before commencing any section of the works.

5.2 **Bill of Quantities and Bid Prices**

- A The Contractor shall before pricing the Work check all Drawings, Specifications and Bill of Quantities and satisfy himself by measurement, enquiry or otherwise as to their accuracy.
- B It shall be the responsibility of the Contractor to satisfy himself as to the Correctness of the Quantities of materials to be supplied and amount of works to be carried out before submitting his bid price.
- C The Contractor shall notify the Employer of any omissions, errors or discrepancies found in the Specifications, Drawings, or Bill of Quantities prior to submitting his tender and shall include in his Bid Price for the particular section of the Works described in the Bill of Quantities and the cost of any materials and works missing or which have been over-looked in the preparation of the Tender Documents and which are necessary for the proper completion of work.
- D Omissions from the Drawings or Specifications or the incorrect description of details of work which are evidently necessary to carry out the intent of the Drawings and Specifications, or which are customarily performed, shall not



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relieve the Contractor from rectifying such omissions and details of work, but they shall be performed as if fully and correctly set forth and described in the Drawings and Specifications.

- E The Contractor shall, after a thorough and careful study of all the required works comprised in the various sections of the several Documents of the Contract, assess the amount of all the works comprised and shall quote in the Bill of Quantities a Bid Price for each of the various items of Works described, which price shall be binding subject to the relative Clauses of the Contract.
- F The Bid Prices inserted in the Bill of Quantities are the full inclusive of the value of the Works described under the several items and shall cover, by way of illustration but not limitation, the cost of all labor, subsistence, traveling, materials, fittings, temporary works, constructional plant, watching and lighting, overhead charges and any other expenses whatsoever together with all risks, liabilities and obligations set forth or implied in the Contract Documents. The Bid Prices shall also include for all ancillary and other work facilities and services relating to the construction of the water supply system, valves, valve boxes and chambers, cleaning and tidying of the Site on completion and all that is required to hand over the Works and surrounds complete in every respect and ready for immediate use in accordance with the Drawings, Specifications, Bill of Quantities and other Tender Documents to the full satisfaction of the Engineer.

5.3 Shop Drawings

The Engineer shall have authority to order at any time and the Contractor agrees to provide at his own expense any number of shop drawings which, in the opinion of the Engineer, are necessary for the proper execution of a specified work. The Contractor shall not proceed with the above mentioned work unless these shop drawings are approved by the Engineer.

5.4 “As-Built” Drawings

All prints of the “Shop Drawings”, where required, shall be corrected by the Contractor and submitted to the Engineer for approval as the Works proceed. Upon the completion of the Works, the Contractor shall prepare a complete set of “As Built” Drawings for the project as executed, including tie-ins, presented on a computerized electronic form, and submit them to the Engineer for approval. When approved by the Engineer, the Contractor shall submit a digital copy on the specified format for each project and six copies of all Drawings duly marked “As-Built”. The final payment shall not be made except for the actual Works that have been completed in accordance with the Specifications and have been duly presented on the “As-Built” Drawings.

The Contractor shall not be entitled to any extra payment or extension of time for the correction, preparation and supplying of the mentioned and transparencies.

5.6 Inconsistency in Contract Documents

A The Contractor shall execute the Works per the provisions of the Contract Documents. In the event of any unforeseen or unintended conflict between the Particular Conditions and Specifications and this Specifications, the former shall prevail.

B If the Contractor should discover that any work has been omitted and / or not indicated entirely or partially from all the documents, but that such work is essential to the safety or proper functioning of the Works, he shall report the facts immediately to the Engineer. If the work is something which in the opinion of the Engineer could not have been foreseen by an experienced Contractor, the Engineer shall issue to the Contractor a variation order stipulating the details of the work to be done. Save as aforesaid in the above paragraph, no additional payment shall be made in respect of work carried out in connection with discrepancies between the various Contract Documents.



6.1 General

The Contractor shall provide, maintain and keep clean, temporary site offices with all associated equipment and services for the exclusive use of the Engineer's Representative and his staff, from commencement of the Permanent Works until a Taking-Over Certificate is issued in respect of the Works.

The temporary site offices shall be either prefabricated portable unit/s or alternatively of some other form of weatherproof design and construction to the approval of the Engineer.

The offices shall have full partitions and room sizes shall be as shown in the attached Schedule of offices. All rooms shall have individual entrance doors.

Corridor and entrance areas shall be additional to the office sizes.

The offices shall be air-conditioned with the exception of the Toilet and Kitchen areas.

All rooms shall have glazed windows complete with fly screens.

Adequate fitted hardware, electrical switches, sockets, lighting, and plumbing fittings, sanitary ware and fittings and fixtures etc., shall be provided as necessary for the different areas.

The electrical installation shall provide for simultaneous use of all electrical appliances.

The Contractor may either arrange for a temporary power supply to the offices or alternatively provide and maintain adequate diesel generator sets. All electricity bills shall be paid by the Contractor.

The Contractor may either arrange for a temporary mains water supply or alternatively provide water tank supply. All water bills shall be paid by the Contractor.

One independent telephone line shall be provided for the offices as shown in the Schedule of Fittings and the Contractor shall pay all installation and rental charges and call charges within Palestine.

The Contractor shall submit any necessary drawings and calculations for the construction of the offices for the Engineer's approval before commencing construction and shall be responsible for ensuring that the offices are structurally sound. The Engineer may request alterations at this stage. The drawings shall be approved in writing by the Engineer before installation/construction shall commence.

The offices shall be completed and all the equipment provided by the Commencement of the Permanent Works.

The Contractor shall provide all items listed in the attached Schedules.

Throughout the duration of the Contract, the Contractor shall ensure an uninterrupted supply of gas, water and electricity to the offices.



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6.1.2 Specific Requirements

1. The contractor shall be responsible for the daily coordination with PIEFZA for working inside the GIE with his equipment.
2. The Contractor shall be responsible for making all arrangements and payments in respects of any land required for the site.
3. The Contractor shall be responsible for the security of the office building and its contents at all times and shall employ watchmen for this purpose.
4. The Contractor shall supply the Consultant's staff with all safety clothing and equipment that shall be necessary for site working such as safety helmets, reflective waistcoats etc.
5. The contractor shall obtain the Engineer's approval for all furniture, and equipment proposed.
6. The Contractor shall retain on site for the exclusive use of the Engineer all codes and standards referred to in the Specification.
7. The office building and services shall be available, fully maintained, until the Taking-Over Certificate for the whole of the works has been issued.

The office building shall become the property of the Contractor after the completion of the Works.

The electrical supply shall be 220-250 volts, 50 Hz. Where the number of rooms required for the site office exceeds 4 No. (Excluding toilet & kitchen) then a minimum of 1 No. Telephone line is required.

The office building shall be as new portable type cabins erected on suitable solid foundation.

SCHEDULE OF OFFICES

The office requirements on this contract are as follows:

<u>Room No.</u>	<u>Description</u>	<u>Size Requirement</u>
1.	Project Manager	4m x 4m Yes
2.	Conference Room	6m x 4m Yes
3.	Toilet	2m x 2m Yes
4.	Kitchen	4m x 2m Yes

SCHEDULE OF FITTINGS

The fittings required under this contract for the site offices indicated in the schedule of offices, shall be to the Engineer's approval and are as follows:

Room No. and Quantity

<u>S/No.</u>	<u>Description of Item</u>	<u>No.</u>
–	Executive desk with two locking drawers and chairs	1
–	Desk with two locking drawers & chair	1
–	Conference table	1
–	Desk with two locking drawers & chair	4
–	Chair plastic covered padded, steel frame	12



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-	Typist desk and chair	1
-	Full size drawing board with stand, stool & 'T' square	1
-	Six drawer plan chest	3
-	Samples cupboard	3
-	Four drawers steel filing cabinet	3
-	In/Out tray	4
-	Four tier filling tray	3
-	Telephone hand set	1
-	Waste paper basket	4
-	Portable dry powder fire extinguisher	2
-	European W.C suit	2
-	Wash hand basin, shelf, mirror & towel rail	1
-	Extractor fan	2
-	2 ring gas burner	1
-	Refrigerator 6 cubic feet	1
-	Water filter	1
-	Electric kettle	1
-	Local telephone authority approved Fax machine with a separate telephone line	1
-	Plane paper photocopier (A3/ A4 format, reduction/enlargement facility, cassette feeds sorting facility).	1
-	Lab top HP Core I7, Hard disc 1 tiara, internal ram 8GB with all needed accessories	1
-	And about the Printer it's HP 5200 LaserJet Printer A4 & A3 (Lab top and printer will become the property of the lint at the completion of the contract)	1
-	Camera (Auto focus with 30-100 range lens and date imprint facility)	1

In addition to this requirement the Contractor shall supply mobile charges 200 NIS per month for all the duration of contract.

6.2 Contractor's Representatives

A Full information shall be given in the tender about age, theoretical education and practical training of the supervisors to whom is intended to entrust the performance on site of the works. Change of supervisors is not allowed without the written approval of the Engineer.

B The Contractor will be required to send one or more qualified Engineer to all meetings with the Employer, the Engineer or other parties at which his attendance is deemed necessary by the Engineer. Such Engineer(s) must have the authority to act on behalf of Contractor and will be expected to take part in relevant discussions and decisions. All decisions given to or by the said Engineer(s) will be deemed to have been given to or by the Contractor and all ensuring action will be based on these decisions and no claims on the part of the Contractor will be entertained on account of misinterpreted or misunderstood decisions or instructions.



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- C Should the Contractor fail to send Engineer(s) for any meeting at which his presence has been requested, all decisions shall be taken and instructions given as if the Contractor had been present and subsequent actions and orders based as aforesaid.

6.3 Temporary Water and Electricity Supplies

A The Contractor shall provide all necessary water to the construction site both for carrying out the Contract and as potable water for his workmen at his own expense. This will be together with all temporary plumbing and storage, pay all charges, and alter, adapt and maintain temporary work as necessary and remove and make good at completion.

B The water shall be of a chemical and purity standard such that it will not be pollute, injure or cause any deterioration of the Works, and it shall generally comply with the requirements specified.

C The Contractor shall provide all necessary lighting and power for the execution and protection of the Works and for the Engineer's office facilities, with all meters, temporary wiring and fittings, etc., pay all charges, and alter, adapt and maintain the temporary work as necessary and remove and make good at completion.

6.4 Contractor's Yards and Stores

A The Contractor shall make his own arrangements for all yards, weather proof shed stores, workshops, offices, etc., and for all services in connection therewith. The location of all yards, stores, workshop, offices, etc. , shall be agreed beforehand with the Engineer's Representative and shall be such as to avoid obstruction and nuisance to the public.

6.5. Planning and timecontrol

i) General.

The Contractor shall submit to the Engineer full details of his proposed construction Program within the period stipulated in the Contract. He shall also submit details both of the construction plant and labour force which he proposes to employ and shall broadly describe his proposed construction methods.

The details of the construction plant force shall include the make, type, capacity or rating and the number of units. Details of the labour force shall include senior staff, trade of specialist categories indicating the proportion of local labour which the Contractor expects to employ and shall show the variation in staff and labour levels and their distribution throughout the duration of the Contract consistent with the program.

ii) Details of Work Programme

The Contractor shall furnish the following agreed details of his work programme to the Engineer and to local Authorities responsible for traffic and traffic control at the times and in the manner detailed below.

a) Within one week of the Order to Commence, the Contractor shall submit to the Engineer an overall programme of work indicating the period of executing each section of work in or along side highways including details of anticipated road diversions (Traffic Plan). At the same time he shall provide a more detailed programme describing his proposal for the first month of work.



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iii) Sequence of Construction

When preparing the programme of works as specified, the Contractor shall take account of the priority order described for various activities of the Work.

iv) Continuous Working

A If in the opinion of the Engineer, it is necessary for the safety of the Works or for any other reason, the Contractor shall carry out any part of the Works continuously by day and by night when so instructed in writing by the Engineer.

v) Cancellation Due to Slow Progress

If the Engineer shall be of the opinion that having regard to the state of the Works at any time, the Contractor will be unable to complete any section of the Works by the time specified or by such extension thereof as he may be entitled to, under the Contract and the Contractor has failed to carry out steps and to expedite the work in accordance with the Conditions of Contract or, if the Engineer is of the opinion that such steps are inadequate, the Engineer may after written warning notice, by written order, omit the whole or any part of the uncompleted work included in that section. The Employer shall be then, at liberty to execute such omitted work by his own workmen or by other Contractors. If the cost of such omitted or incomplete work shall exceed the sum which would have been payable to the Contractor on due completion of the said work, then the Contractor shall, upon demand, pay the Employer the amount of such excess and it shall be deemed debt due by the Contractor to the Employer and shall be recoverable accordingly.

vi) Lines and Grades

- A The Contractor shall keep the Engineer informed, a reasonable time in advance, on the times and places at which he intends to do work, in order that lines may be established and necessary measurements for record and payment made with a minimum of inconveniences to the Engineer or delay to the Contract. The Contractor shall have no claim for damages or extension of time account of delays in the giving of lines and grades, making record measurements or destruction of such marks and the consequent necessity for replacement.
- B The Engineer will furnish the Contractor with such basic lines as he, the Engineer, deems necessary, but this shall not be constructed to mean all lines, elevations and measurements. It shall be the Contractor's responsibility before commencing any section of the Work to locate the permanent bench marks to be used. The Contractor shall refer all temporary bench marks thereto.
- C The Contractor shall be responsible for the stake-out survey for construction purposes and the replacement of monuments and property, markers disturbed by the work. The survey shall proceed in advance of the construction at a rate satisfactory to the Engineer. The Contractor shall keep the Engineer fully informed as to the progress of the stake-out survey.
- D The exact position of all work shall be established from control points which are given or modified by the Engineer. Any error, apparent discrepancy or omission in the data shown or required for accurately accomplishing the stakeout survey shall be referred to the Engineer who shall take whatever corrective measures be deemed necessary.
- E The Contractor shall be responsible for the accuracy of his work and shall maintain all reference points, stakes, etc., through the life of the Contract. Damaged, destroyed or inaccessible reference points, bench marks or stakes shall be replaced by the Contractor (existing or new control points) that will be or are destroyed during construction shall be re-established and all references ties recorded therefore shall be furnished to the Engineer.



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- F All computations necessary to establish the exact position of the work from control points shall be made and preserved by the Contractor. All computations, survey notes and other records necessary to accomplish the Work shall be neatly prepared and made available to the Engineer upon request or furnished upon Contract completion.
- G All labour, instruments, equipment, stakes and other material necessary to perform the Work shall be provided by the Contractor.
- H All stakes used shall be of a type acceptable to the Engineer, clearly and permanently marked, so as to be legible at all times. It shall be the Contractor's responsibility to maintain these stakes in their proper position and location at all times. Any existing stakes or markers defining property lines and survey monuments which may be established during construction shall be properly tied in to fixed reference points before being disturbed and accurately rest in their proper position upon completion of the Work.
- I The Engineer may check all or any portion of the stake-out survey work or notes made by the Contractor and any necessary correction to the Work shall be immediately made. Such checking by the Engineer shall not relieve the Contractor of any responsibilities for the accuracy or completeness of his work.

7 COMMUNICATION AND NOTIFICATION PROVISIONS

7.1 Notices of commencement of Work Co-operation with Authorities

Before commencing any excavation the Contractor shall :

- A. In railway, public highways, footways or verges, give two weeks notice to the Engineer and PIEFZA, and shall also give such notices to the authorities as are required by the official regulations before breaking open the road, footway or verge until receipt of approval from the concerned authorities. Co-operation shall be maintained with the Police and Local Authorities regarding the control and diversion of vehicular and pedestrian traffic as may be necessary.
- B. In private lands or roads, give all necessary notices and make timely and reasonable arrangements with the occupiers before entry on the land.
- C. Give notices to the concerned Governorate, the Municipality Tele-communication Corporation the Electric Company / Authority and the police and military forces of work which may affect their cables, manholes, etc. ,The Contractor is not allowed to break any cable or manhole without the written permission of their Employer. The Contractor's attention is also draw to his responsibility to comply with Government Regulations.
- D. Before commencing any new section of work the Contractor shall have obtained the formal approval of the above mentioned Authorities. The procedure leading to such approval is described as below:
 - 1. The Contractor shall first discuss with and obtain the approval of the Engineer for the proposed working methods for each section of work.
 - 2. The Contractor shall then submit to the relevant Authorities as agreed with the Engineer notifications of his intention to commence work and give details of his proposal. The Contractor shall modify such proposed working methods if directed by the Authorities. Particular attention shall be given to the following:
 - The diversion and control of traffic. Methods for dealing with and the crossing of other services.
 - The reinstatement of excavated areas.
 - The discharge of water from excavations. - Public safety.



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7.2 Permits, Licenses and Fees

- A Unless otherwise indicated in these Contract Documents, the Contractor shall obtain and pay for all construction permits and licenses. Employer shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the Work. Contractor shall also pay all charges of utility service companies for connections to the work.

7.3 Site Progress Meetings

- A During the course of the work, Site Progress meetings shall be held at regular intervals at least once every week in the presence of the Engineer for the purpose of co-ordinating the Contractor's Works and to ensure that full compliance with the various Site meetings will be recorded, copies will be distributed to all persons concerned and full effect shall be given to all instructions contained herein.
- B Prior to such meetings the Contractor shall give to the Engineer's Representative details in writing of that portion of the Works he proposes to construct during the coming two weeks with details of the plant and methods he proposes to employ. These proposals shall be discussed at the meeting and no work based on such proposal shall proceed without the approval of the Engineer's Representative.
- C The Contractor shall have no claim against the Employer for costs incurred by him in changing the method of working or in the provision and use of other additional plant.

8 MATERIALS, GOODS AND WORKMANSHIP

8.1 General

- A Materials, goods and workmanship shall be of the best quality of their respective kind. The Contractor shall carry out everything necessary for the proper execution of the Works, whether or not shown on the Drawings or described in specifications.
- B Work for which provisional quantities are specified will be measured and dealt with in the manner stated in the conditions of Contract for provisional sums.

8.2 Customs and Local Dues

- A All state dues, tolls rates, fees and charges in connection with the works shall be deemed to be included by the Contractor in his Contract Unit Rates.

8.3 Specified Manufacturer's Products

- A Manufacturer's name or catalogue number, if shown in the specification or indicated on the Drawings, are given only for indicative purposes and for general reference only. It shall be understood that the actual material supplied shall meet the requirements of the specifications. If necessary, the material specified under such manufacturer's name or catalogue indicated for reference, shall be modified under the direction of the Engineer.
- B Provided always such modified material shall meet the requirements of the specified material together with the requirements of other materials specified for other trades in these specifications.
- C Any modification under such conditions shall not give the right to the Contractor to claim against any loss or extra cost incurred.



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8.4 Alternative Materials

- A Should the Contractor wish to offer alternative items or materials to those specified, he shall supply details of such alternatives together with details of any reduction in the Contract price should the alternative be allowed to be substitute for the specified items of materials. All offered alternatives shall comply fully in all respects with the specifications of the particular items or materials. Acceptance or refusal of such alternatives will be entirely at the discretion of the Engineer.
- B If during the course of the Contract certain materials or items required for use in the Works should be unobtainable, despite the best effort of the Contractor, he may offer for the approval of the Engineer alternative materials or items, provided that they possess the minimum requirements of the originally specified material.
- C In the event of acceptance of any alternative materials or items, a suitable price reduction shall be made in respect of any decrease in value but no price addition shall be made in respect of increase in value.
- D In the event of refusal of any alternative materials or items the Contractor shall not be relieved of any of his obligations under the Contract and shall be solely liable for any delay or loss occasioned by his failure to provide the material or items as specified.

8.5 Imported Materials

- A The Contractor is required to produce documentary evidence that all imported materials or items have been ordered shortly after the site is handed over for the commencement of the Works. This means materials or items which have to be ordered from abroad. As soon as orders have been placed, copies of such orders shall be submitted to the Engineer.
- B Consequently, no claim will be considered for extension of the Contract Period due to non-availability of materials unless for force measures as decided by the Engineer.

9 PROTECTION AND CONSERVATION OF THE WORKING ENVIRONMENT

9.1 Precautions against Contamination of the Works

- A The Contractor shall satisfy the Engineer that all his personnel working on the site are medically fit to be in contact with a public water supply and his personnel shall undergo any necessary medical test to show that they are free from any infectious diseases and are not carriers of any such diseases.
- B The Contractor shall at all times take every possible precaution against contamination of the Works. The Contractor shall give strict instructions to all persons employed by him to use the sanitary accommodation provided.
- C Throughout the Contract the Site and all Permanent and Temporary Works shall be kept in a clean, tidy and sanitary condition.
- D The Contractor shall at all times take measures to avoid contamination of existing water-courses and drains by petrol products or other harmful materials.
- E The Contractor shall be responsible for making all arrangements for the disposal of wastewater including the disposal of water from the water testing of mains on his own expense. He shall be responsible for obtaining permits from Local Governates prior to such disposals.



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9.2 Archaeological Site and Artefacts

- A If, during construction, excavations reveal remains and artefacts of archaeological interest, the Contractor shall immediately inform the Engineer and abide by the Engineer's directions, and shall coordinate and modify the sequence of the execution of the Work. It should be understood that the sole owner of the archaeological site and artefacts is the Palestinian National Authority.

9.3 Suppression of Noise and Pollution

- A The Contractor shall make every reasonable endeavor both by means of temporary Works and by the use of particular plant or silencing devices to ensure that the level of noise or pollution resulting from the execution of the Works does not constitute a nuisance.
- B The Contractor shall take all such precautions as may be necessary in the conduct of the work to avoid water pollution, air pollution, noise pollution harmful to health, spreading of plant diseases and pests or damage to natural resources or the environment, all as is consistent with good practice and as required by applicable laws, ordinances and regulations or lawful orders or authority having jurisdiction.

9.4 Site Cleanliness

- A The Contractor shall make every effort to keep his site in a clean and orderly manner. He shall not deposit his builders' refuse indiscriminately but shall arrange for all waste to be transported to an authorized pit. He shall not deposit his refuse into trenches in backfilling.
- B Public highways services, streets, paved paths, passages, pavements, etc., must be kept clean and free of spoil and rubbish and must be brushed and washed as required by the Engineer.
- C If the Contractor fails to keep his site clean after receiving the Engineer's written warning notice, then the Engineer will instruct a third party to carry out the work and the costs shall be recovered from the Contractor through the Contract.

9.5 Cleaning Up

- A On or before the completion of the work, the Contractor shall, unless otherwise especially directed or permitted in writing, tear down and remove all temporary buildings and structures built by him; shall remove all temporary Works, tools and machinery or other construction equipment furnished by him; shall remove, acceptably disinfect, and cover all organic matter and material containing organic matter and in, under and around privies, houses and other buildings used by him; shall remove all rubbish from any grounds which he has occupied and shall leave the roads and all parts of the premises and adjacent property affected by his operation in a neat and satisfactory condition.
- B The Contractor shall restore or replace, when and as directed, any public or private property damaged by his work, equipment, or employees, to a condition at least equal to that existing immediately prior to the beginning of operations. To this end the Contractor shall do as required all necessary highway or driveway, walk and landscaping work. Suitable materials, equipment and methods shall be used for such restoration.
- C The Contractor shall thoroughly clean all materials and equipment installed by him and his subcontractors and on completion of the work shall deliver it undamaged and in fresh and new appearing condition. All mechanical equipment shall be left fully charged with lubricant and ready for operation.



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9.6 Protection of Works

- A The Contractor shall take every care to prevent damages to the Works from whatever cause and shall ensure that adequate protection is given to all Works from activities of following trades and nominated Sub-Contractors. Vulnerable parts of the Work particularly liable to damage, shall be protected as may be reasonable required by the Engineer's Representative.
- B The Contractor shall keep all persons (including those employed by Sub-Contractors) under control and within the boundaries of the Site. He will be held responsible for the care of the existing premises and of the Works generally until their completion, including all work executed and materials, goods and plant (including those of sub-Contractors and suppliers) deposited on the Site; together with all risks arising from the weather, carelessness or of work people, damage or lost by theft or any other cause; and he shall make good at his own expense, all such damage and loss.
- C The Contractor shall keep the Works well drained until the Engineer certifies that the whole of the Works is substantially complete and shall ensure that so far is practical, all Work is carried out in the dry weather. Excavated areas shall be kept well drained and free from standing water.
- D The Contractor shall construct, operate and maintain all temporary dams, watercourses and other Works of all kinds including pumping and well point de-watering plant that may be necessary to exclude water from the Works while construction is in progress. Such temporary Works and plant shall not be removed without the approval of the Engineer's Representative.
- E Notwithstanding of any approval by the Engineer of the Contractor's arrangements for the exclusion of water, the Contractor shall be responsible for the sufficiency thereof and for keeping the Work safe at all times particularly during any floods and/or making good at his own expense any damage to the Works including any that may be attributable to flood. Any loss of production of additional costs of any kind that may result from floods shall be at the Contractor's own risk.

9.7 Operation of Existing Utilities

- A The existing utilities must be kept in continuous operation throughout the construction period. No interruption will be permitted which adversely affects the level of service provided.
- B Provided permission is obtained from Employer and Engineer in advance, portions of the existing utilities may be taken out of service for short periods corresponding with periods of minimum service demands. Such permission will not relieve the Contractor of any of his responsibilities under the Contract.

9.8 Location of Existing Subsurface Structures and Utilities

- A Before beginning excavation operations, the Contractor shall contact the specified Departments and Authorities and notify them of his intention to begin excavation operations.
- B The Contract Drawings may show certain utility or other structures or facilities believed to exist in the working area, the exact location of which may vary from the locations indicated. All other structures or facilities may not be shown. The Drawings do not show all existing subsurface structures or utilities.
- C It shall be the responsibility of the Contractor to determine the exact location of such pipeline, subsurface structures and / or utilities ahead of his Work by exploratory, excavation or other means and to take suitable precautions to prevent damage to them and to prevent interruption of the services which such facilities provide. If they are



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- unintended broken or damaged, they shall be restored by the Contractor or the appropriate utility at the Contractor's expense.
- D Where necessary, the Contractor shall use hand tools to excavate test pits prior to excavation to determine the exact locations of existing utilities. It shall be the responsibility of the Contractor to make such explorations sufficiently in advance of construction to enable the Engineer to approve modifications, if any, to be made to the pipeline, structure or conflicting utility. The Contractor shall obtain the permission of the Engineer before commencing any test pits and shall fence, mark and protect them, as required by the Engineer. Test pits shall be refilled by hand as soon as practicable after the necessary information has been obtained.
- E As the excavation approaches sewers conduits, cables or other underground facilities, and with care the excavation shall be continued by means of hand tools. Where necessary, the Contractor shall provide temporary support for the existing utilities to prevent damage during his operations. Notwithstanding these provisions, if damage to existing utilities results from the Contractor's operations, such damage shall be repaired without delay by the Contractor or such repairs shall be borne by the Contractor.
- F If damage to existing utilities causes disruption to Contractor's Schedule of Work by delaying Work in the area of such damage, the Contractor shall readjust his Schedule, methods of working and resources so that critical dates in the Schedule for the completion of the Contract are not affected.
- G In case of pipelines, subsurface structures and /or utilities encountered in the work coincide with the pipe line route, the Engineer shall have the authority to change the plans and order a deviation from the line and grade, or arrange with the Employers of the existing structures for removal, relocation or reconstruction of the obstruction following the procedures of the Employer at the Contractor's expense.
- H If the change in plans results in change of the length of pipes to be executed by the Contractor, such altered work shall be done on the basis of payment to the Contractor for extra length or credit to the Employer for less work. This payment will be made for extra exploration and relocation of structures and utilities, pipes, valve chambers, excavation, backfilling and depth of line due to these changes. Conditions of the Contract (please refer to CC clause 62.1)

9.10 Other Construction Activities

- A The Contractor shall note that other works, might be constructed in the Site of Works. He shall co-operate with the construction of such works in organizing their respective contracts so as to cause minimum of interference to each other and to the public. No claims resulting from such co-operation shall be entertained by the employer except as stipulated in the Conditions of Contract.

10 ACCESSIBILITY TO WORKING SITE AND TRAFFIC REGULATION

10.1 Limits and Restrictions to Working Site

- A Generally, working sites shall be confined by physical restrictions and the maintenance of accesses and traffic flow. The Contractor shall agree on the extent of his working areas with the concerned Authorities and the Engineer.

10.2 Access Roads

- A The Contractor shall construct and maintain such temporary access roads as he may require for carrying out the Works at his own expense.



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- B Immediately after ceasing to use any of the temporary roads the Contractor shall restore the road to the satisfaction of the Engineer and the responsible Authority or Employer. The provision of this Sub-Clause shall apply also to the shoulders and verges of any existing sealed road used by the Contractor affected by his operations.
- .C The Contractor shall at his own expense maintain and repair any damage caused to highways, streets and underground structures by his vehicles, irrespective of any protective measure taken.

10.3 Restrictions on use of Roads

- A The Contractor shall not run tracked vehicles or tracked plant on any public or private road without the written approval of the Engineer and the responsible Authority or Employer and subject to such conditions as each may require.
- B The Contractor shall observe all weight and dimension restrictions which apply to roads and tracks in Palestine and he shall comply with all reasonable restrictions which may from time to time be imposed by the Engineer, Employer, Police, Ministry of Public Works or responsible Authority.

10.4 Site along Pipelines in Roads

i) General

- A Without prejudice to the generality of the Conditions of Contract, the site along with pipelines in roads, unless the road is closed as hereafter provided, shall so far as possible be so limited that in all cases a free passage along such roads shall be maintained for vehicular traffic and pedestrians.
- B The Contractor shall provide access to all properties including garages fronting on such roads
- C The Contractor shall assume and have full responsibility for the adequacy of safety provisions on all streets, roads, private ways and walks affected by his work.

ii) Public Roads

- A Notwithstanding requirements stated elsewhere in the Specification, the Contractor shall comply with the additional requirements contained in this Clause whenever carrying out any work in connection with pipelaying in or adjacent to public roads.
- B The Contractor shall at all times carry out any work in or adjacent to public roads in manner to the approval of the Engineer and the competent Authorities and only at such times and during such hours as may be agreed by the competent Authority.
- C At no time shall the Contractor commence work in or adjacent to any public road without the prior approval of the Engineer.
- D The Contractor shall, when working in or adjacent to any public road, cause the least interference possible to the flow of traffic and shall at all times, maintain unimpeded sufficient width of the carriageway, at no time less than 3m, to permit single lane traffic.



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- E The Contractor shall control the flow of traffic past restrictions caused by his operations by means of electrical controlled flashers positioned ahead of and behind the restricted section of heavy traffic road. The traffic lights shall be to the approval of the Engineer and be lit at all time and for as long any restrictions caused by the Contractor's operations exist. Traffic lights shall be continuously attended by flag men and the time interval between light changes shall be capable of adjustment to suit varying patterns of traffic flow. Warning signs shall be posted well in advance of any section of restricted road.
- F All sections of roadway affected by the Contractor's operations shall be bounded by barriers, tapes, bunting or similar means to afford adequate and effective warning, such as flagging, lighting, watching and traffic control to all road users. Such boundaries shall in addition be adequately lit by warning lanterns at all times during the hours of darkness.
- G The Contractor shall at no time string pipes on the carriageway of any public road.
- H The Contractor shall arrange his work in or adjacent to public roads in such a way that at no time the length of road restricted by his operations exceeds 100 meters in urban areas and 500 meters in rural areas.

10.5 Closing of Roads, Traffic Diversion and Control

i) Closing of Roads

- A The Contractor shall not close any road unless the Authority having charge of the road surfaces shall have previously given the appropriate notice or made the appropriate order and without the Contractor having first obtained the written consent of the Local Authority to close the same. In the event of such consent being refused, the Contractor shall have no claim for any additional payment. In the event of such consent being given, the Contractor shall provide, fix and maintain all warning signs and diversion notices as may be required by the said Authority and by the Engineer.

ii) Traffic Diversions

- A Traffic diversions shall be planned by the Contractor with the Engineer, the Traffic Section of the Public Works Directorate and the Traffic Directorate of the Ministry of the Interior. No diversion shall be implemented without the written consent of the Engineer. Access to a closed road shall be made available to any vehicle of the emergency services.

iii) Traffic Signs

- A The Contractor shall provide, erect and maintain on the Site and such locations on the approaches to the Site, as may be required by the Traffic Directorate and / or the Engineer, all traffic signs and traffic control signals necessary for the safe direction and control of traffic. This shall apply whether the Site is in or immediately adjacent to the carriageway such that normal passage of traffic is affected.
- B The size of all such signs and the lettering thereon shall be approved by the Engineer before erection of the signs. All signs shall have directions written in both Arabic and English and shall carry direction arrows where appropriate. The signs shall be reflectorized or adequately illuminated by night in a manner approved by the Traffic Directorate and/or the Engineer and kept clean and legible at all times. The Contractor shall reposition, cover or remove signs as required during the progress of the Works.



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- C Wherever single file traffic is necessary on a highway by reason of the construction of the Works, the Contractor shall provide and maintain a minimum carriageway width of 3 meters or wider where necessary as so instructed by the Engineer.

11 SAFETY PROVISIONS

11.1 Safety and Accommodation for Contractor's Staff

- A The Contractor shall ensure that all safety and welfare measures required under or by virtue of the provisions of any enactment or regulation are strictly complied with.
- B The Contractor shall provide and maintain suitable and sufficient shelters and mess rooms for his workmen and supervisory staff as are customary and necessary.
- C The Contractor shall provide at all construction sites sufficient closets or latrines to comply with Government Regulations. They shall be properly screened and maintained in a clean and sanitary state at all times.
- D Camps for workmen, if provided, shall comply with all relevant Government Regulations and shall be laid out in an approved and orderly manner. Proper provision shall be made for the disposal of all waste and refuse, and there shall be an adequate supply of water for washing, cooking and drinking purposes. Sleeping quarters shall be properly ventilated and lighted, and the whole camp shall be maintained and cleaned at all time to comply with Government Regulations.

11.2 First Aid Outfits

- A The Contractor shall provide and maintain for the duration of the Contract adequate first aid outfits at each construction site. The Contractor shall provide for the transport of serious cases to nearest hospital.

11.3 Protective Equipment and Clothing

- A The Contractor shall provide and maintain all necessary protective and safety equipment and clothing for the operative and Site staff.

11.4 Safety of Adjoining Existing Buildings

- A The Contractor shall take all necessary precautions during the excavation for the Works particularly those excavations which are adjoining existing building and shall protect such buildings from damage or collapse by means of temporary or permanent shoring, strutting, sheet piling or underpinning or excavation in short length and/or other methods as he deems fit. Also, he shall properly support all foundations, trenches, walls, floors, etc., affecting the safety of the adjoining existing buildings.
- B The Contractor shall alter, adopt and maintain all such Works described above for the whole period of the Contract and shall finally clear away and make good all damages done.
- C The construction and efficiency of the shoring, underpinning, strutting, etc. ... , for the purpose for which it is erected shall be the responsibility of the Contractor. Should any subsidence or any other damage occur due to the inefficiency of the shoring, underpinning, strutting, etc. , or any other support provided, the damage shall be repaired by the Contractor at his own expense and responsibility.



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- D The shoring, strutting, piling, etc. , shall be executed in such a manner as to cause as little inconvenience as possible to adjoining Employers or the public and the Contractor shall be responsible for negotiating with the adjoining Employers the means to safeguard their property and for the use of any portion of their land for the purpose of executing the excavations and no claims submitted on this ground will be entertained.
- E The Contractor shall be held solely responsible for the safety of the adjoining existing buildings, the sufficiency of all temporary or permanent shoring, underpinning, strutting, piling, etc.,
- F The Contractor shall keep the Engineer informed as to the manner in which he intends to proceed with the execution of the excavations, submit his proposed methods of shoring, etc., and obtain his approval, such approval if given shall not absolve the Contractor of his responsibility under this clause.
- G The Contractor shall save harmless and indemnify the Employer in respect of all claims, demands, proceedings, damages, costs, charges and expenses whatsoever arising out of or in relation to any such matters in so far as the Contractor is responsible under this clause.

12 VISIBILITY

12.1 Signboards

- A The Contractor shall provide, erect and maintain TWO signboards as specified in the General Conditions of Contract

13 COMMISSIONING AND TESTING

13.1 Tests for Water Tightness of Structures

- A The tests will be applied on structures for projects within high water table areas. Other projects will be evaluated by the Engineer for the necessity of such tests.
- B Water retaining structures shall be capable of withstanding the following tests for water tightness:
 - C When ordered by the Engineer and before backfilling, the structures shall be filled with water by the Contractor at his own expense and with rates and to the depths approved by the Engineer and kept filled for one week.
 - D The water used need to be equal to normal drinking water but the source of the water shall be approved by the Engineer.
 - E The structure when filled shall satisfy the test if at the end of one week no leakage is apparent.
 - F Upon completion of the test the Contractor shall empty the structures and dispose satisfactorily of the contents. He shall clean the structures and any equipment therein of all deposits left by the testing water.
 - G The tests referred to above, shall be performed at the Contractor's expense and shall be considered incidental to the Contractor.



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13.2 Inspection

i) Inspection of Site

- A The Contractor shall be deemed to have inspected and examined the Site and its surroundings and to have satisfied himself before submitting his Tender as to all matters relative to the nature of the site, details and levels of existing services, the quantities and nature of the work and materials necessary for the completion of the works, the means of access to the Site and the accommodation he may require, and in general to have himself obtained all necessary information as to risks, and other climatic hydrological and natural conditions or such contingencies which may influence or effect his Tender. No claim will be entertained in the connection.

ii) Shop Inspection and Testing

- A All materials furnished by the Contractor shall be subject, at the discretion of the Engineer, to inspection and approval at the plant of the Manufacturer. The expenses of the inspection including transportation, accommodation and other logistics will be carried by the contractor.

iii) Inspection of Adjacent Structures

- A Buildings and other structures in such close proximity to the trenches that they may be damaged by excavation and other work shall be inspected before work is commenced. All parties concerned shall be summoned to the inspection by the Contractor. The inspection shall be made by the Engineer and the Contractor together, and the Contractor at his own expense, shall work out an inspection report. The report shall describe the conditions of the buildings or plants in question. Any failure or damage caused by the excavation shall be repaired and maintained by the Contractor at his own expense without delay.

iv) Final Inspection of Works

- A Upon the request of the Contractor items that are completed will be finally inspected by the Engineer. The Contractor shall hereby provide at his own cost all facilities and labour required for the proper inspection all work will be checked so as to meet with the specifications given in the Contract Documents, all streets in the contract area may be inspected by the municipality and test may be carried out to verify that the surface restoration has been completed in accordance with the Specification of the Municipality and the Ministry of Public Works.
- B All restoration work not accepted by the Municipality, whether due to poor workmanship, settlement of trenches or damage to asphalt surface by the Contractor's heavy equipment shall be rectified by the Contractor at his own expense before the provisional handing over certificate is issued.

v) Inspection during Maintenance Period

- A The Engineer shall give the Contractor due notice of his intention to carry out any inspections during the period of maintenance and the Contractor shall thereupon arrange for all necessary equipment labour, etc., and for a responsible representative to be present at the times and dates named by the Engineer. This representative shall render all necessary assistance and take note of all matters and things to which his attention is drawn by the Engineer.



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0.13.3 Late Submission for Testing

- A It shall be the Contractor's responsibility to ascertain which materials and articles are required to be tested and to present such materials and articles or samples or specimens thereof for testing. Should there be doubt as to whether any material or article is required for testing the Contractor shall seek clarification from the Engineer and the Contractor will be entitled to no claim whatsoever for delay or any other cause arising from the rejected of materials or articles which the Contractor omitted to submit for testing.
- B It shall further be the Contractor's responsibility to prepare samples and specimens and submit for testing well in advance of the time the materials or articles will be required for use. The Contractor shall not be entitled to any compensation nor shall any claim be accepted by the Employer in respect of delay, inconvenience, damage, standing time or any other cause whatsoever, arising from or consequent on late submission of materials or articles for testing.



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SECTION 1 WATER QUALITY DATA

1.1 Raw water quality data

Raw water supply as per GIE wells analysis data sheet:

- Total dissolved solids (TDS) < **4,500 ppm.**
- Chlorides = **3,000 ppm.**
- Nitrates = **70 ppm.**

The contractor should make a recent analysis for the raw supply water to confirm the quality of water. The lab should be approved by the engineer.

1.2 Feed water quality data

A The feed water quality (entering the RO unit) should be within the following limits, as indicated in the table below:

Description	UoM	Normal range	Reference Values
Physical			
TDS	mg/l	4000	Max 4,500
Operating water temperature	°C	18 - 28	15 – 30
Cleaning water temperature	°C	40	Max. 45
Turbidity	NTU	< 0,5	< 1
Chemical			
<i>Organic Matter</i>			
Fat, Oil and harmful elements		Not present	
<i>Inorganic Matter</i>			
Operating pH		2,7 – 7,0	2,5 – 7,3
Cleaning pH		--	3 – 11
Free chlorine	mg/l	0	0
Total chlorine	mg/l	0	0
Sulfate as SO ₄	mg/l	2 – 3	
Silica as SiO ₂	mg/l	< 5	Max. 10
<i>Heavy Metals</i>			
Iron Fe	mg/l	< 0,05	< 0,1
Manganese	mg/l	< 0,02	< 0,05
Biological			
Total Bacteria count	CFU/m l	< 5	< 10
Quality Control			
Silt Density Index (SDI)	units	< 3,0	< 4, peak max. 5
Oxidation- Reduction Potential ORP	mV	< + 250	Max. + 350



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1.3 Product water quality data

A The product water quality should be within the following limits, as indicated in the table below:

Description	UoM	Normal range	Reference Values
Physical			
TDS	mg/l	< 200	Norm
Turbidity	NTU	5	max.
Chemical			
<i>Organic Matter</i>			
Fat, Oil and harmful elements			Not present
<i>Inorganic Matter</i>			
pH		7- 8	Min/max
Chlorides (Cl)	mg/l	30	max.
Sulfates (SO ₄)	mg/l	< 50	max.
Nitrates (NO ₃)	mg/l	< 20	max.
Total hardness as CaCO ₃	ppm	100	Min-Max.
m-Alkalinity as CaCO ₃	ppm	30-50	Min-Max
Free Chlorine	mg/l as Cl ₂	< 1	max.
Quality Control			
Langlier Saturation Index LSI		+ 0,1 ÷ +0,3	Positive



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1.4 ELECTRICAL AND CONTROL

1.4.1 Electrical Supply and Management

- A Electrical Control Panel. The R.O. system electrical control panel shall be a FRP enclosure with hinged door, waterproof and dustproof. The main means of control shall be a programmable logic controller. The controller shall be integrated with a touch screen, on which the operators can check operating parameters, and otherwise monitor the plant operation. The panel shall contain all the control logic circuitry for the R.O. system, wells, pre-treatment and post-treatment and distribution systems, with all switches, indicators, etc. mounted on the door. The following switches and indicator lights are required as a minimum:
- ✓ Main Power Indicator light
 - ✓ Control Power Indicator Light
 - ✓ RO Feed Pump Low Suction Pressure Indicator Light
 - ✓ RO Pump High Discharge Pressure Indicator Light
 - ✓ Low Feed pH Indicator Light
 - ✓ High Feed pH Indicator Light
 - ✓ Scale Inhibitor Low Flow Light
 - ✓ Product High Conductivity Indicator Light
 - ✓ Brine Low Flow Indicator Light
 - ✓ Scale Inhibitor Low Level Indicator Light
 - ✓ Acid Level Low Indicator Light
 - ✓ Hypochlorite Level Low Indicator Light
 - ✓ Storage Tank High Level Indicator Light
 - ✓ Storage Tank Low Indicator Light
 - ✓ Distribution pumps on/off/failed-one set for each pump
 - ✓ Product Water pH High/Low
 - ✓ Product Water Turbidity High
 - ✓ Product Water Chlorine Residual High/Low
 - ✓ Hydropneumatic tank air pressure Low
- B An electrical panel shall be provided. The panel shall house the RO pump starter, well pump starter, distribution pump starters, and the hydro-pneumatic system pump controls.

1.4.2 Process Control System

- A This specification includes the functional requirements for hardware, firmware and software, training, testing, and placing in service of a programmable micro-processor-based Process Control System (PCS).
- B Training: PCS supplier will provide 2 days of instruction for operation of PCS, 2 days for programming of the PCS and 2 days for maintenance of the PCS.
- C Programmable Logic Controller : The PLC shall be a microprocessor-based stand-alone device. It shall be a process and logic controller designed for industrial environments. It shall be capable of a mix of logic, timing, counting, computation, and PID loop control necessary for the unit process application and shall include a library of preprogrammed subroutines. The PLC shall utilize a “pre-packaged”/“pre-programmed” approach to functionality to allow its use by personnel who have no formal training in digital equipment, digital communications, or software programming.
- The PLC shall be complete with central processor, memory, power supply, interconnecting cables, and discrete and analog I/O interfaces.



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- D All hardware and software requirements for the workstation must be supplied and placed in service

1.5 WATER QUALITY TESTING UNIT & EQUIPMENT

- A This specification includes all laboratory instrumentation and testing kits to be supplied by the tenderer in addition to the line-mounted control instrumentation for monitoring the water quality throughout the treatment process, and as specified above.
- B The following table lists the elements to be supplied:

LABORATORY INSTRUMENTS AND TESTING KITS			
	Description	Type	Quantity
1	Portable pH / ORP Meter	WTW or equivalent	1
2	Portable Conductivity Meter	WTW or equivalent	1
3	chlorine test 0,05 - 2 mg/l	MERCK or equivalent	1
4	chlorine test 0,5 - 10 mg/l	MERCK or equivalent	1
5	Acidity Test Kit	MERCK or equivalent	1
2	m-Alkalinity Test Kit	MERCK or equivalent	1
7	Total Hardness Test Kit	MERCK or equivalent	1
8	Portable Turbidity Meter	MERCK or equivalent	1
9	standard set Turbiquant 1500 IR	MERCK or equivalent	2
10	Silt Density Meter	MERCK or equivalent	1
11	filter for SDI Type HAWG04700	MERCK or equivalent	100
12	Bottle SIMAX 250 ml	MERCK or equivalent	1
13	Portable Thermometer	MERCK or equivalent	2
14	Volumetric flask, 500 ml	MERCK or equivalent	1
15	1 ltr beaker	MERCK or equivalent	5
12	burettes 50 ml	MERCK or equivalent	5
17	1000ml plastic bottles for samples	MERCK or equivalent	10



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18	1000ml graduated plastic buckets	MERCK or equivalent	2
19	2000ml graduated plastic buckets	MERCK or equivalent	2
20	5000ml graduated plastic buckets	MERCK or equivalent	2

EQUIPMENT FOR CHEMICAL HANDLING AND SAFETY EQUIPMENT			
	Description	Type	Quantity
1	Workbench		1
1	Closed boards for instruments		2
2	Weighting scale Mod. PM-20P		1
3	Plastic container Mod. neoLab		2
4	First aid kit		1
5	Plastic boots for chem. handling		2
2	Apron for chem. handling		2
7	Gloves for chem. handling		2
8	Eye glasses protection mask		2
9	Eye protection mask		2
10	Transportation carriage		1

1.6 COMMISSIONING & TESTING

- A The following sections refer to the commissioning and testing requirements to be met for the successful installation and operation of the works

1.6.1 Running Test

- A Before handing over the Skid Mount Reverse Osmosis Plant, a running test shall be performed at the plant site according to the methodology specified herein after, to comply with the efficiency requirements of the desalination plant.
- B The Running Test shall be performed during 5 (five) days according to the following specifications:

Running Test hours per day:	10 hours
Total Running Test duration:	50 hours
Minimum number of samples per day:	2 samples of permeate water 2 samples of potable water

The collected samples (minimum 4 samples/day) shall be analyzed on a daily basis by an external laboratory, which shall provide the following minim data:

Description	Value	UoM
Physical		



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TDS		ppm
Temperature		°C
Turbidity		NTU
Chemical		
<i>Inorganic Matter</i>		
pH		
<i>Anions</i>		
Bicarbonate (HCO ₃)		mg/L
Chloride (Cl)		mg/L
Nitrate (NO ₃)		mg/L
Sulfate (SO ₄)		mg/L
<i>Cations</i>		
Potassium (K)		mg/L
Sodium (Na)		mg/L
Calcium (Ca)		mg/L
Magnesium (Mg)		mg/L
<i>Other constituents</i>		
Total Hardness		ppm
Total Alkalinity as CaCO ₃		mg/L
Biological		
Fecal Coliforms		MPN/100ml

C The parameters on the following Running Test Sheet shall be provided for the highlighted measuring points:

RUNNING TEST SHEET								
	PARAMETER BY ELEMENT	MEASURING POINT	Date					
			Time					
A	DUAL MEDIA FILTER							
1	Raw water salinity	RO Plant	TDS					
2	Raw water pH value	RO Plant	pH					
3	Raw water temperature	RO Plant	°C					
4	Flow DMF filter	RO Plant	m3/h					
5	Differential pressure dual media filter	RO Plant	bar					
B	REVERSE OSMOSIS PLANT							
1	Differential pressure cartridge filter	RO Plant	bar					
2	RO feed pressure	RO Plant	bar					



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3	RO brine pressure	RO Plant	bar					
4	RO differential pressure	RO Plant	bar					
5	Permeate flow	RO Plant	m ³ /h					
2	Brine flow	RO Plant	m ³ /h					
7	RO feed salinity	RO Plant	TDS					
8	RO feed ORP	RO Plant	mV					
9	Permeate Salinity	RO Plant	TDS					
10	HP pump frequency	RO Elect Panel	Hz					
11	HP pump current consumption	panel	Amps					
12	HP pump voltage	panel	Volts					
C	LIMESTONE FILTER							
1	Limestone filter flow	RO Plant	m ³ /h					
2	Free chlorine	RO Plant	Cl ₂					
3	Potable water pH value	RO Plant	pH					
4	Salinity after lime stone filters	Site Lab.	TDS					
5	TDS	Ext. Lab.	mg/l					
2	Chloride	Ext. Lab.	mg/l					
7	Total Hardness as CaCO ₃	Ext. Lab.	ppm					
8	LSI	Site Lab.						
9	Temperature	RO Plant	°C					
10	pH	Ext. Lab.						

- D The stand by generator shall be available in case of electricity shut down
- E The Running Test shall be performed at the presence of all project partners (UNDP, PIEFZA, PWA representatives).
- F The Running Test costs will be completely at the contractor's charge and all related cost of the project's partners' transportations and accommodation.

1.6.2 Silt Density Index- SDI

- A This test method covers the determination of the Silt Density Index (SDI) of water. This test method is used to indicate the quantity of particulates, colloids in low turbidity water (< 1,0 NTU).
- B The test is specified in the ASTM Standard D 4189. The feed water to RO plant shall have a SDI15 of preferable less than 3, max. 4 .The SDI shall be measured once per week after the cartridge filter. For checking the performance of the dual media filters the SDI in the feed water and after the dual media filter shall be checked in intervals of 2 – 4 weeks.
- C The procedure for measuring the SDI shall be as follows:
1. Before installing the Millipore filter paper, flush the water to be tested through the apparatus to remove entrained contaminants.
 2. Measure the watertemperature.



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3. Open the membrane filter holder, and place a 0.45µ filter (47mm in diameter) on the support plate of the holder. Handle filter only with blunt tweezers to avoid contamination, and puncturing. Do not touch the filter with fingers.
4. Make sure the O-ring is in good condition and properly placed. Replace the top half of the filter holder and close loosely.
5. Bleed out trapped air by cracking the ball valve. Close valve and tighten the filter holder.
6. Open ball valve. At the same time, using a stop watch, begin measuring the time required to collect 500ml of water. Record the time, t_i . Leave the valve open for continued flow.
7. Measure and record time to collect 500ml after 5, 10, 15 minutes of total elapsed flow time.
8. Measure the water temperature. Temperature must remain constant throughout the test.
9. After completing the test, retain the filter paper by taping to a paper with scotch tape. The filter may also be sent for laboratory analysis to determine what materials are on the paper.
10. The SDI is calculated using the following formula:

$$SDI = \%P/T = (100(1-(t_i/t_f)))/T$$

Where:

P30 = plugging at 2 bar feed pressure. For accurate SDI measurements, P30 should not exceed 75%. If this value is exceeded, pre-treatment may be required. t_t = total test time in minutes, usually 15, but tests should also be made at 5, and 10.

t_i = initial time to collect 500ml of filtered sample. Measured in seconds.

t_f = time required to collect 500ml after the test time, usually 15 minutes. Measured in seconds.

D Results of the SDI calculation shall be reported as per the following template:

LOG SHEET FOR SILT DENSITY INDEX MEASURING		
DESCRIPTION	VALUE	REMARKS
Date:		
Test number:		
Test point:		
Medium:		
Water temperature [°C]		
Time for filtration of 500 ml [Seconds]:		
at start (t_i)		
after 5 minutes (t_5)		
after 10 minutes (t_{10})		
after 15 minutes (t_f)		
Test duration time [minutes] (T)		
Calculated SDI		

shown
below,
pressure
bar (30



1. Assemble the apparatus as in the figure and set the regulator to 2 psig)



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Notes for filter disc: Appearance, etc:	
Test made by:	

1.7 TECHNICAL EVALUATION of the RO UNIT

1.7.1 Cost Analysis

A The following table lists the major costs contributing to the monthly running costs. The contractor shall fill in the blanks according to the calculation required and specified here below

BWDP COST ANALYSIS

Expected monthly Total production..... m³

No.	Description			No.	Description		
1	Staff Cost	Salary \$		4	Material fixed cost	Unit	Cost \$
1,1	Operator			4,1	membranes		
1,2	Electrician (Part time)			4,2	spare parts		
1,3	Accountant (Part time)			4,3	Water analysis		
1,4	Guards and cleaner			4,4	Repair & maintenance		
1,5	Guards and cleaner						
	Total				Total		
	Specific staff cost (\$/m3)				Specific material fixed cost (\$/m3)		
2	Power and fuel cost	Qty	Cost \$	5	miscellaneous fixed costs	Unit	Cost \$
2,1	Power consumption Kw/h			5,1	comm.& Computers		
2,2	Fuel consumption (Liter)			5,2	Insurance		
				5,3	Fees		
	Total				Total		
	Specific Power & fuel cost (\$/m3)				Specific miscellaneous fixed cost (\$/m3)		



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3	Chemicals Cost	Qty	Cost \$	2	Other Expenses	Unit	Cost \$
3,1	Hcl (30%) Kg			2,1			
3,2	Sodium Hypochlorite Kg			2,2			
3,3	Sodium metabisulfite Kg			2,3			
3,4	Ferric Chloride Kg						
3,5	Caustic Soda Kg						
	Total				Total		0
	Specific Chemical cost (\$/m3)				Specific Other Expenses Cost (\$/m3)		

TOT. PRODUCTION COST [\$ /m³]			TOT. MONTHLY COST [\$]	
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SECTION 2 - EARTHWORKS

2.1 Scope of Work

- A This section covers trenching and backfilling work and shall include the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property; pipe embedment; surfacing and grading; and other related work.

2.2 Site Preparation

- A Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey, record existing ground elevations and stake the location of trenches to be excavated.
- B The Contractor shall prepare the site for construction by clearing, removing and disposing of all items not indicated on the Drawings to remain or so defined by the Engineer.
- C The Contractor shall obtain relevant excavation and road cutting permits as required to commencing work.

i) Existing Subsurface Structures and Utilities

- A For all works required to deal with existing subsurfaces and utilities refer to General Section of these Specifications.

ii) Clearing, Grubbing and Grading

- A The Contractor shall perform the clearing and grubbing (if any), of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300 mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and off loaded, spread and levelled to approved dumps as directed by the Engineer.



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- B The Contractor shall include for grading the route to provide access for his equipment and personnel, executing all cuttings to remove the high point of rises in terrain and in all respects prepare the route for pipe laying operations, all in accordance with the requirements of good pipeline construction practice.

2.3 Setting-Out

- A The Contractor shall stake-out the work as shown on the Drawings and secure the Engineer's approval of his stake-out before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out, the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-out for further approval in accordance with the relevant Clause of the Conditions of Contract.



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2.4 Excavation

- A The Contractor shall perform all excavation true to lines, widths and depths shown on the Drawings or to such further lines, depths or dimensions as may be directed by the Engineer.
- B Excavation work will be classified according to the quality of the material to be excavated. In three classes as follows
 - 1. Excavation in Rock
 - 2. Excavation in sand
 - 3. Excavation in mixed soil
- C The soil classes in every section of the pipeline will, if necessary, be determined by the engineer on the basis of the following definitions:
- D **Excavation in Rock** shall include the removal of hard and solid rock in continuous layers or boulders that cannot be broken up by ordinary excavating equipment including rooter, and which necessitate the use of pneumatic tools or wedges for loosening and removal.
- E **Excavation in Sand** shall include excavation in loose or dense sand , such as drifting sand(dunes).
- F **Excavation in mixed soil** shall include the removal of all material that cannot be classified as rock or sand as defined above(Heterogeneous Soil).
- G Everything said in the specification with regard to the execution of excavations, disposal of excavated materials, etc. shall equally apply to rock, sand and common excavation, unless otherwise stated.

i) Road along the line .

- A Wherever necessary the Contractor shall prepare a road along the line at such distance from the line that the traffic on the road will in no way interfere with pipelaying work. The Contractor shall also prepare access roads from the highway or other public roads to the said access road.
- B The road along the line and the access roads shall permit the normal movement of trucks and other vehicles and all equipment and plant required for the execution of the works.
- C The employer's employees shall at times have the use of the roads prepared by the Contractor, free of charge.
- D The Contractor shall maintain the road along the line and the access roads in a good and serviceable condition and shall make all repairs that may be necessary during the whole period of construction.

ii) Excavation to reduce levels.

- A Wherever shown on the drawings, the Contractor shall reduce the ground level on the trench site, prior to commencement of trench excavation. Before starting excavation for reducing of levels the Contractor shall move the marking of the alignment to such a distance that the marks will not be destroyed and will not interfere with the execution of the work.
- B Excavation for reducing levels shall be done to the lines and levels shown on the drawings. Where the depth of excavation is not so shown it shall be done to a line parallel to the trench bottom in the section concerned.



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iii) Storing of Suitable Excavated Material

A During excavation, materials suitable for backfill and fill will be stockpiled on the site at sufficient distance from the sides of the excavation to avoid over-loading and prevent cave-ins or mixing with the concrete during the construction of foundation.

iv) Disposal of Unsuitable and Surplus Excavated Material

A Upon the order of the Engineer, all unsuitable and surplus materials shall be immediately removed, loaded and transported off the Site area by the Contractor to approved dumps and he shall abide by the relevant local regulations.

v) Unauthorized Excavation

A If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled by well graded material at the Contractor's expense with thoroughly compacted to an acceptable proctor as directed by the Engineer, if the excavations are for a structure or a manhole, then the void should be filled by class B150 concrete.

2.5 Removal, Restoration and Maintenance of Surface

i) Removal, Cut of Pavement

A **The Contractor shall remove/cut pavement or concrete and road surfaces as a part of the trench excavation,** and the amount removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the installation of valves, fittings, valve chambers, thrust blocks, manholes, or other structures. The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the top width of the trench specified by more than 200 mm on each side of the trench. The widths and lengths of the area of pavement removed for the installation of pipes, valves, fittings, valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 300 mm on each side. Wherever, in the opinion of the Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the Engineer but shall receive no extra compensation therefore. The Contractor shall use such methods, either drilling or chipping, as will assure the breaking of the pavement along straight lines. The cut must be sharp and approximately vertical. The Engineer's representative may require that the pavement be cut with asphalt cut machine without extra compensation to the Contractor.

ii) Restoration of Damaged Surfaces and Property

A If any pavement, trees, shrubbery, fences, poles, or other property and surface structures have been damaged, removed, or disturbed by the Contractor, whether deliberately or through failure to carry out the requirements of the contract documents, state laws, municipal ordinances, or the specific direction of the Engineer or through failure to employ usual and reasonable safeguards, such property and surface structures shall be replaced or repaired at the expense of the Contractor. If the Employer specifies that the replacements or repairs shall be made by the Contractor, he shall replace or repair and restore the structures to a condition equal to that before the work began and to the approval of the Engineer and shall furnish all incidental labour and materials.

2.6 Trench Excavation

i) General

A The minimum trench width at the bottom shall be equal to the external pipe diameter plus 500 mm provided that the minimum clearance between the installed pipe and the trench side shall not be less than 250 mm. The rest of



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the trench, unless otherwise shown on the drawings or instructed by the Engineer, shall be excavated with approximately vertical sides as much as possible.

- B The trench width at the ground surface shall be excavated as narrow as practicable but may vary with , and depend upon its depth and the nature of the ground encountered.
- C Trenches shall be of such extra width, when required, as will permit the convenient placing of timber support, sheeting and bracing and handling of specials.
- D The graded material bedding under the pipe shall be not less than 150 mm thick in any point and as shown on the drawings and as directed by the Engineer.
- E The trench depth shall give the required minimum cover over the pipe as specified.
- F The trench bottom shall be straight and even so as to provide a good support for the pipe on its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating. The excavated material shall be placed alongside the trench in such a manner as not to interfere with the work and to prevent its falling down into the trench.
- G Where welds or joints of pipes and accessories are required to be done in the trench, it shall be widened or deepened to the usual enlarged dimensions or as directed by the Engineer so as to easily permit the proper execution of all welding and fixing works at all their stages, coating repairs, and thorough inspection of all these operations.
- H Separate excavations are to be made for manholes, pipe junctions, etc.

ii) Types of Trench Excavation

1. Common and Sand Excavation.

- A When excavating in ordinary soil or sand the Contractor shall take all precautions to prevent slides caused by material placed alongside the trench or for any other reason.
Wherever the danger of slides exists, the Contractor shall slope the trench walls, install supports, bracing, etc. , and shall make all other arrangements which may be necessary to prevent slides.

2. Trench Excavation in Rock.

- A Trench walls excavated in rock shall be as nearly vertical as possible, and the Contractor shall consolidate the walls wherever they have been loosened by blasting or for other reasons, or shall remove the loosened material.

3. Trench Excavation in water.

- A Where rivers carrying water during construction are to be crossed, the Contractor will have to excavate the pipe trench under water. The depth and width of the trench at such places shall be as specified above. The exact trench profile at river crossing will be shown on drawings or determined by the Engineer on the site. The Contractor shall take all necessary measures to maintain the trench in its proper shape and to prevent it from being filled with eroded earth or mud until the pipe has been laid.

iii) Mechanical Excavation

- A The use of mechanical equipment must be jointed with the approval of the Engineer. The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, buildings, culverts or other existing property, utilities or structures above or below ground. In all such locations hand excavation shall be used. The Contractor will be held responsible for making good at his own cost all additional damage to road surfaces and private lands caused by the use of mechanical excavators.



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- B Mechanical equipment if used for trench excavation shall be of type approved by the Engineer. Equipment shall be so operated that the rough trench excavation bottom can be controlled, that uniform trench widths and vertical sides are obtained at least from an elevation 200mm above the top of the installed pipe when accurately laid to specified alignment will be centered in the trench with adequate clearance between the pipe and sides of the trench.

iv) Alignment and Minimum Cover

- A The alignment of each pipeline shall be fixed and determined from offset stakes. Horizontal alignment of pipes and the maximum joint deflection used in connection therewith shall be in conformity with requirements of the section covering installation of pipe.
- B Pipe grades or elevations are not definitely fixed by the Contract Drawings, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe of 900mm for diameters 150mm and above, 700mm for diameters less than 150mm or as mentioned in the bill of quantities. Greater pipe cover depths may be necessary at certain locations, the locations and depths will be determined by the Engineer, and will be followed by the Contractor. Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finish ground or pavement surface elevation except where future surface elevations are indicated on the Drawings. Where there is no adequate minimum cover, concrete encasement will be used as hereinafter and as shown on the Drawings and as directed by the Engineer.

v) Excavation in Confined Areas.

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

vi) Padding of Trench Bottom.

- A Wherever the trench bottom is in rock or where the Engineer will decide that the trench bottom is unsuited for laying of pipe on it, the trench will be excavated to an additional depth, and the Contractor shall pad the trench bottom with a layer 100 mm thick of selected excavated material not containing stones larger than 30 mm measured in any direction provided that the quantity of stones smaller than 30 mm is not more than 20% by volume.
- B The surface of the padding shall be finished to grade as specified above so as to provide an even and solid support for the pipes to be laid.

2.7 Excavation for Concrete Valve Chambers

- A Excavation for the concrete valve chambers shall be carried out to the dimensions, lines and grades shown on the Drawings or required by the Engineer.
- B Wherever the depth of the excavation or the nature of the soil makes it necessary to avoid caving in, the Contractor shall excavate the walls to a slope or brace and support the excavation.
- C Should nevertheless earth slides occur, the Contractor shall remove the material resulting therefrom, clean the excavation of all stones, clods and other loose material and shall provide a clean excavation surface in which concrete can be cast according to the required dimensions and grades.
- D Should it appear that the bottom of the excavation does not provide a solid base for the casting of the concrete floor, the Contractor will be required to consolidate the bottom using hand tampers and increasing the moisture content,



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if required, until the required density is obtained, a/o placing concrete class (B150) as blinding, all as directed by the Engineer.

- E Any over-excavation at the bottom of the structure shall be restored to the proper grade by filling the overexcavation class (B150) concrete or shall be filled with the concrete of which the structure is cast. In the case of over-excavation in the walls, whether caused by careless work or by the necessity to prevent slides by excavating to a slope or for any other reason, the Contractor shall remove all loose material from the excavation, cast the walls of the structure to the dimensions shown on the Drawings and fill the spaces between the structures and the sides of the excavation with compacted backfill in layers of 100mm thickness. The material of the backfill shall be moistened if necessary and compacted to the level of the adjacent natural soil.

2.8 Excavation for Concrete Blocks

- A Excavation for concrete anchoring blocks shall be performed according to the shapes and dimensions shown on the drawings. The bottom and sides of the excavation shall be smooth, even, and solid so that concrete can be cast against them. Wherever necessary, such surfaces shall be moistened and consolidated to make them suitable for the casting of concrete against them. Any over excavation on the bottom or sides shall be cleaned, smoothened out, and filled with concrete cast integrally with block.
- B After the block has been cast, and subject to the Engineer's approval, it shall be covered where necessary with excavated material up to the natural ground surface. The rest of the excavated material shall be removed and dump as specified above for the material excavated for valve chambers.

2.9 Backfilling of Trenches

i) General

- A Every section of the pipeline shall be covered as soon as possible after being lowered into trench, but no section of the line shall be covered without express approval of the Engineer. Each section shall be backfilled after the pipe has been placed in its final position on the trench bottom and after all weld joints and bends have been coated and all defects in the pipe coating repaired.
- B Backfilling shall be done carefully to prevent displacement of the pipe or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench surfaces, without leaving any voids.
- C Care shall be taken that the backfill material does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tyres, ashes, refuse, oil or soil soaked with oil. Stones removed during trench excavation may be used in the second stage of backfilling as specified below.
- D On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench.
- E Where the pipeline crosses natural drainage channels, an opening in the backfill shall be made to avoid interference with normal drainage of the surrounding land.
- F Backfilling shall be done so as not to spoil the road or disrupt its continuity.

ii) Backfilling of Trenches in Cross-Country Areas

Where the pipes are laid cross-country, the backfilling of trenches shall be done as follows:



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- A **Soft Backfill** (surrounding the pipe) shall consist of sand from any approved source or fine aggregates. This material shall be placed 150 mm below the invert level up to 200 mm over the crown of the pipe and for the full width of the trench, or to the depths specified in the Bill of Quantities.
- B **Final Backfill** for the remainder of the trench shall be by using well graded approved backfill material. (as specified herein after in paragraphs 2.11(i , ii))
- C The trench shall be filled to the level of the natural adjacent ground level in layers not exceeding 300 mm, wetted and compacted by rolling, tamping to 90 percent of maximum dry density. If rolling is employed, it shall be by use of a suitable roller or tractor, being careful to compact the fill throughout the full width of the trench.
- D Other layer of the same material shall be mounded 150 mm above the existing grade or as directed by the Engineer.

iii) Backfilling of Trenches in or Adjacent to Streets

Where the pipes are laid in or adjacent to streets, the backfilling of trenches shall be done as follows:

- A **Soft Backfill** shall be done as specified above in paragraph 2.9(ii-A)
- B **Final Backfill** for the remainder of the trench shall be by using well graded approved backfill material. (as specified herein after in paragraphs 2.11(i , ii))
- C The selected backfill shall be up evenly on all sides, in layers not exceeding 250 mm measured before compaction, thoroughly wetted and compacted by rolling, tamping, or vibrating with mechanical compacting suitable equipment or hand tamping, to 95 percent of maximum dry density. Where these methods are not practicable, compaction shall be done by using of pneumatic ramming with tools weighing at least 10 Kg. The materials in this case being spread and compacted in layers not more than 150 mm in thickness. If necessary, sprinkling shall be employed in conjunction with ramming.
- D The top 250mm sub-base for pavement replacement, shall consist of one layer of approved base course material, wetted and compacted to 95 percent of maximum dry density.
- E Should the contractor wish to use the material excavated from the trench as sub-base for pavement replacement, the contractor shall at his own expense have samples of the material tested by an independent and certified laboratory at intervals not to exceed 150 m, in order to establish its compliance with the specifications. Only material which has been tested by the contractor and approved by the engineer shall be allowed to be incorporated into the work.

iv) Backfilling of Trenches with Excessive Slopes

- A On trenches with slopes exceeding 15 percent, a 300 mm wide, stone partitions shall be built across the trench every 10 meters length.
- B These partitions shall be done constructed over the first stage of the backfill up to the natural ground level, and shall exceed the trench width with 200 mm from each side inside the ground.
- C The second backfill stage of the trench between the stone partitions shall be done as specified above.

v) Restoring Trench Surface



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- A Where the trench occurs adjacent to paved streets, in shoulders, sidewalks, or in cross-country areas, the contractor shall thoroughly consolidate the backfill and shall maintain the surface as the work progress. If settlement takes place, he shall immediately deposit additional fill to restore the level of the ground. In some areas it may be necessary to remove excess materials during the clean-up process, so that the ground may be restored to its original level and condition.
- B The surface of any driveway or any other area which is disturbed by the trench excavation and which is not a part of the paved road shall be restored by the contractor to a condition at least equal to that existing before work began.
- C Where the pipes are laid in cross-country areas, and where the danger of erosion exists, the uppermost 300 mm part of the trench may be backfilled with common backfill material containing fragments of ledge and boulders smaller than 150 mm providing that the quantity in the opinion of the engineer, is not excessive. Small stones and rocks shall be placed in thin layers alternating with earth to insure that all voids are completely filled.
- D All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

2.10 Backfilling around Structure

i) General

- A Surfaces to receive backfill shall be cleared of debris and unsatisfactory materials prior to the placement of the backfill material
- B When the top 200mm of surface to receive backfill has a density less than the required maximum dry density, break up surface, pulverize, moisten and compact such that the required degree of compaction is achieved to form a "compacted subgrade".
- C Backfill excavations as promptly as the work permits, but not until completion of inspection, testing, approval, and recording of location of underground utilities, as required.

ii) Backfilling - Common Fill

- A Common Fill may be used as fill against exterior walls of structure as indicated on the drawings. Materials conforming to the requirements of common backfill shall be placed in layers having a maximum thickness of 300 mm measured before compaction, each layer of fill or backfill shall be moistened or aerated and compacted to at least 90 percent of maximum dry density, or as specified in the Bill of Quantities.
- B Backfill or fill materials shall not be placed on surfaces that contain excessive moisture, preventing specified degree of compaction.
- C Material placed in fill areas shall be deposited to the lines and grades shown on the drawings making due allowance for settlement of the material.
- D No compacting shall be done when the material is too wet either from rain or from excess application of water. At such cases, work shall be suspended until previously placed and new materials have dried sufficiently to permit proper compaction.

iii) Backfilling - Structural Fill



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A Structural fill shall be placed in layers having a maximum thickness of 200 mm in open areas and 150 mm in confined areas including points where conduit and piping join structures, measured before compaction. Each layer shall be moistened or aerated and compacted to at least 95 percent of maximum dry density, or as specified in the Bill of Quantities, by methods approved by the Engineer. The limits of structural fill adjacent to structures shall extend as shown on the drawings.

B Compaction of Structural fill in open areas shall consist of fully loaded ten-wheel trucks, a tractor dozer weighing at least 13.5 ton and operated at full speed, a heavy vibratory roller, or any method approved by the Engineer.

C Compaction of structural fill in confined areas shall be accomplished by hand operated vibratory equipment or mechanical tampers approved by the Engineer.

2.11 Material Used in Backfill

i) General

- A Backfill and fill material shall be suitable excavated material, natural or processed mineral soils obtained from off-site sources, or graded crushed stones or gravel.
- B Backfill and fill material shall be free from all organic material, trash, snow, ice, frozen soil, or other objectionable material which can't be properly compacted. Soft, wet, plastic soils which may be expensive, clay soils having a natural in-place water content in excess of 30 percent, soil containing more than 5 percent (by weight) fibrous organic material, and soil having a plasticity index greater than 30 shall be considered unsuitable for use as backfill and fill material.
- C Backfill and fill material shall have a maximum of one percent expansion when testing is performed on a sample remolded to 95 percent of maximum dry density at a two percent below optimum moisture content under a 490 kg/m² surcharge.

ii) Common Backfill Material

- A Common Backfill or fill material shall not contain Granite blocks, broken concrete, masonry rubble, asphalt pavement, or any material larger than 150 mm in any dimension provided that this material is not more than 25 percent of the backfill or fill material.
- B Common Fill shall have physical properties, as approved by the engineer, such that it can be readily spread and compacted.

iii) Selected Backfill Material

- A Selected Backfill and Fill material shall conform to the requirements of common Backfill except that the material shall not contain any materials larger than 50 mm in its largest dimension provided that this material is not more than 20 percent of the Backfill or fill material.

iv) Structural Fill

- A Structural Fill shall be gravel, sandy gravel, or gravelly sand. Material shall have a plasticity index of less than 15 and shall conform to the gradation limits shown in table 2.1 below : **Table 2.1**

Sieve Size	Percent Finer By Weight
150 mm	100



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No. 4	20 - 70
No. 40	5 - 35
No. 200	0 - 7

v) Crushed Stones

A Crushed stones shall be sound, durable stone, angular in shape, and free of foreign material, structural defects and chemical decay. Crushed stones shall be of a maximum dimension of 50 mm and in a minimum of 12 mm measured in any direction.

2.12 Quality Assurance

2.12.1 Laboratory Testing

A At least seven days prior to the placement of any Backfill or Fill material, the contractor shall deliver a representative sample of the proposed material weighing at least 22 Kg to an approved soils testing laboratory to perform:

1. Grain size analyses of the samples to determine their suitability for use as Backfill or Fill material in accordance to the material requirements specified in section 2.11
2. The appropriate Proctor analysis to determine the maximum dry densities required for compaction testing as specified in the contract documents.
3. The test results and determinations of suitability shall be delivered to the engineer no later than three days prior to the placement of Backfill or Fill materials.

2.13 Replacement of Pavements and Structures by the Contractor

A Unless otherwise shown on the Drawings or mentioned in the bill of quantities, the Contractor shall restore all pavements, sidewalls, sidewalks, curbs, gutters, shrubbery, fences, poles, sod, or other property and surface structures removed or disturbed as a part of the work to a condition equal to that before the work began, and shall furnish all incidental Labour and materials. No permanent pavement shall be restored unless and until, in the opinion of the Engineer, the condition of the backfill is such as to properly support the pavement and not before written approval from the Engineer to commence such works.

B Where pipelines pass underneath asphalted roads and parallel to the axis of the road, the final 250 mm of the trench backfill shall be furnished as follows:

- 200 mm (after compaction) shall be done by using approved base course material, placed, wetted and compacted to not less than 95 % of the modified Proctor density.

- Spraying 2 kg of prime coat(MCO) per each square meter over the compacted base course, and applying a layer of asphalt mix of size $\frac{3}{4}$ $\square$, in a thickness not less than 50 mm, after compaction which should satisfy the specification of Palestinian Ministry of Public Works.



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2.14 Road Crossing

- A Where water pipeline is crossing main roads, highways, or railways, the pipeline shall be installed inside a protective steel sleeve.
- B Skids must be used to prevent damage to the pipe coating and to provide proper long-term line support.
- C The water pipeline should not rest on the sleeve, skids should properly position the pipeline in the sleeve.
- D Skids may extend for full length of the pipe with the exception of joint to be welded, or may be spaced at intervals. Skids must provide sufficient height to permit clearance between the pipe and the sleeve wall. Skids should be fastened securely to pipe with strapping, cables, or clamps.
- E Table 2.2 specifies sleeve size requirements for wall thickness and maximum skid support spacing for water pipes of various diameters.

Table2.2- of Sleeve sizes

Normal pipe size outside dia (in)	Sleeve		Maximum skid support spacing (m)
	Outside dia (in)	Minimum wall thickness (in)	
3	8	5/32	1.5
4	8	5/32	1.5
6	10	3/16	2.0
8	12	3/16	2.5
10	14	3/16	2.5
12	16	1/4	3.0
14	18	1/4	3.0
16	20	1/4	3.0

- F Upon completion of pipe insertion, cast in place concrete B-150 shall be used to restore the ground level to 50 mm less than the previous asphalt level grade.
- G After the concrete surface is dry, the asphalt is reinstated by spraying 0.5 kg of tack coat per each square meter prior to laying a 50 mm asphalt mix that satisfies the specifications of the Palestinian Ministry Of Public Works over the concrete surface.
- H The ends of the sleeve shall be protected by casting concrete blocks B-150 for its full diameter and 150 mm thickness.



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I Insulating Casing Spacers

Where the pipe crosses another pipe which is cathodically protected the new pipes shall be installed inside a casing to electrically isolate the pipes from each other. To ensure the electrical isolation, modular insulating casing spacers shall be installed instead of the wooden kids as previously specified. The modular, insulating casing spacers shall be bolt-on devices which fully encircle the pipe and are to be fabricated from stainless steel encirclement bands with pre-molded, insulating plastic skids. Modular casing spacers shall be as manufactured by Cascade, PSI, or equal.

SECTION 3 - PIPELAYING

3.1 Handling and Transporting Pipes

i) General

- A The Contractor's arrangements for handling, lifting, transporting and stacking pipes, valves and specials, shall ensure that these articles are brought to their final place in the works undamaged and in good order.
- B All damage to the pipes or their coating while in the Contractor's charge shall be repaired as required and directed by the Engineer, and all expenses in connection with such repairs shall be borne by the Contractor. In the event of any pipe being damaged to such an extent as to make the repair thereof, in the Engineer's opinion, impossible or uneconomical the Employer will provide a new pipe in place of the damaged one, and the Contractor shall pay the cost thereof to the Employer.
- C When loading and unloading, handling, transporting, and moving and placing the pipes alongside and in the trench, care shall be taken to preserve the undamaged condition and roundness of the pipes, particularly at the ends. Special care shall be taken to keep the pipe coating intact.
- D Pipes shall not be stacked on the vehicles to such a height as may cause flattening of the lowermost pipes or damage to the coating. The height of the load for the various pipe diameters shall be as recommended by the Manufacturer and approved by the Engineer. Pipe specials shall be supported by sandbags or other padding and lashed down as described above so that they are not damaged during transport.
- E The trucks and cars used for the transporting of the pipes shall be adequately equipped to prevent displacement of pipes and/or damage to pipes or coating. Pipes shall be well secured to the vehicles to ensure stability of the load, and all parts of trucks and cars as well as cables coming into contact with coated pipes shall be well padded.
- F Unloading of pipes from trucks or cars shall be done by means of cranes or other suitable equipment ensuring slow and careful lowering of each pipe length. Pipes shall not be gripped by hooks or other equipment liable to injure or distort pipe ends.
- G The Contractor shall provide cranes for lifting and lowering pipes at the site of work and at the storage area and wherever pipes are being handled.
- H Pipes must not be dropped on the ground or on other pipes. When lifting or lowering pipes by means of a crane, each pipe shall be kept under full control when suspended to prevent its colliding with equipment, rocks, trees or any other objects that may injure the pipe or its coating.
- I Pipes shall not be moved by dragging them on the ground, but shall be lifted by crane or other means and placed carefully at their new locations. In rocky country, pipes shall be deposited with their bare ends on wooden skids at least 100 mm wide.



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- J Each pipe placed on the ground shall be prevented from rolling. Walking on coated pipes in the field shall not be permitted. Pipes shall also be protected from contact with metal tools or heavy objects that may injure the coating.
- K No steel cables or ropes likely to injure the coating shall be used for handling the pipes, but only belts at least 250 mm wide or such special tackle as will not damage the coating.

ii) Polyethylene External Coated Steel Pipes and Fittings

3.2 Description of Pipes

Except as otherwise specified, steel pipes shall meet the requirements of S.I. 530 for the grade and wall thickness shown on the Drawings. Pipes shall be either with plain ends for butt-welding or with a bell on one end for fillet welded lap joints. Pipes shall normally be supplied with a cement- mortar lining on the inside. Pipes for installation below ground shall be supplied with an external polyethylene coating.

3.3 Dimensions and Tolerances

3.3.1 Dimensions

The pipes shall be supplied with minimum wall thickness of 3/16" for diameters of 14", 12" AND 10", and with minimum wall thickness of 5/32" for diameters of 8", 6" and 4" pipes.

The pipes shall be supplied in 12 meters lengths. Each supply may include a percentage of short pieces. However, pipes shorter than 6 meters shall not be accepted and the percentage of short pieces shall not exceed 5% of the total lengths of each supply.

3.3.2 Tolerances

The tolerance on the specified wall thickness is +12% and -5% (except on weld areas where maximum height of weld reinforcement shall be 3mm) with a minimum of +0.5 mm.

The tolerance on the outside diameter is +0.75 or +-10mm.

3.3.3 Cement Lining

The cement lining shall consist of a mixture of sand with a gradation varying between 0.16 mm and 5mm and with a 96% purity index, potable water and portland or blast furnace cement with low water solubility.

The cement lining shall be carried out in the mill by means of centrifugation and shall have a smooth surface coat consisting of fine grains of sand and cement.

The specific gravity of the mortar used shall be not less than 2.2 after centrifugation. The thickness of cement lining shall be as per AWWA C205 -85 stipulations.

3.3.4 Inspection and Repair

Surface of lining shall be checked on 100 percent of production; the Contractor shall submit to the Engineer manufacturer's certificates to this effect. All over-sanded areas, blisters, cracks as a result of impacts and unsatisfactory thin spots shall be cut to the minimum permitted length.

Temperature and shrinkage cracks less than 1 mm width need not be repaired. Wider cracks have to be repaired if they do not heal under continuous soaking in water. When cement lining is damaged locally, protection of the bare zone shall be ensured by either applying a bituminous primer Endolac or similar followed by a coat of mastic bitumen or another product recommended by the pipe manufacturer, or by cutting out and replacing by hand to the full required thickness of the cement lining. Which method of repair to be used will be decided by the Engineer.



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- A Coated pipe shall be handled, stored and shipped in a manner that will prevent damage to the coating. Pipe shall be handled with wide belt slings or rubber padded forklifts. Chains, cables or other equipment likely to cause damage to the pipe or coating shall not be used.
- B No metal tools or heavy objects shall be permitted to come into contact unnecessarily with the finished coating. Workmen will be permitted to walk upon the coating only when necessary, in which case they shall wear shoes with rubber or composition soles and heels. All pipe and fittings, specials and couplings shall be examined before laying, and no piece shall be installed which is found to be defective. Any damage to the coatings shall be repaired as acceptable to the Engineer.
- C If any defective pipe is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense.

iii) Polyvinyl Chlorine (PVC) and Polyethylene (PE) Pressure Pipes

1) Un-plasticized Polyvinyl Chloride (uPVC) Pipes

The pipes shall manufactured according to ISO 4422 or DIN 19532

The pressure rating shall be PN10

Length: Standard 6 meter lengths and All pipes should include Rubber Gasket. Joints:

Integral sockets with rubber seals (46-65 Shore A).

Dimensions and tolerances shall comply with ISO Standards.

Pipes shall have very high rigidity, self-extinguishing with a high ignition temperature and immunity to biological attack

Also pipes shall be smooth internal surface preventing buildup of deposits, and easily joined with integral sockets, no specialized equipment necessary

The raw material from which the pipes are made shall be fit substantially to

- Color: White
- Material: Specific gravity 1.4g/cm³
- Tensile strength 50 N/mm²
- Modulus of elasticity 3000 N/mm²
- Thermal conductivity 0.15 W/m °C
- Specific heat 0.23 kcal/kg °C
- Coefficient of linear thermal expansion 0.08 mm/m °C

2) High Density Polyethylene (HDPE) Pipes

The raw material from which the pipes are made shall be composed substantially of high density polyethylene (HDPE) PE100, PE80, and shall manufactured according to ISO4427 standard or EN12201, DIN8074 The pressure rating shall be PN10

Materials shall comply with ISO standards and other certification from important institutes such as DVGW, and KIWA.

- A Considering all above mentioned general instructions, PVC and PE items deteriorate in sunlight and are slightly brittle, especially at lower temperatures, so care shall be taken in loading, transporting and unloading items to prevent injury to the items. All items shall be examined before installation and no piece shall be installed which is found to be defective. Handling and installation of pipe and fittings shall be in accordance with the manufacturer's instructions, referenced standards and as specified herein.
- B Any pipe or fitting showing a crack or which has received a blow that may have caused an incident fracture, even though no such fracture can be seen, shall be marked as rejected and removed at once from the work.



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- C In handling the items, use special devices and methods as required to achieve the results specified herein. No uncushioned devices shall be used in handling the item.

3) Gravity UPVC Rigid pipes

Gravity UPVC pipes are used for gravity sewerage and drainage works through underground networks.

4) Materials

All UPVC pipes diameter ranging from 110 mm to 500 mm and fittings shall be rigid UPVC gravity piping ring stiffness = 8 kN/m², conforming to Israeli Standard 884 or an approved equal standard for UPVC gravity sewer pipes and joints.

UPVC pipes and fittings with spiral profile, for diameters ranging from 600mm to 1500mm, shall be of dual wall ring stiffness = 8kN/m² conforming to Israeli Standard 435 or an approved equal standard. The material from which the pipe is produced shall consist mainly of polyvinylchloride to which, may be added small quantities of those additives needed to facilitate the manufacture of the polymer. The finished pipe shall be of good and sound quality, surface finish, mechanical strength and capacity. No chemicals shall be used in the pipe manufacturing process that will impair its welding and strength properties.

The solid wall thickness of UPVC pipes shall not be less than the relevant thickness shown in Table below:

Nominal Diameter									
(mm)	110	160	200	250	315	355	400	450	500
Minimum Wall thickness (mm)	3.2	4.7	5.9	7.3	9.2	10.4	11.7	13.2	14.6
Maximum Wall thickness (mm)	4.0	5.4	6.7	8.3	10.4	11.7	13.1	14.8	16.3

UPVC pipes with spiral profile shall have thickness not less than the relevant thickness shown in Table below:

Nominal Diameter (mm)	600	800	1000	1200	1500
Wall thickness (mm)	21.50	29	35	42	53

All pipes and fittings shall be packed in such a manner to reduce the warping of pipe and loss of fittings. Prior to its installation all pipes and fittings shall be inspected by the Engineer or his representative for any defects. Any pipe or fitting which in the opinion of the Engineer or his representative shows any signs of defects in material or workmanship shall be rejected and removed from Site.

Pipe Dimensions

Pipe dimensions shall be designated by the nominal diameter and the wall thickness.

Workmanship

All pipes shall be homogeneous throughout and free from visible cracks, holes and foreign inclusions and shall be reasonably round. The internal and external surfaces of the pipes shall be smooth, clean and free from grooving and other defects that would impair their performance in service. The ends shall be clearly cut and square with the axis of the pipe.



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Marking

All pipes and fittings shall be clearly marked at intervals not greater than 1 m. All markings shall show the following: Manufacturer's identification, the seal of the Israeli or other equivalent Standard Institutions and the nominal diameter of pipe, ring stiffness, length, batch number and date of manufacture.

Assembly

All pipes shall be assembled by bell socket assembly with the appropriate rubber sealing ring as required for the job and directed by the Engineer or his representative.

Fittings

All fittings used shall be of the same quality as the pipe and conforming to the Israeli Standard 884 and 435 or an equal approved standard. The Engineer or his representative may require fittings to undergo similar type tests to those specified in (1) to (7) below. Such tests shall be carried out in accordance with the appropriate standard and the tested fittings shall generally be of similar quality to the pipes.

Joints

Except where otherwise shown on the Drawings all pipes and fittings shall have flexible joints. Joints shall be of the spigot and socket or the UPVC double socket coupling type having a rubber ring. All joints shall be capable of withstanding while maintaining the specified test pressures a deflection of not less than 1.5° in any direction.

Rubber rings shall be of the nitrile rubber SBR or EPDM rubber formulations and shall at least meet the requirements of the appropriate parts of BS2494.

Dimensions of single sockets shall be in accordance with ISO 2045. Dimensions of double sockets shall be in accordance with ISO 2048.

Pipes with plain ends including cut pipes to be used with rubber ring type joints shall be chamfered as described in ISO 2045 clause 5.

The results of type test appropriate to the proposed pipes and fittings shall be used to determine the properties of pipes. Each type test shall have been carried out on samples of pipes and fittings to be used. If the manufacturer does not have appropriate results of these tests available or if significant alterations are proposed to the method of manufacture or pipe design, the Contractor shall carry out all the type tests required by the Engineer or his representative to provide the adequacy of the proposed pipes and fittings.

The following type tests shall be conducted:

1. Vicat Softening Point

When two random samples taken from the pipe are tested in accordance with ISO 2507 the deformation temperature of each sample shall not be lower than 79°C .

2. Impact Resistance

When tested in accordance with ISO 3127 pipe samples shall have a true impact rate (TIR) below 10% at a confidence level of 90%.



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3. Heat Reversion

When three samples of each pipe size are tested in accordance with ISO 2505, at no position around the pipe shall the length change by more than 5%. After testing the samples shall show no faults, e.g. cracks, cavities, blisters.

4. Hydraulic Test.

Specimens of pipe of each pipe size shall be tested in accordance with ISO 1167, three specimens at 20° C and a further three specimens at 60° C.

Samples of pipe shall sustain the following stresses for the following times without failure:

Test Temperature (c) °	Minimum Time to Failure (hrs)	Induced Stress (N/mm2)
20	1	42
60	1000	10

5. Effect of Sulphuric Acid

Specimens of pipe of each pipe size shall be tested in accordance with ISO 3473 and shall meet the required characteristics stated therein.

6. Resistance to Acetone

Specimens of pipe of each pipe sizes shall be tested in accordance with ISO 3472 and shall meet the required characteristics stated therein. Two pipes of each pipe size shall be jointed and tested in accordance with requirements of Section 6.5 of ASTM D3262 but with the following exceptions:

- I. The positive test pressure shall be 10 meters water head.
- II. The negative pressure test shall be conducted to determine the adequacy of the joint against infiltration. An external test pressure of 10 meters water head shall be applied to two sections of pipe assembled with a misaligned joint.
- III. The deflection during the misaligned joint tests shall be 1.5°.

3.4 Stacking and Storage of Pipes

i) General

- A Pipes stored in the field shall be arranged in piles in such a manner that the pressure of the pipes placed on each other will not cause deformation of the pipe or damage to the coating.
- B The Supply Contractor shall properly stack the pipes in the storage yard of the Employer and the stacks shall be laid out in a regular pattern and the limits of each stack marked to that the movement of cranes and vehicles is restricted to access tracks between stacks and the control of delivery and removal pipes is facilitated.
- C The number of tiers of steel and ductile iron pipe stacks shall be as per the Manufacturer's instructions and approval of the Engineer and each pipe, including those in the bottom course, shall bear evenly upon not less than three timbers with an aggregate width not less than 300 mm. The pipes shall be stacked parallel to each other and arranged so that in each course all sockets are at one side and in the next course all spigots are on the other side.



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- D The timbers supporting each course of pipes in a stack shall be of uniform thickness and stiff enough for the pipes to be rolled across the stack and shall be supplied by the Contractor at his own expense.
- E The outermost pipes in each course shall be secured against rolling by sandbags or by wedges.
- F Where the pipes are to be delivered and stacked by the Supply Contractor on designated sites lying on the pipeline route, unless it is otherwise specified elsewhere, the areas where the pipes are to be stacked shall, if required, be graded flat by the Supply Contractor at his own expense to provide a firm even surface, and kept free from loose stones, rubble or waste liable to damage the pipe coating.

ii) Steel Pipes

- A A Stored pipe shall at all times be supported on sand bags, or other suitable support. Bags shall be of sufficient size to prevent contact of the pipe coating with the ground or any other obstruction. Rolling the pipe on the coated surface will not be permitted.

iii) PVC and PE Pipes

- A While stored, pipe shall be adequately supported from below at not more than 900mm intervals to prevent deformation. The pipe shall be stored in stacks no higher than that given in the table 4.2 : **Table 4.2**

<u>Pipe Diameter</u>	<u>Max. No. of Rows Stacked</u>
200mm or less	5
300 to 530mm	4
600 to 760mm	3
840 to 1220mm	2

- B Pipe and fittings shall be stored in a manner which will keep them at ambient outdoor temperatures and out of the sunlight. Temporary shading as required to meet this requirement shall be provided. Simple covering of the pipe and fittings which allows temperature build-up or direct or indirect sunlight will not be permitted.
- C If any defective item is discovered after it has been installed, it shall be removed and replaced with an exact replacement item in a satisfactory manner by the Contractor, at the Contractor's own expense. All pipe and fittings shall be thoroughly cleaned before installation and the interior shall be kept clean until testing.

3.5 ***Materials supplied by the Employer***

- A In case the pipes and ancillary fittings, specials and valves are to be supplied by the Employer the latter shall supply to the Contractor free of charge at his stores or at the place indicated in the Particular Conditions and Specifications, the required quantities of different pipes of various diameters together with the respective fittings, specials, adapters and valves as outlined in the Particular Conditions and Specifications and the Contractor shall load transport and unload the materials so supplied at the site of works and shall be responsible for proper unloading, stacking and storing .
- B The pipes shall be unloaded from the trucks in an approved manner and the Contractor shall take utmost care not to damage the pipes or any of the materials so supplied. Any damage caused to the materials in loading,



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transport and unloading at the site of works shall be repaired by the Contractor at his own expense in accordance with the Engineer's instructions and to his satisfaction.

- C Material irreparably damaged shall be replaced by the Contractor at his own expense or charged to his account. The Contractor shall stack the pipes in a secure, safe and approved manner and in a way to allow easy handling.
- D Pipes found damaged before handling them over to the Contractor shall be counted and stacked by the Contractor separately each diameter aside and the damage of each pipe, shall be fully described. Such pipes shall not be used in the works unless and until the Contractor has used all the sound pipes delivered to him and is so ordered by the Engineer.
- E The Contractor will be required to sign the vouchers for the materials supplied to him, and shall keep proper stores book to show at any time the quantity of materials received and those which have taken from the stores for use in the works. The Engineer or his representative shall have the right to inspect at any time the store books, and to check the materials in the stores and on site of works to satisfy themselves that everything is in order and the Contractor will be required to account for any discrepancy found.
- F The Contractor shall at his own expense provide and constantly maintain day and night watching and shall be responsible for the theft or loss for any materials supplied to him by the Employer whether theft occurred from the stores or from the site of works. Any materials so found missing shall be immediately replaced by the Contractor at his expense.
- G On completion of works, the materials used in the works shall be counted and / or measured and the balance shall be handed over by the Contractor to the Employer at his indicated storage yard. The loading, transport, unloading and proper stacking of materials shall be carried out in accordance with the relative clauses of the Specifications and shall be at the Contractor's expense.
- H Any materials not accounted for shall be replaced by the Contractor at his own expense or shall be charged to the Contractor's account C.I.F. site plus 20% as the Engineer deems it suitable.

3.6 Pipe fittings

3.6.1 General

Pipe fittings shall comprise any of the following items; flanged spigot, and socket fittings, couplers, flanged couplings, tees, elbows, bends, reducers, extension pieces, or any other special fitting identified in the schedule of pipes and fittings.

Valves and Accessories are specified separately in Sections 4 and 5.

Pipe fittings shall be suitable for potable water supply.

Pipe fittings shall conform to ISO Standards.

All Pipe fittings shall be pressure rated PN 10.

All ISO, or alternative, recommended tests and witnessed tests shall be carried out and certified in writing to the Purchaser, on delivery of the batches.

Pipe fittings shall bear clear and permanent markings showing the nominal diameter, pressure rating, type, year of manufacture and the manufacturers name or trade mark. Markings on pipe fittings shall always be at the same end.

Painting of data shall be acceptable for all pipe fitting materials.

Pipe fittings shall be compatible with the associated pipes and have equal or higher pressure ratings as the associated pipes. The supplier shall provide sufficient quantities of inert, waterproof filler paste, flange wrapping tape and paste, to protect all bolted connections of flanges, couplers and fittings.

All pipe fittings specified to be coated with 'epoxy paint' shall be defined to mean that they are coated with epoxy resin powder electro-statically applied to a thickness of 250 microns. The supplier shall submit full details and technical specification of any alternative protective coating system proposed at the time of tender, for approval by the Purchaser.



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3.6.2 Fittings materials

Pipe fittings may be fabricated from either UPVC, HDPE, mild steel, stainless steel, ductile iron or copper alloy. UPVC fittings shall be formed in injection moulds or machined from extruded stock. Fittings fabricated by solvent cement techniques shall not be accepted.

Materials, properties and strengths of the fittings made of UPVC shall equal or exceed those of the pipe.

HDPE fittings shall be supplied by the same manufacturer and shall be made from the same raw material and with the equivalent or superior quality requirements as those of the HDPE pipe.

Materials shall comply with ISO standards and other certification from important institutes such as DVGW, and KIWA.

3.6.3 Couplings and Flange Couplings

All couplings fabricated from ductile iron shall be coated with epoxy paint or similar approved by the Purchaser.

Couplings shall be supplied with a central register or locating plugs. The central collar shall be 1.5 times thicker than the equivalent standard pipe thickness.

Every coupling, and flange coupling shall be capable of withstanding without leakage the pressure rating of the section of pipeline it is supplied with and have large tolerance adoption.

Sealing of the couplings shall be made of Elastomer EPDM fit to BS EN 681-1 and bolts and nuts shall be zinc plated

Flange couplings for jointing plain ended pipes to specials shall be capable of maintaining a watertight joint over a range of axial movement of at least 25mm and an angular deflection of not less than 2 degrees. The pressure rating shall be clearly stamped on all couplings and flange couplings

3.6.4 Flanged Fittings

All flanged fittings, fabricated from mild steel or ductile iron, shall be des-caled and coated with epoxy paint or similar approved by the Purchaser.

Flanges shall comply with ISO Standards and bolt holes shall straddle the vertical axis of the flange.

All steel flanges shall be welded to the pipe by the electric arc process or other approved method. The flanges shall be of the raised face type and shall be truly faced over their whole width. Bolt holes shall be drilled on centre lines, truly in line end to end with the longitudinal axis. All flanges shall be rated as PN 10. All flanges shall be adequate to withstand test pressures for the specials to which they are attached.

Flanged joints shall be full US \$had complete with gaskets, bolts, nuts and washers.

The supplier shall provide additional gaskets, bolts, nuts and washer sets, equivalent to 5% of the scheduled quantity, to allow for wastage or losses during the rehabilitation installation works.

All gaskets shall be full faced and suitable for potable water supply in the Middle East climate. The supplier shall demonstrate the suitability of the gasket at the time of tender.

Bolts and nuts shall be in carbon steel and shall be hot-dipped galvaUS \$ed spun (to a standard sufficient for a saline environment). The bolts shall be hexagonal head type, and their dimensions shall conform to ISO Metric Black Hexagon Bolts, Screws and Nuts. "Normal Thickness Nut Type, or similar approved by the Purchaser.

3.6.5 Compression Fittings

All fittings shall be used for HDPE pipes that comply with ISO 4427, EN12201 and DIN 8074

3.6.6 Fittings Material

All fittings shall be made from top quality raw materials approved for drinking water by WRC, DVGW, and KIWA Body:

Polypropylene, high-grade copolymer.

Nut: Polypropylene, high-grade copolymer.

Split Ring: Acetal (POM)



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Liner: Acetal (POM)

Reinforcing ring: Stainless steel on all female offtakes from 1¼" up to 4"

Bolts: Stainless steel. Nuts: Stainless steel.

All fittings shall connect with metal and plastic accessories with ISO 7 thread

All fittings shall stand up rating pressure 16 bars at 23°C and not less than 47 bars at 40 °C

3.7 Valves

3.7.1 General

Valves shall be suitable for potable water supply.

All protective coatings shall be non-toxic and shall not foster micro biological growth nor impart any odour, taste, cloudiness or discoloration to the water. All ferrous surfaces in contact with water shall be coated with epoxy paint or similar approved by the Purchaser. All to be cast in raised letters, upon an appropriate part of the body. Where appropriate the marking shall have a minimum size of 25mm (1 inch), raised 3mm (1/8 inch).

After completion of assembly, each valve shall be shop operated three times from the fully open position to the fully closed position and returned to fully open under no flow condition to demonstrate that the assembly is working.

All valves shall be hydraulically tested at the place of manufacture to the pressures specified and shall satisfactorily pass the specified tests before they are packed for delivery.

The operating gear of valves shall be such that one man can open and close the valve against an unbalanced head 15% in excess of the maximum to be encountered in service.

Packed glands shall be arranged for easy replacement of the packing, which shall be accessible without removal of the valve from the pipe and while the valve is still in service. Precautions shall be taken to prevent corrosion of the valve spindles in contact with the gland packing.

Flanges of valves shall be to PN10.

3.7.2 Gate Valves

Gate valves shall be soft resilient flanged conform to ISO standards or BS 5163, or DIN 3352.

All Gate valves shall be fabricated in ductile iron.

The minimum working pressure of all gate valves shall be PN10.

Gate valves shall be of the resilient face type and the operating stem shall have 'o' -ring seals. Valve ends shall be flanged type face to face dimensions according to EN-BS 558 -1.

Gate wedge shall be covered with EPDM Elastomer, stem from stainless steel AISI 303/304 and stem nut from bronze DIN 1705

All external body, interior surfaces except the flange, seating surfaces and flange surfaces shall be coated with blue epoxy paint with a minimum thickness of 200µm according to DIN 30677 or similar approved by the Purchaser.

The direction of opening for all gate valves shall be anti-clockwise as viewed from the top.

For resilient faced gate valves, a hydrostatic test pressure equal to twice the rated working pressure of the valve shall be applied to the body with the gate in the open position. The test shall show no leakage through the metal, flanged joint, or stem seals. Subsequently, a test shall be made from each direction at the rated working pressure to prove the sealing ability of each valve from both directions of flow. The test shall show no leakage through the metal, pressure - containing joints, or past the seat.

3.7.3 Check Valves (Non Return Valves)

Check valves shall be of the swing type with an extended hinge pin extended from both sides. Check valves shall be used to prevent automatically reversing of flow. Check valves shall comply with BS 4090 with cast iron body, door and cover, gunmetal seats and stainless steel hinge pin. All materials shall be to appropriate British Standards.



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3.7.4 Butterfly Valve

Butterfly valves shall comply with B.S.5155 or B.S.3952. The valve body and disc shall be of cast iron to B.S. 1452 with stub shafts of stainless steel to B.S.970. The seal shall be of nitrile rubber sealing against phosphor bronze seats. The valve body shall be attached to the pipeline with flanges. Butterfly valves in the smaller sizes may be of the water type where the valve is bolted in between pipe flanges. The seal shall be of nitrile rubber covering and lapped over the internal surface of the valve. Valves of this type shall be only for sizes up to and including 300 mm. All valves above this size shall have integral flanges.

For both wedge gate valves and butterfly valves manual mechaUS \$ms for operation shall be provided. The gearing shall be such that seven to eight complete revolutions of the hand wheel is required for complete closure. All valves shall be operated by handwheel unless otherwise specified. No valve shall be lever operated. Tee keys and bars may be specified on washout valves.

Handwheels shall be turned in a clockwise direction to close the valve and shall be clearly marked with the word "CLOSE" in English and an arrow in the appropriate direction. Handwheels shall be of cast iron or plastic encased steel.

3.7.6 Solenoid Valve

Since the water well production will delivered to the blending tank at well location. A solenoid 6 inch diameter, flange type, water level control system is highly recommended to insure sustainable and water quality standers.

The contractor shall supply and install the recommended solenoid valve with the necessary wiring and connections to be added to the control panel board.

3.8 Accessories

3.8.1 Surface Boxes and Chambers

All surface boxes shall be fabricated from ductile iron.

Surface boxes shall be heavy duty and resistant to damage or displacement by heavy traffic.

Surface boxes shall be either square opening or round with chains attached to the covers and frame.

Covers shall have the letter 'W' on the top surface.

All chamber boxes shall be fabricated in uPVC, have the equivalent clear opening dimensions of the respective surface box and shall be 300mm deep.

3.8.2 Tapping Saddles

Tapping saddles shall be of the type fitted to the top of the pipe and shall be capable of allowing insertion of the ferrule cock under working pressure.

Tapping saddles may be fabricated from ductile iron, copper alloy or plastic (Polypropylene, high-grade copolymer) . The supplier shall ensure full compatibility of the saddle with the under-pressure equipment and ferrule cocks, and shall provide full details of the system at the time of tender.

3.8.3 Ferrule Cocks

Ferrule cocks shall be fitted to the top of the pipe and shall be capable of being fitted under working pressure. Ferrule cocks are to be fabricated in copper alloy.



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3.8.4 Combined Tracer and Marker Tape

The combined tracer and marker tape shall be manufactured in metallic mesh, 100mm wide, of maximum opening size of 25mm and shall be detectable by an electronic main locator at a depth of 1m.

The metallic strip is to be protected from corrosion by PVC coating coloured blue.

Other material may be considered subject to the supplier submitting alternative details at the time of tender

3.8.5 Requirements for Flanges, Gaskets, Nuts, Bolts and Washers

All flanges shall be drilled to ISO or DIN EN 1092-2. Where pipes connect to existing flanges, the new pipe flange shall be drilled to suit the existing flange.

Flanges shall be perpendicular to the pipe centre line and bolt holes shall be aligned as required in BS 4504, and to ensure that adjacent pieces of pipe work can be joined as required.

The nominal flange size to be used shall correspond to the nominal bore of the pipe selected.

Gaskets shall be full face fabric reinforced neoprene (chloroprene) rubber 3mm thick suitable for making a long term.

All bolting shall be hot dip galvanized mild steel or zinc coated with metric threads and conforms with ISO 4032 or DIN 934 and bolts shall be with hexagon head

Flange Gaskets shall be made from Non-Asbestos, EPDM or Cloth Inserted Rubber according to EN DIN 1092-2

Gasket shall fit for PN 10, ring type with 3mm thickness for $DN \leq 100$ and 4mm for $DN > 100$ mm. and seal shall be resistant to mechanical, chemical or bacteriological attack.

The lubricant must have the consistency and lubricating properties suitable for field jointing of push in type rubber ring pipes and fittings and be able to applied by brush

Containing an approved bactericide that non toxic and on significant inhibitor of bactericidal activities.

3.9 Pipe-laying in Trenches

i) General

- A Pipes and fittings will be installed in strict accordance with the Manufacturer's Specifications and instructions to the satisfaction and approval of the Engineer.
- B The pipe route shall be determined by the Engineer. The Engineer reserves the right to vary or abandon any part or parts of the routes of pipelines indicated on Drawings and the Contractor shall lay the pipes in accordance with any such variations which the Engineer may issue.
- C The Contract Drawings show the approximate lines and levels to which the pipeline is to be built and are subject to amendments by the Engineer on site. Before setting out any sections of the pipeline, the contractor or his representative shall make an inspection of the site in company with the Engineer and obtain from him his instructions in this respect.
- D All pipes, curves, bends and other specials shall be laid accurately in accordance with the alignment, levels and gradients so determined, so that the top of the pipe is not less than the minimum specified depth below the finished ground level along the pipeline. Changes in gradient and the numbers of air valves and washout valves will be the minimum necessary to secure efficient operation and economy in excavation.
- E The Contractor shall provide the surveying instruments, surveyors, skilled staff and everything necessary for setting out the works to line and level and for checking the accuracy of pipe-laying and jointing. He shall attend upon the Engineer and provide him with such assistance as may be necessary to enable him to check the setting out of the works.



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- F The finished pipeline shall run straight between bends or curves and a uniform gradient shall be accurately maintained between changes of gradient shown on the drawings or authorized by the Engineer.
- G The bottom of the trenches shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of pipe and bell holes shall be provided. The Contractor shall inform the Engineer sufficiently in advance when the formation levels of the trenches are ready for inspection. No pipe laying will be allowed until the bottom of trenches have been inspected and approved by the Engineer and the depths of the trenches and the kind of excavation have been recorded and agreed upon by both the Contractor and the Engineer.
- H As a general rule, water pipes and sewers should not be laid in the same trench. They should be laid in separate trenches at least 3m apart in horizontal direction. If local conditions, such as in very narrow streets, do not permit the horizontal minimum separation of 3m, this distance could be decreased but the bottom of the water pipe must be kept at least 500 mm above the top of the sewer. But if the vertical separation of not less than 500 mm can not be obtained, concrete encasement shall be provided to sewer pipe as shown on the Drawings.
- I The pipe shall be positioned and bedded in the trenches in an approved manner and properly aligned. Before being positioned, each pipe shall be thoroughly examined to ensure that it is free from defects and shall have all dirt removed from the inside thereof. The Contractor shall cut the pipes if and where needed to the required length and shall thread, chamfer or bevel the cut ends of pipes as the case may be and shall supply and install all fittings, specials and adapters as may be necessitated for the proper execution of the works and shall joint the pipes in accordance with the Specifications and to the Engineer's Satisfaction.
- J All pipe shall be sound and clean before laying. Good alignment shall be preserved in laying. The deflections at joints shall not exceed that recommended by the manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided.
- K Any injury to the protective coating of the pipes from any causes during the construction of the pipeline shall be repaired by the Contractor at his own expense to the satisfaction of the Engineer.
- L At the end of each day's work a strong watertight plug or other approved means shall be firmly fixed in each open end in order to exclude all foreign materials.
- M In order to prevent the pipes from "creeping" from the mechanical joints and to protect the welds against thermal stresses, which are specially dangerous when pipe-laying is done in summer, the following instructions shall be strictly adhered to :
1. Lowering-in and jointing of sections shall be done, as far as possible; in the early hours of the morning.
 2. As soon as the tack-welds have been completed, in the case of overhead weld joints, or as soon as the bolts have been tightened, where sections are connected by mechanical joints, the first stage backfill (between joints) shall be executed, so that no more than one section at a time will remain uncovered in the trench.
 3. Lowering-in and/or placing of welded sections on temporary supports shall be done carefully so as to prevent any damage from being done to existing coating or paint.
 4. The method employed for lowering-in shall be subject to the Engineer's approval.

ii) Steel Pipes

- A The Contractor shall regulate his equipment and construction operations such that the loading of the pipe does not exceed the loads for which the pipe is designed and manufactured.



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- B Except as otherwise provided herein, pipe and fittings shall be installed in accordance with the requirements of AWWA M11.
- C The Contractor shall permit and aid in the inspection of the coating on the underside of the pipe at the time of installation and shall repair any damage before lowering the pipe into the trench. While being laid, the pipe shall not be rolled, skidded, or otherwise moved, when it contacts with the ground at any point.
- D The method of jointing the pipe shall be in strict accordance with the manufacturer's instructions. The Contractor shall arrange for the manufacturer to supervise the installation of at least the first three standard joints and the first restrained joint. Pipe shall be laid with bell ends upstream, unless otherwise approved by the Engineer.
- E As soon as the pipe is in place and before the come-along (if used) is released, granular fill shall be placed to the top of the pipe for at least one half the length of the pipe. Not until this backfill is placed shall the jacks or come-along (if used) be released. If any motion at joints can be detected, a greater amount of backfill shall be placed before pressure is released.
- F Before bedding of galvanized pipes, in situ cold bitumen coating, of minimum thickness (0.5 mm) should be applied for underground installations, and extended at least 200 mm for pipes partially laid above the ground.
- G Field joints shall be wrapped in accordance with AWWA C209. The joints shall be cleaned, primed and wrapped with two wraps of tape with a 0.89mm (35 mils) thickness each and holiday tested. When the alternative extruded polyethylene coating is used, field joints shall be coated in accordance with AWWA C216.
- H The Contractor shall have on hand a sufficient supply of assorted short pipe lengths, adapters and any other fittings necessary to prevent delays in pipe laying.
- I Restrained joints shall be installed to the limits indicated on the Drawings or as directed by the Engineer in accordance with applicable provisions of the above. Restraining shall be harnessed coupling or field welded.
- J Pipes shall be installed true to alignment and with rigidly supported anchors adequately designed for the worst loading conditions. After installation, the piping shall be tested in accordance with applicable provisions of AWWA C600.

iii) PVC and PE Pipes

- A No single piece of pipe shall be laid unless it is straight. The centerline of the pipe shall not deviate from a straight line drawn between the centers of the openings at the ends of the pipe by more than 1.5mm per 300mm of length. If a piece of pipe fails to meet this requirement check for straightness, it shall be rejected and removed from the site. Laying instructions of the manufacturer shall be explicitly followed.
- B If any defective pipe is discovered after it has been installed, it shall be removed and replaced with a sound pipe in a satisfactory manner at no additional cost to the Employer. All pipe and fittings shall be thoroughly cleaned before installation, shall be kept clean until they are used in the work and when laid, shall conform to the lines and grades required. Pipe and fittings shall be installed in accordance with requirements of the manufacturer, and AWWA C605 or as otherwise provided herein.
- C When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. cut ends of pipe to be used with a bell shall be bevelled to conform to the manufactured spigot end.
- D The Engineer may examine each bell and spigot end to determine whether any performed joint has been damaged prior to installation. Any pipe having defective joint surfaces shall be rejected, marked as such and immediately removed from the job site.



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- E Each length of the pipe shall have assembly mark aligned with the pipe previously laid and held securely until enough backfill has been placed to hold the pipe in place. Joints shall not be “pulled” or “cramped”. Deflection in horizontal or vertical alignment shall not be performed without the approval of the Engineer’s Representative as to the extent of the deflection. In no case shall such deflection be done at the pipe joint. If any bending is required it should be done at the central portion of the pipe and not exceeding the limits specified by the manufacturer. Whenever the required deflection exceeds the permissible limits, the Contractor shall install proper bends in the line and anchor same as required. Care should be exercised to lay the pipe in such manner as to minimize the high and low points in it.
- F Before any joint is made, the pipe shall be checked to assure that a close joint with the next adjoining pipe has been maintained and that the inverts are matched and conform to the required grade. The pipe shall not be driven down to grade by striking it. Bell or coupling holes shall be formed so that, upon being placed only the pipe barrel is in contact with the trench bottom.
- G Jointing of PE pipes will be made using electro-fusion method. During jointing with electro-fusion, care should be taken that joints are not moved before the cooling process has been completed.
- H For PVC pipes, flexible joints with spigot and sockets sealed with rubber rings or gaskets will be used. Spigot ends shall be centralized within sockets, and shall be pushed into the socket, strictly following the manufacturer’s instructions, until reach the depth of the entry mark. The pipe should never be over inserted.
- I Precautions shall be taken to prevent flotation of the pipe in the trench.
- J When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care shall be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe, or disturbance of the pipe bedding and the backfill. Trench boxes, moveable sheeting, shoring or plates shall not be allowed to extend below top of the pipe. As trench boxes, moveable sheeting, shoring or plates are moved, pipe bedding shall be placed to fill any voids created and the backfill shall be recompacted to provide uniform side support for the pipe.
- K Concrete thrust blocks shall be installed at all fittings and other locations as directed by the Engineer. Minimum bearing area shall be as shown on the Drawings. Concrete shall be placed against undisturbed material and shall not cover joints, bolts or nuts, or interfere with the removal of any joint. Wooden side forms shall be provided for thrust blocks.
- L Restrained joints shall be installed where shown on the Drawings.
- M Joints shall be made in strict accordance with the manufacturer’s instructions.

3.10 Jointing of Pipes

All joint surfaces shall be cleaned. Before forming the joint, the previously installed unit shall be checked to ascertain that a close joint exists with the previously installed unit and that the inverts conform to the required grade. The pipe shall not be forced to the required grade by mishandling. Immediately before jointing the pipe, the pipe end shall be lubricated in accordance with the manufacturer’s specification. Each pipe unit shall then be carefully pushed into place without damage to pipe or gasket. Approved devices shall be used to ease the pipe units together to the specified insertion depth. Spigot ends of uPVC pipes shall be pushed into the socket end strictly following the manufacturer’s instructions until it reaches the insertion depth. The pipe should never be over-inserted.

Except in the case of flanged fittings and when jointing to existing pipelines of different materials, all joints will be:

Electro-fusion for polyethylene pipes (50mm)

Flexible joints with spigot and sockets sealed with rubber rings or gaskets.

Basic requirements for all types of joints are:



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Cleanliness of all parts.
Correct location of components.
Centralization of spigot within sockets.

Strict compliance with the Manufacturer's specification.

Long radius curves in the pipeline shall conform to the Manufacturers specification.

The deflection at joint of pipes used in the work shall not exceed one degree.

The Contractor shall take care that all pipes and couplings are clean and free of foreign matter before subsequent sections are jointed.

During jointing with electro-fusion care should be taken that joints are not moved before the cooling process has been completed.

The Contractor shall make himself and his employees acquainted with and comply with the instructions issued by the manufacturers of the various types of proprietary joints and couplings for incorporation in the work. The Contractor shall be responsible for obtaining copies of these instructions.

Connection of UPVC or HDPE pipes to flanged fittings shall be by means of flanged adapters or couplings (dressers). Connection of new plastic pipes to existing pipes of mainly asbestos and steel will be done by special flange adapters, if required. Saddle connections to UPVC and Steel Mains shall be in accordance with the suppliers specifications.

Connections may be made in the dry or under pressure.

All joints shall be capable of withstanding the various tests as specified in the applicable standards.

The pipes shall be laid and bedded in 15 cm. full sand surround except where concrete protection may be specified. The granular fill shall be placed over the full width of the bottom of the trench. The side fill shall be placed in thin layers and well compacted.

Depth of back fill above the sand surround and surface material shall conform with the requirements for the appropriate road or pavement construction. The back fill material may be the excavated soil, provided it is suitable for compaction. Adequate precautions shall be taken by the way of backfilling or other means to anchor each pipe securely to prevent floatation of the pipeline in the event of the trench being flooded or during possible concreting.

3.10.1 Pipe Welding

i) Welding Methods

- A All welds shall be made by the manual shielded metal-arc method. The welding procedure to be applied by the Contractor shall be submitted to the Engineer for approval before any commencement of the Work. All requirements as to the quality of the welds shall apply equally to roll welding and position welding. All welds shall be made only by welders having passed the welders' qualification test. The Contractor will not be allowed to use a piece-work system on welding work, but there shall be no limitations to the amount of work a welder may produce during one day, provided that the welds meet all the requirements of the specification.
- B The use of welding machines with two outlets will not be permitted; every welder shall work with his own machine.

ii) Electrodes

- A Electrodes used on welding work shall have a diameter of 4 mm and 3.25mm and shall approximately meet the requirements of ASTM Specification A 233 as last revised. Generally, with D.C. generators, class S 6010 electrodes shall be used. In any event, the electrodes proposed by the Contractor shall be subject to the Engineer's approval prior to their use.
- B Electrodes shall be stored in unopened original containers in such a manner as to prevent absorption or loss of moisture or mechanical damage to the coating. Electrodes in open containers shall be protected against moisture. Electrodes that have been damaged, become moist or otherwise deteriorated shall be rejected.



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iii) Cleaning of Pipes

- A Pipe ends to be welded together shall be thoroughly cleaned of any dirt, oil, residues of paint and asphalt, and any other foreign matter that may adversely affect the quality of the weld. Paint and oil residues shall be removed with kerosene or benzene.
- B Before welding the root bead, the cleaning pig with the cable attached to it shall be introduced into the pipe last laid before the new pipe. When the root bead has been completed, the pig shall be extracted by means of the cable; in passing the seam the pig will remove all metal bubbles and slag that have entered the interior of the pipe.

iv) Welding Positions

- A The welds shall be made either by roll welding or position welding. Roll welding will be permitted, provided alignment is maintained by the use of skids and roller dollies supporting two or more lengths of pipe. Position welding shall be done with the pipes resting on skids at the proper height over or alongside the trench, so as to permit completing the weld on the whole circumference.

v) Weather Conditions

- A No welding shall be done when adverse weather conditions such as rain, mist, sand storms, or strong winds may affect the quality of the welds. The Engineer will decide in each case whether weather conditions permit welding to be done.

vi) Cutting and Preparing Pipes for Welding

- A The cut shall be made with an approved mechanical pipe cutter and in conformity with the pipe manufacturer's recommendations. The edges of the cut shall be clean, true and square. The edges of the cut together with those parts of the pipes from which the coating has been removed shall be given two coats of bituminous paint and the internal lining repaired, if damaged, to the approval of the Engineer. When the cut pipe is to be inserted in a "Tyton" type joint it shall be bevelled for 10 mm at 30° to pipe axis to remove sharp or through edges.
- B The Contractor shall be solely responsible for the provision of all equipment necessary for cutting and preparing pipes.
- C Spare cut lengths shall as far practicable be used elsewhere in the pipeline.

vii) Welding of Joints

- A The number of beads in each weld seam shall not be less than two, and their thickness shall not exceed 3.0mm.
- B In butt welds, the thickness and number of the beads shall be so adjusted that the height of the weld reinforcement shall be not less than 0.8mm and not more than 1.5mm above the pipe surface. The width of the cover bead shall be approximately 3.0mm more than the width of the groove before welding. In fillet welds the thickness of the throat shall be at least (0.707) of the pipe wall thickness cutting back of the edge of the bell shall be kept to a minimum. All weld metal shall be thoroughly fused to the parent metal and to the previously placed weld metal.
- C After the completion of each bead, the weld shall be thoroughly cleaned of all scale, slag, or dirt. All spots on the weld where electrodes are changed shall also be cleaned.

viii) Jointing of Line Sections

- A Pipes shall be connected to each other by welding as specified above, while they are placed on suitable supports on the trench bottom or on the ground beside the trench. The places of welded joints should be wrapped according to the instructions of the manufacturer.
- B The length of sections to be welded together before lowering shall be as determined by the Engineer. The position of every pipe or elbow in the section shall be such that, when the section has been lowered to the trench bottom, the



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longitudinal seams will be located between the figures 10 and 2 on the clock face, so that repairs on the seams can be done in the trench without necessitating deep excavation.

- C Before being connected to the line, each pipe and each elbow shall be cleaned on the inside.

ix) Repair of Weld Defects

- A The Engineer may permit repairs of defects in the root or filler beads to be made, but any weld that shows evidence of repair work having been done without such permission may be rejected.
- B Pinholes and undercuts in the final bead may be repaired, but such repairs shall be subject to the Engineer's approval. Undercuts not exceeding 1.0mm in depth will not be considered as defects.
- C Before repairs are made, the defective areas shall be removed by chipping, grinding, or flame gouging. All slag and scale shall be removed by wire brushing. When cracks are found, the entire seam shall be cut and re-welded.
- D The Contractor shall clearly mark with oil paint on top of the pipe any defect that may be discovered in the pipe or weld.

3.11 Above Ground Pipe-laying

- A In addition to all specifications here before mentioned for each type of , the following instructions shall be considered for the above ground pipes :

1. All pipes and fittings exposed to view shall have its surface prepared, finish painted and marked in accordance with the manufacturer's instructions and as required by the Engineer in identifying pipe contents, direction of flow and all else required for proper finish painting and marking of pipe.
2. Concrete inserts for hangers and supports shall be furnished and installed in the concrete as it is placed. The inserts shall be set in accordance with the requirements of the piping layout and jointing method and their locations shall be verified from approved piping layout drawings and structural drawings.

3.12 Flanged Joints

- A The flanges shall be scraped clean and correctly positioned and the component parts including any insertion ring cleaned and dried. Insertion rings shall be fitted smoothly to the flange without folds or wrinkles. The faces and bolt holes shall be brought fairly together and the joints shall be made by gradually and evenly tightening bolts in diametrically opposed positions. Only standard length spanners shall be used to tighten the bolts.
- B The protective coating, if any, of the flange shall be made good when the joint is completed.

3.13 Mechanical Joints

- A Before installing mechanical joints, the pipe ends shall be cleaned of any paint, asphalt and dirt and their perfect roundness shall be ensured for a distance of not less than 200 mm from the edge.
- B Joint rings shall slide freely into the pipes. Forcing on of rings by hammer blows will not be permitted.
- C Rubber gaskets shall be protected against sunlight until immediately before installation. Where a "bored Dresser" is required, the ridge in the central ring shall be removed by turning on lathe in the shop or by chiseling if the work is done in the field. Removing the ridge by flame gouging is strictly prohibited.
- D Where shown on the drawings or required by the Engineer, Dresser couplings shall be fitted with anchors. The shape and method of installation of these anchors shall be as shown on the drawings.



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- E Every Dresser coupling shall be bridged for cathodic protection as shown on the drawings (see clause 6.2).

3.14 Fabrication of Steel Fittings

- A Fabrication of fittings by welding pieces of pipes is not accepted. The fabrication shall be done as follows :

1. Elbows must be fabricated by forging or by hot or cold forming of pipes.
 2. Reducers must be fabricated by hot or cold forming and annealing of pipes.
 3. Tees must be fabricated by forming of pipe or by hot or cold forming and annealing of pipes.
 4. Caps must be fabricated by hot or cold stamping or forging of plates heat treated.
- The fabricated pieces shall be of the same thickness as the used pipe .

3.15 Thrust and Anchor Blocks

- A If not otherwise instructed the Contractor shall provide thrust blocks at all bends, tees, branches and tapers and at blank ends as specified by the pipe Manufactures and the Engineer. Enlargements shall be excavated in sides and bottom of the trench to accommodate anchorage and thrust blocks. The back of supports and blocks shall abut on to undisturbed solid ground. All loose material shall be removed before concreting.
- B The thrust blocks shall be designed by the Contractor in accordance with the BS.8110 - the structural use of concrete. The Contractor shall show that soil resistance is greater than or equal to 1.2 times the force exerted by the pipe when subjected to the test pressure. The soil resistance shall be calculated as the frictional resistance of the soil against the thrust block. The passive resistance of the soil shall not be considered in thrust block calculations.
- C Concrete shall extend to undisturbed ground on thrust faces of thrust blocks and on both faces of anchor blocks.
- D Where details are not shown on the drawings, the Contractor shall prepare proposals for thrust and anchor blocks and submit them to the Engineer's Representative for approval. Such approval shall not relieve the Contractor of his responsibility for the adequacy of his proposals. Special details shall be shown on the drawings or instructed at site where environmental or ground conditions dictate.
- E Plywood plates, suitably moulded to the pipes barrel, shall be used to prevent direct contact between the concrete and uPVC pipes.
- F The blocks shall, unless otherwise shown or directed by the Engineer, be so placed that the pipe and fitting joints will be accessible for repair.
- G Where it is not possible to brace against undisturbed soil, suitable fenders shall be arranged as directed by the Engineer.

3.15 Valves Installation

- A All valves shall be in accordance with the Specifications and shall be installed on the pipelines in the positions and to the details shown on the Drawings.
- B To facilitate their removal for maintenance or repair, flanged gate valves installed on ductile iron lines shall have a flange-spigot connector on one side and a flange-socket connector with a clearance assembly of 35 to 45 mm on the other side.
- C Flanged gate valves installed on black steel lines with welded joints shall be provided on one side with the appropriate Viking Johnson flange adapter and those installed in galvanized steel threaded pipelines shall be preceded or followed by the appropriate galvanized iron union.
- D Pressure reducing valves shall be provided with by-passes and shall be preceded and followed by the appropriate pressure gauges in accordance with the Detailed Drawings and Specifications.



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- E Covers and surface boxes shall be securely fixed either by bedding and haunching in cement mortar or by building into concrete, as indicated on the Drawings. They shall be accurately positioned (and refixed if necessary) such that they are level with the finally reinstated surface.

3.17 Future Connections

- A Where future connections and extensions are shown on the Drawings of the lines to be constructed under the Contract, the Contractor shall provide at such points Tees and / or the proper and appropriate fittings to facilitate such connections. The dead ends shall be closed with blind flanges. In case of ductile iron pipes the blank flanges or caps shall be provided with thrust blocks in accordance with the Detailed Drawings.

3.18 Connections to Existing Mains

- A Where connections are to be made to any part of the existing mains the Contractor must make all necessary arrangements with the Engineer and have all necessary material, plant and labour in readiness on the ground and shall complete the work as rapidly as possible with the minimum of inconvenience to consumers. The actual connection to an existing main will be the Contractor under the close supervision of the Engineer.

3.19 Protection of Joints

- A All buried steel and ductile iron flange joints, flange adapters and couplings shall be protected by wrapping with “Denso Tap” or similar approved material.
- B The joints shall be thoroughly cleaned to remove all loose rust and extraneous matter and thoroughly and adequately wrapped with the protective tape to the satisfaction of the Engineer.

3.20 Hydrostatic Pressure Test

i) General

- A After pipe-laying, casting of concrete structures on the line and partial backfill have been completed, the line shall be subjected to a hydrostatic pressure test. The line shall be tested over its entire length or, in the case of long lines, in sections. The pressure test shall only be performed in the presence of the Engineer.
- B The test pressure shall be determined by the Engineer in each case. The required pressure shall be obtained by means of a special pressure pump or by connecting the line to a suitable source of pressure.

ii) Preparations for Pressure Test

- A Filling of the line with water shall not begin until 6-7 days after the last concrete structures have been cast. Prior to filling the line, all joints and structures shall be inspected and the good condition and proper functioning of all valves shall be ascertained. When testing a section not ending in a valve, the open end shall be bulk headed and securely anchored. The testing installation and the working of the pump shall also be examined.

iii) Filling the Line with Water

- A The line shall not be filled until the Engineer’s written approval thereto has been given. The line shall be filled gradually and slowly in order to prevent water hammer or chattering in the pipe and to permit the escape of all air from the pipeline.
- B At the commencement of filling, all blow-out valves shall be open, and each valve shall be closed after the water has flushed all dirt that may have accumulated in the pipes.



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- C After the filling has been completed, but before the pressure is raised, all valves shall be inspected for watertightness and all leaks in gaskets and stuffing boxes shall be stopped. Should this inspection show any leaks at the joints or defects in the valves that can not be repaired while the line is full of water, the line shall be drained and the necessary repairs done. This inspection shall be repeated until all leaks are stopped.
- D Prior to hydraulically testing the pipelines the Contractor shall provide adequate temporary thrust blocks at the ends of uncompleted sections, pipes shall be partially backfilled to about 500 mm above the crown of the pipe, in order to anchor the pipes during testing. Joints and fittings, however, shall remain uncovered until the pipeline has been tested satisfactorily. All house connection pipes that are connected to the pipe under testing shall be temporarily plugged with approved fittings.
- E The length of the section of pipeline to be tested may be determined by the contractor but shall not exceed 500 meters. Levels of the length of pipe under test shall be such that the minimum test pressure specified is achieved at all points whilst the maximum test pressure specified is nowhere exceeded.

iv) Pressure Test

A The pipelines of the transmission and water distribution system and all the joints shall be tested by the Contractor at a test pressure as shown in table 4.3 below

Table 3.3

<i>Working Pressure Range [atm]</i>	<i>Factor *</i>
0 - 12	1.5
13 - 20	1.25
more than 20	1.1

Test pressure = Working pressure * Factor

The testing shall be carried out in sections as the pipes are laid.

- B The length of sections and the procedure of testing shall have the prior approval of the Engineer. The Contractor shall furnish and fix on the pipelines at locations indicated by the Engineer Tees provided with 1/2" stop-cooks for the purpose of releasing the air from the pipelines. After pressure testing of the lines the stop-cook shall be removed and the opening properly plugged.
- C An efficient stop and strutting block shall be placed at the end of the section to be tested. After the pipes have been completely filled with water and all air has been exclude therefrom, the pressure shall be raised by pumping to the specified test pressure as instructed by the Engineer.
- D The pipeline shall be maintained under this pressure for a period of 24 hours, during which period the pressure shall not be allowed to fall below 75% of the test pressure but shall be restored to the full test pressure by such pumping as may be necessary.
- E The test pressure shall be calculated as one and a half times the maximum working head at the lowest point in the section to be tested.
- F The test shall be deemed to be satisfactory if the pipeline holds after the initial 24 hours the specified pressure for a final period of not less than two hours or such final period as is determined on site by the



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Engineer, with a loss not exceeding 5 % of the total test pressure during this two hours period. No pumping shall be permitted during this final test period.

- G If the test is not successful, the Contractor shall proceed to locate immediately and rectify the defects, after which he shall re-test until a satisfactory test result can be secured.
- H The Contractor shall provide the clean water, all pumps, meters, pressure gauges and other appliances required for the purpose of the test. The Contractor shall also arrange for meters and gauges to be tested for accuracy, if required to do so by the Engineer.

3.21 Sterilization of the Lines

Pipelines, manholes, chambers/structures will be inspected again before commissioning or taking over (whichever is sooner) and shall be cleaned again in whole, flushing with clean water and a swab to be pushed through the length of the pipeline by hydrostatic pressure. The swab shall be first soaked in sterilizing solution.

Flushing of the new pipeline may be carried out by temporary connections to the existing water system if present in the working area. CMWU will charge for giving the water to the Contractor as per for flushing including all other necessary requirements such as water tankers in the absence of mains water.

- A After the lines have been hydraulically tested and before they are put into service, they are to be flushed with clean water to remove foreign matter. This process will be continued until the flushing water runs clear.
- B After flushing they are to be sterilized by the Contractor, and The Contractor shall prepare a solution of chlorinated dosing solution using calcium hydroChlorine at a rate of 77g/cu.m of system water volume, or with chlorinated water containing between 30 and 50 mg per liter of free chlorine. The solution shall be slowly pumped into the pipeline and a Chlorine level of 50 ppm. shall be maintained for a period of 8 hours.
- C The pipe work shall be flushed out until the Chlorine level drops below 0.2 ppm when tested with standard DPD (Diethyl-P Phenylenediamine) method and shall be clear of any detergent content when tested in accordance with BS 2690 - Part 11. The Contractor shall be responsible for the disposal of water.
- D The sterilization of the lines can be done in sections, and the process shall obtain the prior approval of the Engineer.
- E The Contractor shall provide the clean water, chemical compounds and all the necessary equipment, and shall make all connections necessary to carry out the sterilization of the system. The pressure testing and the sterilization of the lines shall not be measured for direct payment and their cost shall be deemed to be included in the unit price for the perspective bill of quantities item.

SECTION 4 - CONSTRUCTION & CIVIL WORKS

4.1 CONCRETE AND REINFORCED CONCRETE WORK

General

The All materials shall be subject to such tests as the Project Manager may direct and provision for such tests shall be included in the price for such materials inserted in the Bill of Quantities or Schedule of Rates unless otherwise provided for.

Properly representative samples of all materials to be used in the works shall be submitted by the Contractor for the Project Manager's approval when required.



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Where tests are required by the Project Manager, the Contractor shall take samples and send to a firm experienced in analysis of the material. Reports shall be submitted to the Project Manager. The Contractor shall bear all expenses consequent to the provision, taking and cartage, etc. of samples, in addition to the costs of performing the tests and reporting the results.

The Project Manager reserves the right to reject any material which, in his opinion is objectionable in any respect, notwithstanding its apparent compliance with the relevant Standards. Any such rejected material shall be removed from the site at the Contractor's expense at once.

4.1.1 Formwork for Concrete

The Contractor shall supply, design, erect, strike and remove the formwork and be entirely responsible for its stability and safety so that it will carry the fresh concrete and all incidental loadings and preserve it from damage and distortion during its placing, vibration, ramming, setting and curing. It shall be so constructed as to leave the finished concrete to the dimensions shown on the Drawings and of a material capable of providing the surface finish specified. In any event, the maximum permissible deflection under all loads shall not exceed 2mm or 1/600 of the free span, whichever is less.

Formwork shall be of new timber and / or metal and shall include all temporary concrete moulds and their supports. Bolts to be used for fixing the formwork shall be approved by the Project Manager before starting the work.

For concrete surfaces which are to remain exposed wrought formwork shall be used. Wrought formwork shall be of timber or steel framing lined with 12mm thick smooth-faced plywood or an equal lining approved by the Project Manager, or of metal, suitable to obtain a fair face finish on the concrete. All external angles or fair faced in-situ concrete shall have chamfers formed with 15x15mm (5/8"x5/8") wrought hardwood angle fillets planted in the angles of the formwork, unless larger chamfers are shown on the drawings.

Formwork ready to receive concrete shall be thoroughly clean and the internal faces properly painted with an approved shutter oil or other preparation. Joints shall be tight to prevent leakage.

Wherever required and prior to placing of the reinforcement the internal surfaces of all formwork shall be treated with an approved mould oil.

All formwork shall be inspected and approved by the Project Manager prior to concreting. This approval, however, does not relieve the Contractor of any of his responsibilities.

The striking of all formwork shall be carried out with the greatest of care to avoid damage to concrete.

The formwork to vertical surfaces such as walls, columns and sides of beams may be removed in accordance with the table below although care must be taken to avoid damage to the concrete, especially to arrises and features.

Minimum periods for striking other formwork should be in accordance with the following table, or as directed by the Project Manager Ordinary Portland Cement Concrete

Slabs (props left under)	3 days
Beam soffits (props left under)	7 days
Props to slabs	7 days
Props to beams	16 days
Vertical surfaces as walls, columns and sides of beams	1 day

Formwork, shuttering, props, or any other means of temporary or semi-permanent support shall not be removed from the concrete until the concrete is sufficiently strong to carry safely the load (dead and temporary).

The Contractor shall inform the Project Manager when he is ready to strike the formwork, or remove any form of temporary support, and shall obtain his written consent before proceeding.

The times given for the removal of props are based on the assumption that the total live plus dead weight to be supported at the time of removal is not more than one half of the total design load.

For horizontal members where the loading is to be a higher proportion of the total design load these times may need to be increased.

The Contractor shall be responsible for any damage to the concrete work caused by or arising from the removal and striking of the forms and supports Any advice, permission or approval by the Project

Manager relative to the removal and striking of forms and supports shall not relieve the Contractor from this responsibility.

Any work showing signs of damage through premature loading is to be entirely reconstructed at the Contractor's expense.

The Contractor shall confirm positions and details of all



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- (a) permanent fixings
- (b) pipes and conduit
- (c) holes and chases to ensure that alterations are not made without the knowledge and approval of the Project Manager.

The Contractor shall fix inserts or box out as required to correct positions before placing concrete, and shall form all holes and chases. He shall not cut hardened concrete without approval.

4.1.2 Reinforcement for Concrete

Steel reinforcement shall generally be hot rolled mild, medium or high yield steel smooth round or deformed bars complying with BS 4449 or similar approved standard .

In case any other type of reinforcement is required, it shall comply with the requirements of the BOQ and drawings. All reinforcement shall be free from rust and mill scale and any coating such as oil, clay, paint etc which might impair the bond with the concrete.

Manufacturer's test certificates for all classes of reinforcement shall be supplied when required. Specimens sufficient for three tensile tests and three cold-bending tests per ten tons of bars or fraction thereof and for each different size of bar shall be sampled under the supervision of the Project Manager. Testing shall be in accordance with BS 4449 or other approved standard and batches shall be rejected if the average results for each batch are not in accordance with the specification. All tests should be made on the Contractor's expense.

All steel is to be totally free from dirt, paint, loose rust or scale when in position ready for concreting.

The Contractor shall cut and bend bars to BS 4466 and to schedule provided unless otherwise instructed by the Project Manager.

Straight sections of bars must be kept out of winding. The internal radius of bends shall in no case be less than four times the diameter of the bar, except for stirrups, column binders, and wall shear bars which are to be bent to fit closely around the main bars.

Great care is to be taken to bend stirrups and columns binders separately and to the sizes shown.

All bars will be cut and bent cold using approved machines.

Lengthening of bars by welding, and rebending of incorrectly bent bars will not be permitted, except where requested by the Project Manager.

The Contractor shall provide on site facilities for hand bending to deal with minor adjustments.

Unless otherwise allowed for in the particular specification splices in reinforcing bars shall be formed by lapping. Such laps in bars in any member shall be staggered. Except as otherwise indicated on the drawings the minimum overlap of lapped splices shall be 50 bar diameters or 400mm whichever is greater.

The steel is to be fixed in position exactly as indicated, and the bars are to be securely wired together with 1.6 or 1.4mm soft galvanized iron wire or approved spring galvanized steel clips wherever necessary to prevent any displacement during concreting.

Spacers, chairs and the like, temporary or permanent, are to be used as required to ensure that the steel has the exact amount of cover indicated. No permanent spacers may show on a surface where a fair faced concrete finish or a brushed aggregate finish are required. Type of spacers shall be approved by the Project Manager before starting the work. Unless otherwise indicated, the minimum cover to the reinforcing bars is to be as listed below or equal to the diameter of the bar, whichever is greater.

<u>Position Minimum cover-</u>	<u>mm</u>
Main bars in internal faces of columns and beams	25
Main bars in external faces of columns and beams	25
Main bars in floor slabs and soffits of roof slabs	20
Main bars in top of roof slabs	20
Outermost bars in internal faces of walls	25
Outermost bars in external faces of walls	25



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Bars in top of ground slabs

30

Bars near faces in contact with soil

50

The placing of all reinforcement will be checked by the Project Manager and in no case is concrete to be poured around any steel that has not been passed by him. The Contractor is to ensure that no steel is displaced from its position during the placement of concrete and until the concrete is set.

The insertion of bars into or removal of bars from concrete already placed will not be permitted.

Reinforcement temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Project Manager.

Secondary reinforced concrete members for which no reinforcement details are given in the drawings or the Bill Of Quantity shall have a minimum ratio of reinforcement area to concrete area of 0.33 %.

4.1.3 Concreting

4.1.3.1 Cement

The cement used shall be Portland Cement conforming in all respects to BS EN 197-1:2000, unless otherwise required, bags shall contain 50kg net + 1%.

The Contractor shall at all times furnish the Manufacturer's statement of the above Standard Specifications together with the date of manufacture, certified by an independent agency in the country of origin approved by the Project Manager. The cement shall be delivered to the site by the Contractor in the original sealed and branded bags or containers of the manufacturer in batches not exceeding 100 tons and shall be stored in a proper manner off the ground to prevent deterioration. Each batch shall be stacked separately and used in the order of delivery.

No cement shall be used which has been manufactured more than twelve months prior to its proposed use on site.

All cements whether stored in bulk, bags, or containers in warehouses or on site shall be sampled for testing according to ASTM C183 (Methods of Sampling Hydraulic Cements). Test samples over and above those specified shall be taken at any time if so requested by the Project Manager. Testing of cement shall be in accordance with the methods required by BS EN 197-1:2000 or any other accepted by the Project Manager.

4.1.3.2 Aggregates

This specification covers fine and coarse aggregates other than lightweight aggregates for use in the production of concrete. When lightweight aggregates are required they will be defined in the BOQ.

The aggregates shall be crushed gravel or stone and shall comply with BS 882 for graded or single size aggregate and shall be obtained from any quarry in the mountains approved by the Project Manager.

For convenience part of Clause 5 of BS 882 (grading) including Tables 1, 2 and 3 are reproduced herein.

Coarse aggregate: the grading of coarse aggregate, when analysed by the method given for sieve analysis in BS EN 1097 shall be within the limits given in Table 1.

Fine aggregate: the grading of a fine aggregate, when analysed by the method of sieve analysis described in BS EN 1097, shall be within the limits of one of the grading zones given in Table 2, except that a total tolerance of up to 5 per cent may be applied to the percentages under-lined. This tolerance may be split up; for example, it could be 1 per cent on each of three sieves and 2 per cent on another, or 4 per cent on one sieve and 1 per cent on another.

The fine aggregate shall be described as fine aggregate of the grading zone into which it falls, e.g. BS 882, Grading Zone 1. NOTE: It is intended that individual zones should not be specified in contract documents relating to concrete but that the concrete mixes should be modified to make the best use of the materials readily available.

If approved by the Project Manager. Single-sized aggregate to BS 882 Table 1 may only be used for reinforced concrete when combined in two or more sizes to provide a well-graded mixture approved by the Project Manager.

Sampling and testing of aggregates shall be as required by BS 882 and in accordance with BS 812 'Methods for Sampling and Testing of Mineral Aggregates, Sands and Fillers'. All sampling shall be done by or under the supervision of the Project Manager.

The combined percentage of sulphates and chlorides by weight in coarse and fine aggregates shall not exceed 0.05 per cent (500ppm) of the combined weight of total aggregates.



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Just before use the aggregate will be washed down with potable water to reduce the content of sulphates, chlorides and other extraneous material.

Table 1 : Coarse Aggregate

BS 410 Test Sieve	Percentage by weight passing BS sieves							
	Nominal size of Graded aggregate		Nominal size of Single-sized aggregate					
	400mm to 5mm	200mm to 5mm	14mm to 5mm	63mm	40mm	20mm	14mm	14mm
75.0	100	-	-	100	-	-	-	-
63.0	-	-	-	85-100	100	-	-	-
37.5	95-100	100	-	0-30	85-100	100	-	-
20.0	35-70	95-100	100	0-5	0-25	85-100	100	-
14.0	-	-	90-100	-	-	0	85-100	100
10.0	10-40	30-60	50-85	-	0-5	0-25	0-50	85-100
5.0	0-5	0-10	0-10	-	-	0-5	0-10	0-25
2.36	-	-	-	-	-	-	-	0-25

Table 2 : Fine Aggregate

BS 410 Test Sieve	Percentage by weight passing BS sieves			
	Grading Zone 1	Grading Zone 2	Grading Zone 3	Grading Zone 4
mm				
10.00	100	100	100	100
5.00	90-100	90-100	90-100	95-100
2.36	60-95	75-100	85-100	95-100
1.18	30-70	55-90	75-100	90-100
microns				
600	15-34	35-59	60-79	80-100
300	5-20	8-30	12-40	15-50
150	0-10	0-10	0-10	0-15

The choice and preparation of sites for stockpiling of aggregates, the number and sizes of stockpiles and the methods adopted to prevent segregation of component sizes shall be agreed with the Project Manager.

Coarse aggregate shall be stockpiled in three separate gradings: 38-19mm, 19-10mm, 10-5mm. When aggregates of different gradings are stockpiled close together the stockpiles shall be separated by bulkheads.

Stockpiles are to be on concrete or other hard surface sufficiently sloped so that water is not retained in the base of the stockpiles.

All aggregates are to be handled from the stockpile in such a manner as to secure a typical grading of the material, care being taken to avoid crushing the aggregates and contamination with extraneous matter.

Aggregates need not be stockpiled when a crushing-screening plant is used in tandem with a batching plant properly equipped with several bins for different sized aggregates having the appropriate weighing scales at such bin such that a mix of the desired gradation is obtained consistently and the whole operation is conducted to the satisfaction of the Project Manager.

4.1.3.3 Water

Unless otherwise authorised in writing by the Project Manager, only chilled water from potable supply system may be used for mixing concrete and other products containing cement.

Similarly only potable water may be used for curing concrete and cement products during the first 24 hours after pouring. Later, fresh water, or other water containing not more than 4750 ppm dissolved solids of which not more than 1000 ppm may be chlorides, may be used for curing.



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No additives of any kind shall be used in the concrete without the express approval in writing of the Project Manager.

4.1.3.4 Quality Of Concrete

Concrete shall be a mixture of cement, aggregates and water as covered respectively by 4.4.1 to 4.4.3 above.

The mix proportions, workability and strengths of the various types of concrete shall conform to Table 4.

The terms contained in Table 4 are defined as follows: WATER/CEMENT RATIO: the term water/cement ratio means the ratio by weight of the water to the cement in the mix, expressed as a decimal fraction. The water is that which is free to combine with the cement in the mix.

This includes free water in the aggregate but excludes water absorbed or to be absorbed by the aggregate.

The aggregate for this purpose shall be taken in a saturated surface-dry condition.

The absorption of the aggregates shall be determined in accordance with BS EN 1097 or any other method approved by the Project Manager.

The strengths specified are for ordinary Portland cement to BS EN 197-1:2000; if other types of cement are specified, the required strength shall be as defined in the Bills of Quantities.

**Table 1 : Mix Proportions , Workability and Strength
Grades of Concrete**

Grade	Minimum Works cube Strength kg/cm ²		Max. Agg mm	Limits of agg./ Cement ration by weight		Use of concrete if not otherwise specified
	At 7 days	At 28 days		Max.	Min.	
(A)	150	200	20	7:1	5:1	RC structures in general
B-200	150	200	37	8:1	6:1	RC Foundations
(B)	200	300	20	5:1	3:1	High load columns
B-300	200	300	37	5:1	3:1	High load foundations

**Table 2 : Mix Proportions , Workability and Strength
Standard Mixes**

Grade of Concrete	Minimum works Cube Strength Kg/cm ²		Weight of dry sand per 50 k of cement	Standard Mixes						Max. desigm W/C ratio
				Weight of dry coarse aggregate per 50 kg of cement						
				Workability						
	7 days	28 days		20mm max. size			37mm max. size			
				Low	Med.	High	Low	Med.	High	
			kg	kg	Kg	kg	kg	kg	kg	
B-200	150	200	91	193	159	136	226	193	170	0.55
B-300	200	300	68	147	113	91	170	136	113	0.45

**Table 3 : Mix Proportions , Workability and Strength
Workability**

Degree of Workability	20 mm Max. size aggregate		37 mm Max. size aggregate		Use for which Concrete is suitable
	Slump Mm	Compacting Factor	Slump mm	Compacting Factor	
Low	13-25	0.82-0.88	13-50	0.82-0.88	Simple reinforced sections with vibration
Medium	25-50	0.88-0.94	50-101	0.88-0.94	Heavily reinforced sections with vibration
High	50-127	0.94-0.97	101-117	0.94-0.97	Sections with heavily congested reinforcement where vibration is difficult



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The cubes used for the compression tests shall be 150x150x150 mm as specified in BS 1881. In case cylinders are used for determination of concrete compressive strength in accordance with ASTM C 39, the corresponding cube strength shall be obtained by using a multiplication factor of 1.2.

AGGREGATE/CEMENT RATIO: the term aggregate/cement ratio means the ratio by weight of aggregate to cement in the mix. For this purpose the aggregate is taken in a saturated surface-dry condition as for the water/cement ratio above.

FINE/TOTAL AGGREGATE RATIO: the term fine/total aggregate ratio means the ratio by weight of the fine aggregate to the total aggregate in the mix expressed as a percentage. For this purpose the aggregate is also taken in a saturated surfacedry condition as for the water/cement ratio above.

VOLUME OF AIR ENTRAINED: the air content expressed as a percentage by volume of concrete shall be determined by ASTM C231, 'Air Content of Freshly Mixed Concrete by the Pressure Method'. At least one test for each 120 cubic meters of concrete shall be made.

SLUMP: the slump of the freshly mixed concrete shall be determined in accordance with BS EN 12350-2:2000. At least one morning and one afternoon test shall be made and whenever directed by the Project Manager.

STRENGTH OF CONCRETE: Preliminary Test Cubes shall be taken from the trial mixes designed to select the job mix and shall be made and tested in accordance with BS EN 12390-3:2002.

SAMPLING FOR COMPLIANCE TESTING: Works Test Cubes shall be those used for control during construction and shall be made and tested in accordance with BS EN 12350-1:2000 and BS EN 12390-2:2000.

Recommended Minimum Rates Sampling

Average Rate of Sampling One Sample (6 cubes) per	Maximum quantity of concrete at risk under any one decision
10 m ³ or 10 batches	40 m ³
20 m ³ or 20 batches	80 m ³
50 m ³ or 50 batches	200 m ³

The Contractor when tendering having knowledge of the source and types of cement, aggregate, plant and method of placing he intends to use shall allow for the aggregate/cement ratio and water/cement ratio which he considers will achieve the strength requirements specified and will produce a workability which will enable the concrete to be properly compacted to its full depth and finished to the dimensions and within the tolerances shown on the Drawings. In any event the aggregate/cement ratio and the water/cement ratio shall not exceed the upper limits specified in Table 4 for each type of concrete. Furthermore, the quantity of cement per cubic metre of concrete shall in no case be less than the minimum specified in Table 4.

As soon as possible after signature of the Contract, the Contractor shall prepare such trial mixes as required to satisfy the Project Manager that the specified concrete strengths will be obtained using the materials and mix proportions in accordance with the above clauses. The proportion of cement shall be increased if necessary to obtain the strengths required.

From each trial mix, six Preliminary Test Cubes shall be made and tested at 7 days and four at 28 days, the test at 7 days being intended to give an early indication of possible variation from the required strength. If the difference between the highest and lowest test results from any one trial mix is more than 15 per cent of the average of the strength test results, the test is to be discarded and a further trial mix made, unless all test results so obtained are above the required strength.

Separate trial mixes are required for each type of concrete. The trial mix or mixes agreed by the Project Manager shall be designated job mixes and used as a basis for actual concrete production.



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4.1.3.4 Batching And Mixing Of Concrete

All concrete shall be batched by weight and mixed mechanically. Hand mixing shall not be allowed except only upon the written permission of the Project Manager.

Concrete may either be batched and mixed on site or outside the site and transported thereto.

When mixed outside the site and transported to it, batching and mixing shall be in accordance with ASTM Specification C94. 'Standard Specification for Ready-Mixed Concrete'.

When mixed on site, batching and mixing shall be as follows:

BATCHING BY WEIGHT: The cement and each size of aggregate shall be measured by weight. The water may be measured by weight or volume. The weight-batching machines used shall be of a type approved by the Project Manager and shall be kept in good condition while in use on the Works. Checks are to be made as required by the Project Manager to determine that the weighing devices are registering correctly.

BATCHING AGGREGATE BY VOLUME: When batching aggregates by volume is allowed as and when required, the cement shall be batched by weight and the water by weight or volume. Each size of aggregate shall be measured in metallic containers the depth of which is at least equal to their greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

MIXING CONCRETE: the location of the batching and mixing plant shall be agreed with the Project Manager.

The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the drum.

On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean mixing water. If old concrete deposits remain in the mixer drum, they shall be rotated with clean aggregate and water prior to production of new concrete.

Concrete mixed as above is not to be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

4.1.3.5 Work In Cold Or Hot Weather

Concrete is not to be mixed or placed at a shade air temperature below 2 deg .C on a rising thermometer or at a shade air temperature below 3 deg .C on a falling thermometer.

When the shade air temperature is 25 deg .C and rising, special precautions shall be taken during concreting operations, such as shading of the aggregates and plant, cooling of the mixing water or other methods approved by the Project Manager, so that the temperatures of the concrete when placed shall not be in excess of 32 deg .C.

Fresh concrete placed at these temperatures shall be shaded from the direct rays of the sun to the satisfaction of the Project Manager for a period of at least 24 hours.

4.1.3.6 Placing

Concrete shall be conveyed from the mixer to its final position in any suitable manner , provided there is no segregation , loss of ingredients or contamination.

It shall be placed in its final position before initial setting takes place and within 20 minutes of the addition of the water to the mixer without using any additives. In case additives will be used, the manufacturer specifications of such additives must be handed over to the Project Manager to be approved before using it.

The order of placing concrete shall be such as to prevent water from collecting at the ends, corners and along the faces of forms. It shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the form.

Whenever possible concrete shall be placed and compacted in even layers with each batch adjoining the previous one. The thickness of the layers shall be between 150 and 300mm for reinforced concrete and up to 450mm for plain (nonreinforced) concrete, the thickness depending on the width of forms, the amount of reinforcement and the need to place each layer before the previous one stiffens.

Concrete shall not be allowed to drop freely for more than 2 metres. To convey the concrete as near as possible to its final position, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections.

Concrete shall be carefully compacted when placed to ensure a dense and uniform mass free from air holes and cavities.

Concrete type "A" and "B" shall be compacted by vibration. Vibration shall be performed by mechanical or electro



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mechanical vibrators. The vibrators shall be of the plunger (poker) type for insertion in the concrete: except that plate type vibrators (external) shall be used if requested by the Project Manager.

The plunger (poker) type vibrators shall have a diameter compatible with the lowest spacing of reinforcement, a sufficiently high frequency and be properly handled by experienced personnel. They shall be immersed at regular intervals close enough to vibrate all of the concrete , but not too close to affect previously vibrated and partially set concrete . Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed.

When external vibrators are used as directed by the Project Manager, they shall be clamped to the forms whenever possible to avoid large impact during handling, and the forms shall be so constructed as to withstand the additional vibrations. All vibrations, compaction and finishing operations shall be completed within 15 minutes from the time of placing the concrete in its final position. Until it has hardened sufficiently to carry weight without distortion, workers shall not be allowed to walk over freshly placed concrete.

Concreting of any one part or section of the work shall be carried out in one continuous operation, and no interruption of concreting work will be allowed without the approval of the Project Manager. Where beams and slabs together form an integral part of the structure they shall be poured in one operation.

A record is to be kept by the Contractor on site of the time and date of placing the concrete in each portion of the works and the number and identification of the Works Test Cubes, corresponding to these portions. Such records are to be handed to the Project Manager weekly during the progress of the work .

4.1.3.7 Admixtures

No admixtures of any type shall be used in the preparation of concrete or concrete products unless so required or directed by the Project Manager. In case any such admixtures are used the rates and methods of application shall be strictly in accordance with the manufacturer's instructions which must be approved by the Project Manager before using it.

4.1.3.8 Joints

- A. Working joints in the concrete will be permitted only in places marked on the Drawings or as approved by the Engineer.
- B. Working joints will not be measured for payment and Contractor will incorporate their cost in the unit prices for concrete works.
- C. Joints with P.V.C water stops will be constructed as marked on the Drawings or requested by the Engineer.
- D. The water stops will be of P.V.C strips 240 x 4 mm. supplied by an approved manufacturer and approved by the Engineer. Contractor must furnish samples of water stop to be used along with the manufacturer's certificate specifying the characteristics and quality of the material.
- E. Engineer's approval of the sample does not release the Contractor from any responsibility to the quality of the material and the proper execution of the joint.
- F. Water stops will be furnished to the site as complete units having the shape and dimensions as indicated on the Drawings.
- G. The edges of the water stop will be joined by welding since no overlap will be permitted.
- H. The water stop will be inserted accurately in the elements of the structure cast first and will be properly protected from any damage, dirt or distortion of its shape and position. Prior to casting the adjoining part of the concrete element, face of the joint will be properly cleaned and a 3 mm. hot asphalt coat will be applied on the whole of the joint area. Sealing of joints shall be completed by filling the groove with an elastoseal pack as marked on the Drawings.

4.1.3.9 Curing

i) Materials

Hessian or Burlap : They shall be clean and free from harmful materials. Their unit weight shall be not less than 230g/.m³

Impermeable membranes : The following impermeable membranes may, with the Engineer's approval, be used.

Clear polyethylene film with no holes, tears, scratches and contamination of any type.



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Hessian coated with white polyethylene of density not less than 300g/sq.m. The coating may be on one side only but shall be not less than 0.1mm thick and shall not peel during and after use.

Curing Compounds : These shall conform to AASHTO M148 (ASTM-C309).

Sand : It shall be natural sand free of silt and clay and contaminants which can be harmful to the concrete.

Water : It shall satisfy the requirements of Section 3.2 of the Specification. **ii) Method of Curing**

General : The method of curing to be used shall be approved by the Engineer. It shall not cause any undesirable blemishes such as surface discoloration and surface roughness. Curing compounds shall not be used on construction joints and surfaces that are to receive waterproofing, paint or membranes.

Ponding : Curing by ponding may be used for horizontal surfaces such as bases, pile caps and slabs. Large areas of horizontal surfaces shall be separated into ponds not exceeding 5 sq.m. The ponds shall first be filled between 12 to 24 hours after pour, unless otherwise authorized by the Engineer, and shall be replenished from time to time so as to maintain the ponding for the specified curing period. The concrete temperature and the temperature of the curing water shall be not greater than 20°C.

Sprinkling : Unless otherwise approved by Engineer, curing by spraying shall commence between 12 to 24 hours after the concrete pour. The concrete shall be maintained damp at all times during the curing period by periodic light sprays. Wet

Hessian / Burlap : Members to be cured by wet Hessian or wet Burlap shall be completely wrapped with the material which shall be kept moist at all times during the curing period by regular spraying. Unless otherwise approved by the Engineer, the overlap under normal conditions shall be not less than one-quarter the width of the Hessian or Burlap and not less than one-half the width in windy and/or rainy conditions. Before members are wrapped for curing, they shall first be evenly moistened. Unless approved by the Engineer, Burlaps shall be supplied only in rolls and Burlap bags shall not be used. Second-hand Hessian and Burlap, if approved for use, shall be clean without holes and contamination of any kind that can affect the concrete.

Waterproof Sheets : Waterproof sheets used for curing shall, unless directed by the Engineer, be spread immediately after the pour. The sheet shall, unless approved by the Engineer, be clear of the concrete surface but be arranged in such a manner as to prevent the movement air over the concrete surface. Waterproof sheets shall not be used when the air temperature is 25°C or higher.

Curing Compounds : Curing compounds shall be applied in two applications at a coverage rate of not less than 1 Ltr/ 7.4 sq.m. per application or as recommended by manufacturer.

The first coat shall be applied immediately after the removal of the forms and the acceptance of the concrete finish and after the disappearance of free water on unformed surfaces. If the concrete is dry or becomes dry, it shall be thoroughly wetted with water and curing compound applied just as the surface film of water disappears. The second application shall be applied after the first application has set. During curing operations, any unsprayed surfaces shall be kept wet with water. The curing membrane will not be allowed on areas against which further concrete is to be placed.

Hand operated spray 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 during usage.

The curing membrane shall be protected against damage for the entire specified curing period. Any coating damaged or otherwise disturbed shall be given an additional coating. Should the curing membrane be continuously subjected to injury, the Engineer may require wet burlap, polyethylene sheeting, or other approved material to be applied at once.

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

Steam Curing

Low Pressure Steam Curing : This shall be in accordance with recommendations of ACI 517.

High Pressure Steam Curing : This shall be in accordance with the recommendations of ACI 516. **iii)**

Curing Time

A The minimum curing time shall be the number of days given in the Table below unless the average surface temperature of the concrete during the required number of days falls below 10°C, in which case the period of curing shall be extended until the maturity of the concrete reaches the value given in the following Table:

NORMAL CURING PERIODS

Minimum periods of protection for different types of cement



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Conditions under which concrete is maturing	Number of days (where the average surface temperature of the concrete exceeds 10°C during the whole period)			Equivalent maturity (degree hours) calculated as the age of the concrete in hours multiplied by the number of degrees Celsius by which the average surface temperature of the concrete exceeds minus 10°C.		
	Other*	SRPC	OPC or RHPC	Other*	SRPC	OPC or PHPC
1. Hot weather or drying winds	7	4	3	3500	2000	1500
2. Conditions not covered by 1.	4	3	2	2000	1500	1000

NOTE Other* includes all permitted cements except OPC, PHPC and SRPC.
KEY. OPC = Ordinary Port land Cement
RHPC = Rapid-hardening Portland Cement.
SRPC = Sulfate Resisting Portland Cement.

B The minimum curing time given in the Table above shall be compared with the time required for cubes, cured under identical conditions to those which the concrete is subjected to, attain 70% of the characteristic strength. The greater shall be taken as the minimum curing time.

4.1.3.10 Formed Finishes

1 - Basic finish

General requirements:

- Produce an even finish with a sheet material.
- Arrange panels in a regular pattern.
- Blowholes not more than about 10mm in diameter will be permitted but otherwise surface is to be free from voids honey combing and other large defects.
- Variation in colour resulting from the use of an from discoloration due to contamination or grout leakage.

The finish will be left as struck; making good or small defects will normally be permitted but only after inspection by the Project Manager. All blowholes shall be filled with a matching mortar to an approved sample unless otherwise instructed by the Project Manager. All faces shall be protected from damage, especially arrisses.

All faces shall be protected from rust marks and other surface disfigurements. Form tie holes shall be filled with a matching mortar to an approved sample accepted by the Project Manager . 2 - Fine finish (Fair Face) General Requirements:

- Produce a smooth even finish with an impervious sheet metal.
- Make panels as large as is practicable and arrange to approval.
- Blowhole not more than about 5mm in diameter will be permitted but otherwise surface is to be free from voids, honey combing and other defects.
- Variation in colour resulting from the use of an impervious form lining will be permitted, but the surface is to be free from discoloration due to contamination or grout leakage. e) Concrete cover spacers shall be used only if approved.

The finish is to be left as struck. Making good will not normally be permitted. All form tie holes are to be filled with a matching mortar to an approved sample. Wire form ties shall not be used. Approval of the Project Manager for the position of tie holes is to be obtained before use.

4.1.3.11 Quality Control Testing Etc.

Prior to commencing the work the contractor shall make available on site the following minimum approved equipment kept in good condition at all times:

- Six Cube moulds. - Slumpcones.
- Thermometer.



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- Any other accessories as required by the Project Manager.

All samples and testing shall be done in the presence of the Project Manager or his authorized representative either on site or in an approved testing laboratory in the area.

The frequency of testing shall be as noted in the clauses of this section and whenever required by the Project Manager.

The works Test Cubes shall be made as follows for types of concrete (A) and (B):

- (a) At least three times weekly per mixing plant.
- (b) At least once for three individual parts of the structure.
- (c) At least once per 100 cubic meters of Concrete or fraction thereof.

At least six cubes shall be made at one time. Two of the six cubes are to be tested at seven (7) days. The remaining four cubes are to be tested at 28 days, and their average strength must not fall below the minimum strength specified for each type of concrete and the lowest test result shall not be more than 20% below the average of the four cubes.

When the result of 7-day test is unsatisfactory, the Contractor may elect to remove and replace the defective concrete without waiting for the 28-day test. If the result of the 28-day test is unsatisfactory all concreting shall be stopped at the Contractors expense and shall not proceed further without the written permission of the Project Manager.

The Contractor shall then, in accordance with the instructions of the Project Manager, remove cores and test same or conduct in- situ tests in accordance with CP 144 from or on suspect portions of the works, under the supervision of the Project Manager.

Concrete judged by the Project Manager to be defective shall be forthwith cut out, removed and replaced at the Contractors own expense.

In the event of strengths consistently higher than those specified being obtained, a reduction in the number of tests may be authorized by the Project Manager.

4.1.3.12 Position of Reinforcement

The actual concrete cover to all steel at any point should not be smaller than the required nominal cover by more than 5mm. The effective depth of fully or nearly fully stressed tensile reinforcement should not be less than that given on the drawings by an amount exceeding 5 per cent of the effective depth of the section being considered or 5mm whichever is the greater.

4.1.3.13 Ready mixed concrete

Ready - mixed concrete as defined in BS 1926 , batched off the site will be used with agreement of the Project Manager and shall comply with all requirements of the Contract . The quality and strength of cements shall be determined by site tests. No test results supplied by Ready-Mix Supplier shall be accepted as proof of the quality and strength of the concrete. The concrete shall be carried in purpose made agitators operating continuously, or in truck mixers. The concrete shall be compacted and in its final position within 1 hour of the introduction of cement to the aggregate or as agreed by the Project Manager. The time of such introduction shall be recorded on the Delivery Note together with the weight of the constituents of each mix.

When truck mixed concrete is used, water shall be added under supervision either at the site or at the central batching plant as agreed by the Project Manager but in no circumstances shall water be added in transit.

Unless otherwise agreed by the Project Manager Truck mixer units and their mixing and discharge performance shall comply with the requirements of BS 4251. Mixing shall continue for the number and at the rate of revolutions recommended in accordance with BS 4251 or, in the absence of the manufacturer's instructions, mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.

Prior to any ready mixed concrete being ordered, the Contractor shall submit to the Project Manager details of the supplier and shall arrange for the Project Manager to inspect the supplier's works if required.

Truck-mixer units shall be maintained and operated strictly in accordance with the manufacturer's recommendations.

4.1.3.14 Concrete Surface Hardener

Monolithic surface hardening compound to provide a highly abrasion resistance surface with a dry shake method. The abrasion resistance of the hardening compound shall comply to BS 784 1953, and the compressive strength not less than 70N/mm² after 28 days, tested according to the BS EN 12390.



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The hardening compound shall be applied in rate of 7 kg/m² on the floor surface at the time when the concrete has stiffened to the point when light foot traffic leaves an imprint of about 3mm. The hardening compound shall be applied in two application stages:

Stage 1: using $\frac{1}{2}$ to $\frac{2}{3}$ of the required material. When the material becomes uniformly dark by the absorption of moisture from concrete then the floating can be applied.

Stage 2: spreading the remaining material on the surface, and apply floating to the surface after the moisture being absorbed.

Final finishing of the floor shall be done using mechanical trowelling machine when the floor has stiffened sufficiently. Curing for the surface shall be applied as clarified above.

4.1.4 Construction of Manholes

4.1.4.1 General

- A. The Contractor shall construct manholes in reinforced cast-in-place concrete or in precast concrete rings to the levels, dimensions and shapes shown on the Drawings, or as directed by the Engineer.
- B. All manholes shall be constructed with incoming and outgoing pipes neatly and truly concreted in, complete with cast iron steps and manhole cover and frame as here specified and shown on the Typical Drawings.

4.1.4.2 Manholes

- A. The Contractor shall construct a well compacted blinding layer of plain concrete Type B 150 to the required levels after the Engineer has inspected and approved bottoms of excavations. The surface of the blinding layer shall be regular and smooth.
- B. The Contractor shall set tops of manhole frames and covers to the elevations as indicated on Drawings, unless otherwise directed.
- C. All items built into walls of manholes and structures such as pipe ends shall be adequately sealed to obtain watertight construction to the satisfaction of the Engineer. Steps shall be installed in a staggered pattern to the extent indicated at not more than 300 mm centers and shall be well grouted. D. Drilling shall be used when connecting pipes into manholes.
- E. Covers and frames shall be well centered and anchored all around to the approval of the Engineer.
- F. After the installation of the cast iron frames, the Contractor shall provide plain concrete Type B 200 in surrounds as indicated on Drawings. Surrounds shall be well hunched all round and trowelled smooth.
- G. All manholes steps, covers and it's frames shall be well cleaned and painted with black paint of bituminous base after complete installation and to the approval of the Engineer.

4.1.4.3 Cleaning

- A. All manholes shall be cleaned of any accumulation of silt, mortar, debris or other foreign matter and shall be free of any such accumulation at the time of final inspection.

4.1.4.4 Reinstatement of Staircases

- A. Staircases shall be reinstated as shown on the Typical Drawings and the type of reinstatement shall be decided by the Engineer according to the equal to that before the work began.



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4.1.4.5 Black Bitumen Paint

The black bitumen paint shall be applied in the thickness and number of coats described in the BOQ or drawings, and to be applied with a coverage rate of 8m²/litre for concrete surfaces.

All surfaces must be sound and free from dust, dirt, all loose material, grease and oil etc., and dry before applying the black bitumen paint.

The black bitumen paint shall comply to BS 3416 Type I and II, as well as BS 476: Part 7 class 1 for fire resistance.

4.2 BLOCKWORK

4.2.1 Manufacture

Generally the blocks used shall be of local manufacture made with concrete in approved vibrated pressure machines. The fine aggregate to be used for blocks shall be clean and sharp approved sand. It shall be chemically and structurally stable and shall comply with the Table of Gradings given hereunder. The cement, coarse aggregate and water to be used for blocks shall comply with the requirements given for

Concrete Works, and the methods of measuring and mixing the material shall be the same. The following Mixing Table shall be strictly adhered to in all cases. Water/cement ratio shall be strictly governed to produce a mix of nil - slump.

Blocks of walls and slabs shall be tested according to the BS 6073 for the following:

- Compression Strength
- Absorption Test
- Dimension Test

Mixing Table

Nominal Mix (all by volume)

1 part Cement, 2 parts Fine Aggregate and 5 parts Coarse Aggregate. The quantity of cement shall not less than 225 kg/m³ of concrete.

Table of Grading

(a) Fine aggregate

<i>BS 410 Sieve No.</i>	<i>Approximate size: mm</i>	Percentage(by weight) Passing BS sieve
-	10.00	100
-	5.00	90-100
7	2.36	75-100
14	1.18	55-90
25	0.60	35-59
52	0.30	8-30
100	0.15	0-10

b) Coarse
aggregate 10mm single size aggregate.

The blocks shall be hard, sound, square and clean with sharp well defined arrises and shall, unless previously approved by the Project Manager, be a work size of (400 x 200 x 200mm) with properly formed half blocks for bonding.



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Hollow blocks, where required, shall be similar quality and overall size to solid blocks, and shall be of local manufacture made with concrete as described above in approved vibrated pressure machines. The design of the cavities and webs shall be submitted to the Project Manager for approval before manufacture. The thickness of the membranes or solid portions of hollow blocks shall be not less than (25 mm) each and the combined thickness of the solid portion shall exceed one forth of the total thickness in either horizontal direction.

Light weight lime - blocks can be used according to drawings, bills of quantities and Project Manager's approval.

Arrises shall be sharp and true; blocks which have damaged arrises are not to be used in the works and shall be discarded at the expense of the Contractor.

Immediately after moulding the blocks shall be placed on clean, level, non-absorbent pallets. Blocks shall not be removed from the pallets until inspected and approved by the Project Manager. Blocks shall be cured by being kept thoroughly wet by means of water sprinklers or other approved means for a period determined by the Project Manager but in all cases for not less than three days. Blocks must not be left on earth or sand during the curing process. Blocks shall be stacked in honeycomb fashion. Solid stacking will not be permitted.

Blocks for roofs slabs shall be of the shape and dimensions shown in drawings.

The average crushing strength of solid or hollow blocks shall be not less than 35 kg/cm² of gross area (a average of 12 blocks) .

4.2.2 Mortars

The sand to be used for mortar shall be clean and sharp. It shall be chemically and structurally stable and shall comply with the Table of Gradings below. The lime if used for mortar shall be hydrated lime complying with BS EN 459-1:2001.

Where colored mortars are required these shall be obtained either by the use of coloured cement or by addition of pigments complying with BS 1014.

The cement and water to be used for mortar shall comply with the requirements given under Concrete Works Section, and the methods of measuring and mixing shall be the same. The following Mixing Table shall be strictly adhered to in all cases.

Mixing Table

Normal Mix	Cement Kilos	Sand m ³	Lime (Dry Hydrate) Kilos
1:4	360	1.00	as approved by the PWA Project Manager

Table Of Grading

BS 410 Sieve No.	Approximate Size: mm	Sand Passing Through Sieve: percentage
-	3	95-100
7	2.4	80-100
14	0.2	60-100
25	0.6	30-100
52	0.3	5-65
100	0.15	0-15
200	0.08	0-5

Note: the

above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned. The mortar generally shall be cement and sand (1:4) mix .



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Where plasticiser is added to the mortar the following mixes shall be used:

- (a) Building mortar - cement and sand (1:6) and
- (b) Mortar for pointing - cement and sand (according to plasticizer manufacturer recommendation)

The plasticiser shall be used strictly in accordance with the manufacturer's instructions, and subject to the Project Manager's approval.

All mortars shall be used before the initial set has begun. Mortar shall not be remixed after the initial set has taken place. The full description given under Plaster Work Section, shall apply also to the measuring, mixing etc. of mortar for block work.

4.2.3 Construction

All blockwork shall be set out and built to the dimensions shown on the Drawings.

Walls shall be carried up regularly without leaving any part more than one meter lower than another unless the permission of the Project Manager is first obtained. Work which is left at different levels shall be racked back. In the case of cavity walls, both thicknesses shall not be carried up more than about 400 mm.

The courses of blockwork shall be properly leveled. The perpendicular joints shall be properly lined and quoins, jambs and other angles plumbed as the work proceeds.

All walls shall be thoroughly bonded in accordance with the best constructional practice and as directed by the Project Manager. Broken blocks shall not be used except where required for bond (if approved by the Project Manager).

All concrete blocks shall be soaked with water before being used and the tops of walls left off shall be wetted before work is resumed. The faces of walls shall be kept clean and free from mortar droppings and splashes

All blocks shall be properly spread with mortar before being laid and all joints shall be thoroughly flushed up solid through the full thickness of the wall at each course as the work proceeds.

Walls to be left unplastered shall have a fair face consisting of selected blocks pointed with a neat weathered or flush joint as the work proceeds using the same mortar mix as for jointing.

Walls to be plastered shall have the horizontal joints raked out to depth of 15 mm to form a key.

Blockwork shall be bonded to concrete columns and the like with one tie every two courses made of electrogalvanized steel ties 2mm thick, 10cm length along the column and 15cm along the course, forming a right angle with fish-tailing at end of 15cm length, and fixed to column by an expansive bolt of suitable length but not less than 4cm. Gunning ties to concrete will not be permitted (other ways of bond must be approved by the Project Manager).

Allowance shall be made for the temporary leaving of open courses immediately under all structural members built into the walls. These open courses shall be left in suitable positions to permit the structural members to take up their full deflection. The open courses shall be made good and pointed up after the structural members have been fully loaded and before completion of the works.

4.2.4 Workmanship

The contractor shall cut and fit block work around steel work, etc., leave of form chases for edges of concrete slabs, staircases, end of partitions, etc., cut chases for pipes, conduits, etc., and make good.

The contractor shall build all oversailing courses, corbels, etc., where shown and build in the cut and pin ends of sills, steps, lintels, etc., as required.

Wooden plates and doors and window frames shall be bedded and exposed edges pointed in a sealant and fixing, cramps shall be built in.

The contractor shall perform all cutting away and making good for all trades.

4.2.5 Expansion Joints

The expansion joints shall generally be of 19mm thick fibreboard impregnated with bitumen accurately cut, with butt joints and fixed vertical and straight. The top 10mm of the joint shall be filled with a grey polyurethane gun grade sealant which conforms with BS 4254. Expansion joints shall continue into the tilted tile, skirtings and fillets.

4.2.6 Steel Channels, Cramps, Ties and Dowels

Cramps and angles shall be electro-galvanized (zinc-plated) as described in this item.



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Galvanized of the metal shall be zinc by electroplating, so as or provide a thin, uniform and ductile protective coating. Small holes and threads shall be satisfactorily coated. The ductility of the zinc coating shall be such as to allow for bending of the components without causing any damage. The galvanized gauge and process shall be in compliance with BS 1707:1960.

Block to columns ties shall be of electro-galvanized steel ties 3mm thick, 10cm length along the column and 15cm along the course, forming a right angle with fish-tailing at end of 15cm length, and a hole for expanding bolt fixation to column.

4.3 PLASTER WORK

4.3.1 General

The British Standards (BS) govern the work covered in this section .

BS EN ISO 1461:1999 Hot dip galvanized coatings on fabricated iron and steel articles.

Specifications and test methods BS 729

BS EN 459-1:2001 Definitions, specifications and conformity criteria 890

BS EN 197-1:200002 BS

4449:1997

4.3.2 Materials

Portland cement, fine aggregate and water shall be as previously specified in Concrete Work section .

The sand for plastering shall be clean fine sand and shall be chemically and structurally stable. The sand shall be sieved and graded in accordance with the Table of Grading given below .

Table Of Grading

BS 410 Sieve No.	Approximate Size mm	Sand Passing Through Sieve Percentage :	
		UNDERCOAT	FINISH COAT
7	2.4	95-100	100
14	1.2	80-95	95-100
25	0.6	30-55	30-85
52	0.3	5-50	5-50
100	0.15	0-10	0-10

figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

Imported lime shall be of the hydrate type complying with BS EN 459-1:2001.

Bonding agents where required shall be of a type approved by the Project Manager, and shall be used as recommended by the manufacturer

4.3.3 Mixing

The methods of measuring and mixing shall be as laid down under Concrete Work section, and the proportions shall be in accordance with the Mixing Table given below.



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Mixing Table

Nominal mix	Ratio	Cement Kg	Fine Aggregate or Sand m ³	(I) (dry hydrate) kg
1:5 cement		289	1.00	-
1:4 cement		361	1.00	-
1:3 cement		476	1.00	-
1:2½ cement		577	1.00	-
1:2 cement		721	1.00	-
1:1 cement		1442	1.00	-
1:5 cement with 20% (I)	1:5:1	289	1.00	124
1:4 (I) with 10% cement	1:10:2½	145	1.00	161

* I = Imported Lime

With regard to the lime mortars gauged with cement, the addition just before use of the cement to small quantities of the lime/sand mix shall preferably take place in a mechanical mixer and mixing shall continue for such time as will ensure uniform distribution of materials and uniform colour and consistency. It is important to note that quantity of water used shall be carefully controlled.

4.3.4 Plastering and Similar In-Situ Finishing and Backings

All plastering shall be executed in a neat workmanlike manner. All faces except circular work shall be true and flat and angles shall be straight and level or plumb.

Plastering shall be neatly made good up to metal or wooden frames and skirting and around pipes or fittings.

Angles shall be rounded to 5mm radius.

Surfaces of undercoats shall be well scratched to provide a key for finishing coats. Screed marks or making good on undercoats shall not show through the finishing coats.

Surfaces described as trowelled smooth shall be finished with a steel trowel to a smooth flat surface free from trowel marks.

Surfaces described as floated shall be finished with a wooden or felt float to a flat surface free from trowel marks.

All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to prevent the plaster or other materials from being contaminated by pieces of partially set material which would tend to retard or accelerate the setting time . Coating work shall not be started until all:

- a) required openings, chases or other apertures have been cut
- b) pipes, fixtures, fixing pads and plugs have been fixed
- c) making good has been completed .

The Contractor shall protect all existing work and approaches, with boards, dust sheets etc. All droppings onto finished work shall be cleaned off immediately.

The Contractor shall ensure that all plant and tools are kept clean and free from previous mixes.

The Contractor shall make good defective or damaged coatings before starting decoration works.

4.3.5 Preparation for Plaster etc.

All surfaces to be plastered shall be clean and free from dust, loose mortar and all traces of salts. Projections and concrete fins shall be hacked off. Traces of mould oil, paint, grease, dust and other incompatible materials shall be removed by scrubbing with water containing detergent.

Where cement plaster is to be applied the surfaces shall first be wetted and dashed with a mixture of Portland cement and sand (1:2) mix to form a key. This should be kept wet with a fine water spray until set, and allowed to harden before applying undercoat for a minimum of 3 days.

All surfaces shall be thoroughly sprayed with water and all free water allowed to disappear before plaster is applied.

Bonding agents where required shall be applied in accordance with the manufacturer's instructions and must be approved by the Project Manager.

4.3.6 Curing Of Plaster etc.



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Each coat of plaster should be kept damp for the first three days. Care must be taken to prevent too rapid drying out during hot weather and in drying winds.

Any cracking, discoloration or other defects caused by inadequate curing shall be remedied at the Contractor's expense.

4.3.7 Uses of Plaster

Slurry Coat

Before starting the actual plasterwork, all concrete surfaces shall receive a slurry coat evenly dashed on the surface with a steel trowel to provide a key for the first coat of plaster. The slurry coat shall be composed of 400kg of cement to one m³ of clean coarse sand.

At least one day shall elapse after the application of the slurry before the succeeding coat is started.

Internal Plaster

Internal plaster shall consist of two coats (other than the slurry coat mentioned above) having a total thickness of approximately 12 mm as follows:

- The first coat shall be 8mm thick, made of 1:4 mix (one part of cement to four parts of uniformly graded coarse sand) and shall be done between screeds not more than 2m apart and shall be floated and trowelled true, even and plumb with no hollows, ridges or irregularities.

This coat shall be scarred to form key and shall be allowed to set for three days, during which period it shall be cured and kept continuously wet.

- The second and final coat shall be approximately 4mm thick and of 1:4 mix (one part of cement to four parts of fine sand) with as approval plasticiser to be used as per the manufacturer's instructions, and shall have a wood or felt floated finish.

External Plaster

External plaster shall consist of two coats (other than the slurry coat mentioned above) having a total thickness of approximately 20 mm as follows:

- The first coat shall be the same as for the first coat of internal plaster, but 14-16mm thick.
- The second and final coat shall be 4-6mm thick and of 1:3 mix (one part of cement to three parts of fine sand) with as approval plasticiser to be used as per the manufacturer's instructions.

Tyroleam Plaster for External Walls

Cement and aggregate for each batch shall be accurately measured and mixed dry until evenly distributed and the mass is uniform in color. All vertices shall be of such size that they can be entirely used within half an hour.

Mechanical mixer of an approved type shall be used for mixing tyroleam plaster, except when hand mixing of small batches is specifically approved by the Project Manager.

Mechanical mixers, mixing boxes and tools shall be cleaned after mixing each batch and kept free of tyroleam mortar from previous mixes.

Water content shall be maintained at a minimum. Mixing shall be continued until plasticity is obtained.

Proportions of materials for tyroleam, by volume shall be as follows:

Scratch Coat: 1part of ordinary Portland Cement to 2 parts of fine aggregate

Finish Coat: 1part of ordinary Portland Cement to 2 parts of fine selected aggregate

For colored finish coats, the contractor has to submit his mix proportions and carry out trial mixes to the approval of the Project Manager.

No lime shall be allowed in either scratched or finishing coat, scratch coat shall be set on spatterdash.

4.3.8 Application of Plaster

After preparation of the surfaces the undercoat shall be applied to the required thickness between screeds laid, ruled and plumbed as necessary. When nearly set the surface of the undercoat shall be scratched. The undercoat shall be allowed to



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set hard and shall be cured. Where plastering is applied in one coat or where roughcast is to be applied the scratching should be omitted.

The finishing coat shall be applied to the required thickness by means of a laying - on trowel and finished to give the required surface.

The surfaces shall be finished to a true plane to correct line and level, with all angles and corners to a right angle unless otherwise specified, and with walls and reveals plumb and square. The surfaces shall be finished to within ± 3 mm of a straight edge 1.80m long placed on face of plaster.

If necessary to correct inaccuracies, dubbing out shall be done in thickness of not more than 10mm in same mix as the first coat. It shall be allowed to dry out before the next coat is applied, and the surface cross scratched on each coat immediately after set.

Dubbing out shall not be permitted on smooth dense concrete surfaces, which shall be thoroughly hacked before dubbing out is commenced.

The undercoat shall be worked well into the interstices of metal work to obtain maximum key.

Each coat shall be applied firmly to achieve good adhesion, and ruled to an even surface.

Each coat shall be applied to each wall and ceiling surface in one continuous operation.

Each coat shall be applied at full thickness down to floor level or skirting lath.

All undercoats shall be cross scratched to provide key for next coat.

Subsequent coats of plaster shall be applied as soon as the undercoat has set firmly, bonded to the background and has developed reasonable suction.

Cement based undercoats shall be allowed to dry out thoroughly to ensure that drying shrinkage is substantially complete before applying subsequent coat.

50 mm each side of angle bead to be finished with neat Keene's cement before plaster finishing coat is applied. Where angle beads are not specified, angles shall be formed with pencil round arris.

A smooth Finish shall be achieved by finishing with a steel laying trowel to an even surface.

4.3.9 Application of Tyrolean

All surfaces shall be clean, free from dust, dirt, oil or other particles that might interfere with a satisfactory bond. Surfaces to receive tyrolean shall be evenly spots, the dry areas shall be dampened again to restore uniform suction. Tyrolean coats shall be applied continuously in one general direction without allowing mortar by dry edges. Edges to be jointed shall be dampened slightly to produce a smooth confluence. Tyrolean plaster shall be three coats and not less than 20mm thick (spatter dash, scratch coat and one finish tyrolean coat).

Scratch coat shall be 14mm thick approximately, and shall be applied under sufficient pressure to form good keys and shall be brought to a plumb, true even surface. The scratch coat shall be damp-cured 48 hours before the finish coat is applied.

Finish coat shall be 6mm thick approximately. Before applying this coat, the scratch coat must be damped by fogspraying. Dampening by brush will not be permitted.

When measured with a 2.0m long, straight-edge applied in all directions, the finish surface shall not vary from a true plane by more than 1.5 mm. The finishing coat shall be applied by means of a proper sparying machine.

Where a pressed tyrolean finish is required, this should be obtained by mechanically flattening the surface of the sprayed final or finish coat.

The degree of flatness shall be determined by the Project Manager based on the set up samples of different degrees on fineness and colours for the tyrolean finish set up by the Contractor.

As soon as the finish coat has taken its initial set, the tyrolean shall be protected against direct rays of the sun or rapid drying for at least 10 days. During this period the tyrolean shall be kept moist by frequent fog or spraying. Care shall be taken to prevent staining of the tyrolean.

Tyrolean with cracks, blisters, pits, checks or discolorations will not be accepted. Tyrolean shall be clean and sound and in accordance with the requirements of the specifications.

4.3.10 Steel Mesh Lathing, Stops and Beads

Steel mesh lathing shall be galvanized type weighing 1.6kg/m².

Steel rods for distancing shall be hot rolled mild steel round bars to BS 4449, diameter to approval, galvanized to BS EN ISO 1461:1999 or bitumen coated.



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Steel clout nails shall be to BS EN 197-1:200002: Part 1, Table 3, galvanized to BS EN ISO 1461:1999.

Galvanized steel angle bead with 50 mm galvanized expanded metal mesh on both sides of bead.

Mesh lathing shall be fixed with the long way of the mesh at right angles to supports.

In horizontal work it shall be fixed with all mesh strands sloping in the same direction, while in vertical work it shall be fixed with all mesh strands sloping inwards and downwards from face of coating.

Lathing shall be fixed from the center outwards so that it is taut. Lathing shall not be lapped within 100mm of angles or curves.

Side edges of lathing shall be lapped not less than 25mm, and secure with tying wire at not more than 100mm centers. Ends of lathing shall be lapped 540mm at supports and 50mm between supports, and secured with tying wire at not more than 100mm centers.

Junctions of lathing shall be reinforced at corners with 75 x 75 mm angled plain mesh, fixed to rails with tying wire at not more than 100mm centers.

Ends of wire shall be bent away from face of coating.

At junctions between dissimilar solid backgrounds in the same plane and with the same coating, steel lathing shall be fixed with 38 mm clout nails or with staples. They shall be driven into drilled and plugged holes or into fixing bricks or plugs built in or cast in:

(a) At single junctions, lathing to be not less than 450mm wide, fixed each edge at 100 mm centers

(b) At columns, lathing to extend not less than 150mm beyond each junction, fixed each edge and centrally at 100 mm centers.

Lathing fixed to metal supports shall be fixed with hair-pin shaped tying wire ties at not more than 100mm centers, passed over the support with both ends through mesh, twisted tight, ends cut off and bent flat.

Concrete, block work or masonry backgrounds shall be drilled and plugged at not more than 100x400mm centers and the lathing shall be fixed with 38mm clout nails or wire staples driven at an angle to tauten the mesh.

Beads and stops shall be fixed plumb, square and true to line and level.

Metal angle beads shall be fixed to solid backgrounds with plaster dabs, and shall be fixed to timber supports with 28mm clout nails. Both types of fixing shall be on each side of angle at not more than 600mm centers.

4.3.11 Protection

All floor, wall and ceiling finishes shall be protected from damage during subsequent work, and shall be thoroughly cleaned before handing over the works.

4.4 PAINTING

4.4.1 General

British Standard (BS) Documents referred to in this section are:

BS 245:2000

BS 544:2000

BS EN 197-1:200012

BS 1336:2002

BS 3698:2000

All wood and steel surfaces and sections shall be thoroughly cleaned and rubbed smooth before painting.

No painting on exterior surfaces shall be carried out during wet or dusty weather, or on surfaces that are not thoroughly dry.

All coats of emulsion shall be thoroughly dry before subsequent coats are applied.

Each coat of paint shall be thoroughly rubbed down with fine sandpaper and where required, filled with an approved putty or filler before the succeeding coat is applied.



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The tints of undercoats shall approximately that of the finishing coat, but there shall be sufficient contrast between the succeeding coats to clearly indicate missing (unpainted) areas.

The priming of all wood and metal works shall be done before installation. Priming paints on copper and galvanized steel are to incorporate a suitable etching agent.

All paints and primers shall be used in strict accordance with the specifications and instruction of manufacturers.

Every possible precaution shall be taken to keep down dust before and during painting processes. No paint shall be applied to surfaces structurally or superficially damp and all surfaces must be ascertained to be free from condensation, efflorescence etc. before the application of each coat.

Primed or undercoated woodwork and metalwork should not be left in an exposed or unsuitable situation for an undue period before completing the painting process. No exterior or exposed painting shall be carried out under adverse weather conditions, such as rain, extreme humidity, dust storms etc.

Metal fittings such as ironmongery etc. not required to be painted shall first be fitted and then removed before the preparatory processes are commenced. When all painting is completed the fittings shall be cleaned and refixed in position. The contractor will be required to repaint at his own expense any work on which the paint is found to be incorrectly applied. The contractor shall be responsible for protecting from damage the paint work and all other work during and after painting operations including the provision of all necessary dust sheets, covers etc.

Brushes, pails, bottles etc., used in carrying out the work shall be clean and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of material.

The number of coats stated in this specification or in BOQ is the minimum, and the Contractor must apply sufficient coats to achieve a proper even finish to the approval of the Project Manager .

4.4.2 Materials

All paints and paint treatments, including wood and steel primers and fillers and all varnishes, shall be European

Type of good quality according to the requirements of BS 4800-1972 and BS 3483.

Material shall be obtained from approved manufacturers and shall be supplied in the manufacturer's sealed and branded container. All materials must be thoroughly stirred before use unless recommended otherwise by the manufacturer. Details of mixing and application shall be in accordance with the specifications of the manufacturers concerned and to the approval of the Project Manager. The mixing paints of different brands before or during the application shall not be permitted. No dilution of painting materials shall be allowed only as detailed by the manufacturers and approved by the Project Manager.

Mordant solution shall be of approved manufacture.

Rust inhibitors shall be of approved manufacture.

Stopping for woodwork to receive clear finish shall be tinted to match surrounding woodwork, to the approval of the Project Manager.

Stopping for internal woodwork, plywood, hardboard, and fiberboard shall be linseed oil putty to BS 544, tinted to match the colour of the undercoat.

Stopping for external woodwork shall be white lead paste and gold size well mixed. Thinners shall be approved turpentine or white spirit to BS 245.

Priming paints shall be:

- (a) For woodwork: Leadless grey priming paint in accordance with the recommendations of the decorative coating manufacturer.
- (b) For steelwork: red oxide priming paint.
- (c) For galvanised, zinc or aluminum alloy surfaces: grey zinc chromate priming paint in accordance with BS 3698. (d) For plaster, concrete and brickwork, ceiling boards etc.: alkali resisting priming paint in accordance with the recommendations of the decorative coating manufacturer.

Knotting shall be in accordance with BS 1336.

Primer paints shall be tested according to the following standards:

Percentage of non-volatile matter ISO 3251/1993

Percentage of pigments ISO 3251/1993

Grinding ISO 1524-1983

Viscosity by Ford cup No.4 ISO 2431/1993

Flexibility 3mm ISO 1519/1973



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Scratch by effect of 800 gm ISO 1518/1992 (for red oxide)

Scratch by effect of 1200 gm ISO 1518/1992 (for zinc chromate) Water

immersing resistance ASTM D50/1981, ASTM D444-1981

Undercoating shall be:

(a) Zinc oxide Alkali Resisting based undercoating paint; (b)

White non lead undercoating paint.

(c) Synthetic alkyd based undercoating in accordance with the recommendations of the decorative coating manufacturer.

Undercoating shall be tested according to the following standards:

Percentage of non-volatile matter ISO 3251/1993

Percentage of binders ISO 3251/1993

Percentage of pigments ISO 3251/1993

Viscosity ASTM D93/1997

Contrast ratio ISO 7724/2-1982

Hiding power ISO 6504/1681

Flexibility ISO 1519/1973 Finishing

paints shall be:

(a) Zinc oxide based oil paint:

(b) White non lead oil gloss finishing paint.

(c) Synthetic alkyd based finishing paint as approved by the Project Manager.

Petrifying liquid shall be used undiluted as supplied by the manufacturer A small quantity of water paint of the finishing colour may be mixed with the petrifying liquid.

Water paint shall be an approved brand of washable oil-bound water paint. Thinning shall be done with petrifying liquid or fresh water only.

Water paint shall be tested according to the following standards:

Percentage of non-volatile matter ISO 3251/1993

Washability ISO 809/1995

Contrast ration ISO 7724/2-1982

Flexibility ISO 1519/1973

Viscosity ASTM D93/1997

Emulsion paint shall be of the Polyvinyl Acetate (PVA) type obtained from an approved manufacturer. The precise specification shall comply with the manufacturer's normal practice. In all cases thinning shall be done with thinners supplied by the manufacturer or fresh water only.

Emulsion paint shall be tested according to the following standards:

Percentage of non-volatile matter ISO 3251/1993

Percentage of pigments ISO 3251/1993

Washability ISO 809/1995

Contrast ration ISO 7724/2-1982

Viscosity ASTM D93/1997

Grinding ISO 1524-1983

Stain for woodwork shall be an approved brand of oil stain complying with BS EN 197-1:200015. Polyurethane

lacquer for woodwork shall be of an approved manufacture.

4.4.3 Preparation Process

1. Internal Plaster, Fair Faced Concrete and Block work

Surfaces shall be allowed to dry out completely and cracks shall be cut out and made good with suitable hard plaster or cement and sand mix as appropriate, such repaired portions shall be allowed to dry out. No painting shall be carried out on plastering less than five weeks old.

Efflorescence shall be completely removed by rubbing down with dry coarse cloths followed by wiping down with damp cloths and allowed to dry. All surfaces shall be rubbed down with fine glass paper and brushed free of dust before applying any form of decoration.



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Surfaces which are to receive water paint shall be treated with one coat of petrifying liquid applied by brush and allowed to dry for at least 24 hours before the application of water paint. A period of 24 hours, or longer if necessary, shall be allowed between subsequent coats.

Fair faced concrete and/or cement and sand plastered surfaces which are to receive oil paint shall be given one thin coat of oil putty and allowed to dry for at least two days.

The surfaces shall then be rubbed down with fine glass paper and given a second thin coat of oil putty and when completely set The surfaces shall then be rubbed down with fine glass paper and given a second thin coat of oil putty and when completely set All surfaces which are to receive oil paint shall be treated with one coat of alkali resisting priming paint applied by brush and allowed to completely harden.

2. Steelwork, Internally and Externally

If delivered galvanized, the surfaces shall be cleaned to remove grease and dirt before priming. Where rusting has occurred through damage to the galvanizing, such rust shall be removed by wire brushing back to clean metal and the galvanizing made good with a rust inhibiting agent.

The surface shall then be treated with one coat of mordant solution and one coat of zinc chromate priming paint.

If delivered primed, the surfaces shall be examined to ascertain that the priming paint is hard, firmly adhering and in good condition. If not satisfactory, the priming paint shall be removed and the surfaces cleaned to remove rust, and reprimed. If the condition of the priming paint is satisfactory, the surfaces shall be cleaned to remove grease and dirt, minor damage to the priming paint being made good with red oxide priming paint after removal of rust.

If delivered unprimed and not galvanized, the surfaces shall be cleaned to remove grease and dirt, and wire brushed and scraped to remove all rust and scale before applying a red oxide priming paint.

Priming paint shall be brushed well into the surface and shall be allowed to dry and harden thoroughly before the application of subsequent coats.

Items of steelwork such as frames to roller shutters, covers to expansion joints etc., which are to be built into walls, shall first be primed.

4.4.4 Woodwork Required To Be Painted

Surfaces shall be cleaned to remove grease and dirt. The surface of teak shall be cleaned with white spirit to remove free oil. The preparation process shall then be:

(a)**KNOT:** all knots shall be treated with shellac knotting

(b)**PRIME:** one coat of primer shall be thoroughly applied by brush to all surfaces and when dry a further coat to be applied to end-grain surfaces.

(c)**STOP:** when priming paint is hard, all cracks, holes, open joints etc. shall be made good with hard stopping and all open grain surfaces filled smooth with linseed oil putty or an approved filler and rubbed down with fine glass paper. No joinery shall be primed until it has been approved by the Project Manager Priming shall be carried out on the site and not in the factory.

Items of carpentry work which are to be built into walls etc. shall be first treated by twice coating with creosote or other approved preservative.

4.4.5 Woodwork Required To Be Stained

Surfaces shall be cleaned to remove grease and dirt. The wood shall then be stopped, filled and rubbed down. In the case of teak free oil shall be removed by cleaning with white spirit.

4.4.6 Finishing Processes

1. Internal Plaster

Where emulsion paint is specified three coats shall be applied by brush in addition to any priming paint. Where water paint is specified two coats shall be applied by brush in addition to the Petrifying liquid.

The water paint shall be thinned to the consistency of thick cream.



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Where oil paint is specified this shall be two or three coat work as instructed by the Project Manager, applied by roller or brush, but not by spray, to produce hard gloss, oil gloss, eggshell or flat finish as required.

The finishing coat of paint to walls and ceilings shall be applied after the completion and testing of the electrical installation. Any paint splashes on electrical fittings shall be carefully cleaned off. **2. Unplastered Block work or Concrete** As for internal plastered surfaces.

Externally a cement type paint may be used, and shall be applied keeping a constantly wet edge, in strict accordance with the manufacturer's instructions.

3. Woodwork Required To Be Painted As for steelwork.

4. Protection of Factory Finished Work

The contractor is to allow for protecting all factory finished doors, frames windows, suspended ceilings and the like at all times to ensure that factory finishes are not damaged and must make good or replace a defective component at his own expense.

4.5 WALL AND FLOOR TILING

4.5.1 General

The British Standards (BS) govern the work covered in this section.

BS EN 197-1:200081

BS EN 197-1:200086

4.5.2 Materials

Portland cement, fine aggregate and water shall be as previously specified in Concrete Work section.

The marble chipping shall be of an approved quality in irregular pieces varying from 2 mm to 10 mm in size depending on the effect required. The pieces should preferably be roughly cubical in shape where flaky shaped pieces shall not be used. The granite chipping shall be of an approved quality graded from 12 mm down with not more than 5 percent fine material passing a No.100 sieve.

Marble and granite aggregates shall comply generally with the Table of Gradings. In connection with marble aggregates the percentages are approximate only. The actual grading should be selected to produce the surface effects required.

Table Of Gradings

BS 410 Sieve No.	Approximate Size mm	Percentage of Aggregate Passing Through Sieve	
		GRANITE	MARBLE
-	13	100	-
-	10	95-100	95-100
-	5	30-60	25-60
7	2.4	20-50	5-30
14	1.2	15-40	0-10
25	0.6	10-30	-
59	0.3	5-15	-
100	0.15	0-5	-

NOTE: the

above figures represent the limits of percentages (by weight) passing sieves of the sizes Mentioned.

Construction

Excavation and adjustment the level are required for the site to maximum depth of 30 cm with the reasonable slopes.



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Then it's damped to the required standard of specification 95% with the complete rising of excess material away. And if there is a need for excavation it should be calculated according to the other articles according to a budget approved by the Project Manager.

A layer of base course 25 cm thick is spread, compacted according to specifications, then a fine sand layer of 5cm thick is spread over the base course to receive the inter lock tiling between two reinforced concrete edge beam as shown in the drawings.

The tiles are fixed tightly a concrete mix is use to fill the spaces for maximum distance of 5 cm near the edge beams, with the same depth of tiles.

Expansion joints every 20 m. are applied of 2 cm width which will be in between two half pieces of tiles filled with a sand bituminous mix up to 2 cm from the upper level of tiles then the rest 2 cm are filled with sand. The following shall be considered during the construction of tiles:

- No dirt of concrete or any other material are allowed to be on the tiles.
- The tiles angles should be straight, equal, and smooth.
- No cracks are allowed in tiles.
- The tiles must be transported & stored or kept in a good way.
- Electrical cutting tools must be used to cut the tiles.

4.5.3 Terrazzo Tiles

Terrazzo tiles shall be formed with a (1:2.5) mix of white or coloured cement or white cement with a colour pigment added and granular marble chippings applied as a facing not less than 5 mm thick to a Portland cement and sand (1:5) mix backing.

All floor tiles shall be manufactured in accordance with the BS CP 202:1972, and shall be tested according to BS 6717 for the following:

- Flexural Test
- Tiles Compression Strength
- Absorption And Dimension Test
- Abrasion Test

The tiles shall be cast in heavy metal moulds under pressure to the proportions and sizes shown in the following table.

Terrazzo Tile Dimensions

Size mm	Size tolerances mm	Minimum total thickness mm
200x200	± 0.5	20
250x250	± 0.5	25
300x300	± 1.0	25
400x400	± 1.0	30

Tiles shall be cured as for cement and sand tiles and then ground, filled and polished before distribution to site.

The Contractor shall submit samples to the Project Manager's approval and bear all laboratory test costs.

Terrazzo tiles shall be laid and bedded direct onto a sand layer with a cement and sand (1:4) mix mortar. This mortar shall be 25mm thick in the case of 25mm tiles and 30mm thick in the case of 20mm tiles. The total thickness of the cement and sand screed and tiles shall not exceed 50 mm.

All tiling shall be grouted up on completion; care being taken to fill all joints completely. The grout shall consist of neat cement of a colour to match the tiling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.



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All terrazzo surfaces shall be polished on completion. Large areas such as floors shall be wet polished by means of approved machines using No. 140 carborundum wheel. Any surface too small for convenient machine polishing may be polished by hand using a No.140 carborundum stone and water Care must be taken during any polishing operation not to damage any of angles or arrises.

Terrazzo covering to items such as sills, treads and risers to steps, skirtings etc., shall generally be applied in accordance with the foregoing specification except that the thickness of the facing shall be at least 10 mm (marble can be used if approved by the Project Manager).

Terrazzo skirtings 100mm or 200mm high with chamfered top edges shall be produced in the same way as for tiles using the same mixes.

4.5.4 Marble

Marble shall be supplied and fixed for stairs, flooring, skirting, sills and thresholds where designated on the drawings. The exposed faces and edges of all marble shall be polished smooth and be free from scratches or other defects. Concealed faces of marble shall be treated with shellac or bituminous paint.

Marble pavings shall generally be 30 mm thick and the size, type and pattern shall be as stated in the Bill of Quantities and/or shown on the Drawings. The marble slabs shall be fixed solid on a bed of cement and sand (1:3) mix 30 mm thick with tight joints grouted in lime putty. A protective slurry of lime putty at least 3 mm thick shall be applied to the marble pavings and subsequently cleaned off.

Treads shall be 30mm thick fixed solid on a bed of cement and sand (1:3) mix 30mm thick. Risers to stairs shall be 20mm thick fixed solid on a backing of cement and sand (1:3) mix 30 mm thick. Window sills shall be 40mm thick bedded hollow on plaster slabs. Skirtings shall be 10mm thick, in lengths of about 1.5 meters, fixed solid on a backing of cement and to coincide with joints in adjacent pavings. Rounded arrises, nosing and moldings shall be adequately protected by means of timber casings. Treads, risers, skirtings and window sills shall be grouted and protected in a manner similar to pavings.

The marble slabs shall be cut square and true and shall be uniform in shape and thickness. Patterns and mouldings shall be accurately formed in accordance with the Drawings.

Exposed edges and mouldings shall be protected by means of timber casing or lime putty coating. The exposed edges and faces of all marble shall be polished smooth and shall be free from scratches or other defects.

4.5.6 Marble Lining

Marble lining to walls, columns and the like shall generally be 20 mm thick and the size, type and pattern shall be as stated in the Bill Of Quantity and/or as shown on the drawings .

4.5.7 Ceramic and Glazed Tiling

▪ Unglazed Ceramic Floor Tiling

Tiles colour and dimensions shall be as indicated on Drawings or Bill of Quantity and subject to the approval of the Project Manager. Samples must be submitted by the Contrator for the approval of the Project Manager.

Ceramic floor tiles and fittings shall be in accordance with BS EN 197-1:200086 type B , vitrified or fully vitrified and the thickness and size shall be as instructed by the Project Manager.

Glazed ceramic floor tiling shall be of the type, thickness and size as as instructed by the Project Manager.

The tiles shall be true to shape, flat and free from flaws, cracks and crazing and keyed on the reverse side and shall be of amanufacture approved by the Project Manager.

Bedding mortar shall be cement and sand all in accordance with the materials stated in Concrete Work and Blockwork sections.

Any admixtures to the mortar must be approved before use.

Grout pointing shall be white or colored cement.

Cement and sand mortar bed of not more than 20 mm or thickness of the tile shall be laid.

Tiles shall be firmly tamped into mortar to form a level surface.

The Contractor shall ensure that when fixing tiles with thin bed adhesive, the base to receive tiles is clean, level and dry, with no loose and friable areas and surface dusting.



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Cement-based adhesive shall be prepared and used in accordance with the manufacturer's recommendations to form a bed not more than 3 mm thick.

Tiles shall be laid dry and tamped well down into the adhesive to ensure a proper bond with base and a level surface. When bedding tiles on thick bed, semi-dry cement and sand (1:3) mortar bed shall be spread not less than 25 mm thick. Before the compacted bed has set a cement and sand slurry (1:1) about 3mm thick shall be spread over the surface.

The tiles shall be laid dry and tamped into the slurry to form a level surface.

Joints shall be even and not more than 3mm wide, in both directions. Joints shall be continuous both horizontally and vertically.

The tiles shall be grouted up with white or coloured cement mortar (1:1) worked well into joints when bed is sufficiently firm to prevent disturbances of the tiles; surplus grout shall be cleaned off from faces of tiles.

Movement joints shall be provided not less than 6 mm wide where shown on the Drawings or as directed by the Project Manager. Movement joints shall be carried through the depth of tile and bedding and partially filled with filling strip and finished flush with sealant to manufacturer's recommendations.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes etc., it shall be carefully cut and fitted to form a close neat joint. Open irregular joints filled with cement and sand or plaster will not be permitted. Tiles shall be cleaned off and polished at completion. No water shall be allowed on new tiling until bedding and grouting have completely set and no traffic shall be allowed on the floor until 4 days after completion and then only light traffic for a further 10 days .

▪ **Glazed Ceramic Wall Tiling**

Tiles colour and dimensions shall be as indicated on Drawings or Bill of Quantity and subject to the approval of the Project Manager. Samples must be submitted by the Contractor for the approval of the Project Manager.

Glazed ceramic wall tiles shall be in accordance with BS EN 197-1:200081 with or without cushioned edges and spacer lugs and shall be white or coloured as instructed by the Project Manager.

Glazed ceramic tile fittings shall be rounded edge or angle bead type to match plain tiles.

The tiles shall be true to shape, flat and free from flaws, cracks and crazing and keyed on the reverse side and shall be of a manufacture approved by the Project Manager.

Bedding mortar shall be cement and sand (1:3) all in accordance with the materials stated in Concrete Work and Blockwork sections. Any admixtures to the mortar must be approved before use.

Grout pointing shall be neat white or coloured cement.

The Contractor shall ensure that the cement render backing is at least 14 days old, firmly bonded to its background, free from dust, with surfaces plumb and true to $\pm 3\text{mm}$ in any 1800 mm.

The tiles shall be immersed in water for 6 hours or until saturated then stacked tightly together to drain with end tiles turned glaze outwards. Tiles shall be fixed as soon as surface water has drained.

The render coat shall be wetted sufficiently to prevent it absorbing water from the bedding coat.

Mortar bedding shall be applied to render background to an even thickness of approximately 10mm.

Each tile shall be buttered evenly with mortar and tapped firmly into position so that the bed is solid throughout.

Thickness of finished bed shall be not less than 6mm nor more than 12 mm.

Any necessary adjustment to tiles shall be made within ten minutes of fixing and tiles cleaned off after not less than two hours.

Tiles shall be cleaned off as soon as bedding is complete.

Joints shall be even and not more than 2mm wide using spacer lug tiles or spacer pegs. Joints shall be continuous both horizontally and vertically.

Tiles shall be fixed to a finished surface that is plumb and true to $\pm 2\text{mm}$ in any 2m.

Joints shall be grouted up not less than 24 hours after fixing tiles to porous surfaces and not less than 3 days after fixing to impervious surfaces.

Tiles shall be grouted by pressing mix firmly into joints, working in areas of not more than 1sq.m . Surplus grout shall be cleaned off as the work proceeds.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes etc. , it shall be carefully cut and fitted to form a close neat joint. Open irregular joints filled with cement and sand or plaster will not be permitted.

Tiles shall be cleaned off and polished on completion.

External tiling shall be protected from inclement weather until grouting is completely set. No water is to be allowed on new tiling until bedding and grouting have completely set.



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4.5.8 Protection

All floor, wall and ceiling finishes shall be protected from damage during subsequent work, and shall be thoroughly cleaned before handing over the works.

4.6 GLAZING

4.6.1 General

British Standards (BS) Documents referred to in this section are: BS 952

4.6.2 Type of Glass

▪ Sheet Glass

Sheet glass shall be flat-drawn clear sheet glass, of the substances shown below.

Nominal Substance or thickness	Limits of thickness		Approximate Weight lb/ft ²	Normal Maximum Size inch
	mm	inch		
20oz	2.75-3.05	0.108-0.120	1 1/2	80x48
26oz	3.1-3.50	0.122-0.138	1 3/4	80x48
32oz	3.8-4.20	0.150-0.165	2	80x48
3/16 in	4.65-5.25	0.183-0.207	2 1/2	50 ft ² max width 84 in
7/32 in	5.3-5.80	0.209-0.228	3	50 ft ² max width 84 in
1/4 in	6.25-6.75	0.246-0.266	3 1/2	75 ft ² max width 84 in

▪ Plate Glass

Plate glass shall be cast, rolled or drawn glass ground and polished on both surfaces, of the thicknesses shown below.

Limits For Clear Plate Glass

Nominal Substance or thickness	Limits of thickness		Approximate Weight lb/ft ²	Normal Maximum Size inch
	mm	inch		
3/16	3.97-5.56	0.156-0.219	2 1/2	100x72
1/4	5.56-7.94	0.219-0.312	3 1/4	175x98
3/8	9.13-10.72	0.359-0.422	5	280x130
1/2	11.91-13.49	0.469-0.531	6 1/2	156x96

▪ Wired Glass

Wired glass shall be polished Georgian wired having both surfaces ground and polished and with square mesh inserted during rolling of the thicknesses shown below. **Limits For Wired Glass**



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Nominal thickness	Limits of thickness		Approximate Weight lb/ft ²	Normal maximum size inches
	mm	inch		
1/4	5.5-7.2	0.216-0.283	3 ½	130x72

▪ Mirror Glass

Mirror glass shall be silvering Quality polished plate glass silvered on one side , copper-backed, varnished and painted according to the BS standard, with pre-drilled fixing holes. Silvering shall be protected against moisture by the electrcopper shellac varnish and pointed backing.

4.6.3 Installation

Cutting and glazing shall be as recommended by the manufacturer of the glass and according to these Specifications. Edges shall be clean-cut with no nipped or seamed edges.

All glass shall be cut accurately to fit its particiular position.

All glazing shall be done with sash in a closed position.

All surfaces to receiver glazing compound shall be cleaned free from dust, water and any foreign matter, which would adversely affect the installation.

Regular cleaners from sides, bottoms and tops of all glass panels shall be maintained.

Mirrors shall be fixed to walls with compressive spacers, fibre washers and chromium plated dome – headed screws, screwed into prepared plugs let into walls and set flush with surrounding wall finish.

Mirrors used as wardrobe doors or as wall linings are to be bedded with an approved mastic on a painted block- board backing not less than 12mm (1/2") thick to walls and 18mm (3/4") thick to doors. Glass sizes will be whole size to doors and minimum 900mm (3'0") wide to wall linings unless otherwise detailed, and backings continuous where possible. Joints in backings must coincide with joints in mirrors.

4.6.4 Cleaning

The Contractor shall replace all scratched, cracked or borken glass and clean all glazing on both sides and all mirrors before handing over .

4.7 IRONMONGERY

4.7.1 General

British Standard (BS) Documents referred to in this section are:

BS 5872:1995 Specification for locks and latches for doors in buildings

The Contractor shall provide and fix the ironmongery required by the Bill of Quantity or shown on the Drawings complete, including all necessary screws, bolts, plugs and other fixings. The use of nails for fixing ironmongery shall not be permitted. The Contractor shall hand over all in a finished state and to the satisfaction of the Project Manager.

All ironmongery shall be of first quality and shall be obtained from an approved manufacturer. Butt hinges are to be aluminium alloy with silver anodised finish with double stainless steel washers, or as approved by the Project Manager. The Contractor shall be required to submit for approval samples of all items of ironmongery he proposes to use. All doors shall be provided with an approved door stop plugged and screwed to the floor and all opening areas of aluminium work shall be provided with appropriate friction stays.

4.7.2 Finish

The finish of the various items of ironmongery shall be as shown in the Drawings or as required and directed by the Project Manager.



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4.7.3 Fitting And Testing

All screws used for fixing ironmongery shall be of a suitable type, material, finish, size and shape to the satisfaction of the Project Manager.

The hinges on which doors, windows, etc. , are hung shall be carefully housed or let into the door, window etc., and to the frames.

All fittings shall be removed before commencing any painting operations and shall be refixed in place after all painting works are completed and approved by the Project Manager.

All ironmongery shall be carefully wrapped and protected until completion of the work and any items or parts which are damaged or defaced or found to be defective shall be replaced at the Contractor's expense before handing over.

On completion of all locks, catches and similar items of ironmongery they shall be clearly labelled, with metal tags approximately 50x20mm and securely fixed to the keys and handed to the Project Manager .

Door closers shall be fitted a maximum of two weeks before handover.

All floor and door springs are to be fully charged with oil and their operation checked to the satisfaction of the Project Manager.

4.7.4 Standard Ironmongery For Internal Doors

Ironmongery is to be hard satin anodised aluminium alloy of best quality with matching screws fully matching and integrated. Where a supplier cannot offer the particular required ironmongery the Contractor shall produce samples of other suppliers' items most nearly matching the general ironmongery and /or produce alternative ironmongery by the main supplier most closely conforming with the Specification for the approval of the Project Manager.

All locks are to be provided with 2 keys on a key ring neatly labelled to indicate clearly the corresponding lock. A 'Master key' locking systems for all doors in station will be provided.

All knob sets shall include the appropriate mortice latch or lock with a 70 mm backset and with standard faceplates and roses unless otherwise noted.

4.8 METAL WORKS

4.8.1 General

British Standard (BS) Documents referred to in this section are:

BS 5872:1995 Specification for locks and latches for doors in buildings

4.8.2 Cleanliness

All materials shall be free from scale, damage or defects. All welding, brazing or hot forging shall be carried out by approved processes.

All metalwork shall be approved by the Project Manager before starting painting works.

4.8.3 Aluminium Windows

Extruded aluminium sections should be used as approved by the Project Manager.

All visible surfaces of the sections shall be brilliantly polished prior to anodising. The colour of anodising shall be as described in the Drawings and /or instructed by the Project Manager. Samples of colour shall be submitted for the Project Manager's approval before work commences.

The sections shall be anodised to a minimum thickness of 25 microns. The supplier must submit necessary evidence to the satisfaction of the Project Manager that the thickness of anodisation is not less than 25 microns. In case of doubt the Project Manager reserves the right to send sample pieces to independent testing laboratories, at the supplier's expense. If the testing laboratory report states that the thickness or quality of the anodisation is deficient, the Employer may ask the supplier to treat the order as cancelled and the supplier in such a case shall indemnify the Employer of any / all losses incurred by the supplier.

All frames shall be made to fit the actual openings with a 5mm clearance all round. Discrepancies in overall width or height exceeding 5mm will not be allowed and the frames will be rejected in such cases. All small discrepancies shall have the gaps suitably backed and then filled with gun- applied mastic / sealant as approved by the Project Manager. At all



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opening windows and where there are louvred screens a flyscreen shall be provided to the approval of the Project Manager, constructed following the principles and specifications as described elsewhere in this Specification.

Insect screens shall be in aluminium mesh, 18x16 meshes per inch. The gap between the insect screen and the shutter shall be covered with an adaptor PVC section.

For reference to window types see general arrangement drawings and elevations.

Tolerances are to be approved by the Project Manager before manufacture.

All ironmongery which is to have the same finish as the frames it is to be installed on shall be approved by the Project Manager.

The Contractor shall provide shop drawings for aluminium windows, which shall be submitted in quadruplicate to the Project Manager for approval.

Approval by the Project Manager of the shop drawings shall not relieve the Contractor of his responsibilities under the Contract.

All assembly screws shall be in 18-8 stainless steel.

Glazing sections shall be in special heat-resisting PVC and of channel type. Separate glazing sections on each side of the glass will not be permitted.

▪ **Sliding Windows**

Weather stripping - high density acrilan or wool weather - pile shall be used. There shall be double brushes at every contact between shutter and frame sections for complete insulation. These shall be present consistently throughout the unit between the inside and the outside and no portions without it are permitted.

The rollers for sliding shutters for windows shall be of an adjustable type. The adjusting screws shall be accessible in the assembled state of the shutters and a vertical adjustment of 7mm shall be possible.

All sections for sliding windows shall be of tubular shape and the cross sectional dimensions of same shall be not less than 60x 40 mm.

The outer frame must be suitable for accommodating sliding flyscreens as required or as directed by the Project Manager.

The handle-latch set shall have all visible surfaces of anodised aluminium or similar non-rusting material to approval.

The handle shall have a proper grip. A small projecting flange or a recess in the shutter sections shall not be accepted to serve as a handle. The latching mechanism shall not be surface mounted but shall be concealed within the sections. ▪

Side Hung Windows

All windows shall be weather stripped with heat resistant PVC sections. The weather fighting action shall be achieved by a positive compressive action against the PVC section and shall not depend on an external contact with the PVC section. At every contact between two profiles two weatherstripping sections shall be provided for complete weather protection.

The shutter sections for windows shall be of tubular type and shall be of overall size 57x45mm for windows.

The shutters of the windows shall be assembled with concealed corners of high rigidity. Hinges shall be concealed within the sections.

Hinges shall be in anodised aluminium with stainless steel pins and nylon washers. Handles shall be in anodised aluminium and mounted with self - lubricating nylon washers .

A mortice cylinder rim automatic dead lock of high quality with double pin tumbler shall be used.

Windows shall have anodised aluminium handles and a latching mechanism securing the shutter to the frame both at the top and bottom.

The glazing vinyl shall be in heat resisting PVC and of channel type to the approval of the Project Manager.

4.8.4 Flyscreens

Flyscreens shall be fitted to all opening leaves of windows, consisting of a separate metal sub-frame filled in with flywire as previously described. The flyscreens shall be adequately secured with suitable clips, set screws or turn buckles and shall be removable for maintenance purposes.

4.8.5 Sealing Joints

The Contractor shall ensure that joints are dry and shall remove all loose material, dust and grease.

Joints shall be prepared in accordance with sealant manufacturer's recommendations using recommended solvents and primers where necessary as approved by the Project Manager. Backing strips shall be inserted in all joints to be pointed with sealant.



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When using backing strips, the Contractor shall not leave gaps and shall not reduce depth of joint for sealant to less than the minimum recommended by the manufacturer.

Cavities shall be filled and jointed with sealant in accordance with the manufacturer's recommendations. Sealant shall be tooled to form a smooth flat bed.

Excess sealant shall be removed from adjoining surfaces using cleaning materials recommended by the sealant manufacturer, and shall be left clean.

4.8.6 Expansion Joint Trims

The Contractor is to provide at all expansion joints in floors, roofs, ceilings, walls and columns extruded aluminium expansion joint cover systems as appropriate and as shown on the Drawings and fixed in accordance with their printed instructions including all necessary components and fixings .

Floor joint covers shall be 2" deep. Butt joints within continuing runs shall be a maximum of 20 feet apart and will be sealed during installation.

Wall and ceiling joint covers shall be standard grey.

Transition pieced at changes of direction and at joints between horizontal and vertical joint covers shall be factory fabricated.

4.8.7 Steel Doors And Gates

Steel doors and gates shall be made of galvanized steel sheets and profiles, and shall be free of any irregularities in dimension or of shape, or other defects that might, of detriment to the construction.

Elements which deviate from the specified shape or form and/or which are defective to such degree that they cannot be repaired without risks of damaging the material or the element itself shall not be used and have to be replaced immediately.

The galvanization for all elements shall be carried out so as to ensure that the zinc covering is uniform, adhering and free from cracks and pits all over the object. The galvanization shall comply with ISO 1461 with a minimum thickness of 65 um for the bolts and 80 um for the other elements.

All deformations of welded elements appearing during galvanization shall be carefully straightened, In such a way that the galvanization is not damaged and the steel does not lose its strength normally, no extra treatment shall be carried out after galvanization. It may be allowed to repair small defects by applying two coats of zinc dust paint. The execution of the work shall be correct and in accordance with professional usage on the best level.

The use of welding for repair of defects shall only be permitted when there is no risk of damaging the steel/ and in no circumstances without the prior approval of the Project Manager. All welding work shall be carried out as are welding according to BS EN 1011, welding electrodes shall be appropriate for the used base metals and the chosen welding method, and shall be able to satisfy tests.

The Contractor must always be able to produce documentation that the used electrodes comply with the standards for the base metal on which they are applied, as regards resistance and quality class.

▪ Execution

Welding work shall be executed in accordance with the prescriptions of BS EN 1011. During welding there may be no rust, nor any layered scales stemming from rolling, nor any metal coating/ nor paint or grease/ nor any burrs from punch cutting nor any other elements which could reduce the quality of the weld,

The elements of the construction shall be executed with excess length to compensate for contractions and possibly with a slight camber or similar to eliminate the effect of thermal contractions.

After the welding, the elements of the construction shall, as far as possible have a final shape which makes truing-up unnecessary,

The elements to be joined by welding shall be placed in correct position in relation to each other in order that the welding contractions / welding deformations, and possible truing-up may be limited to a minimum. The tack welding shall be executed just as carefully as the welding itself.

The tack welding shall be placed as close as possible and be of such a dimension and strength as to be able to resist the contractions appearing during welding.

In case that it is not planned to remove the tack welds as the welding proceeds, these tack welds must be placed and executed in such a manner as to hamper the welding works as little as possible,

Before making the finishing run, it shall be checked that the tack welds have no cracks or other defects, Cracked or defective tack welds shall be removed.



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Welding run materials shall fill up the groove completely in penetration welds and pass evenly into the base metal and shall, moreover/ be free of surface flaws such as crevices, cutting burrs, scales etc.

Intermittent fillet welds shall not be accepted, and all fillet welds must be closed.

The welding runs must be flat or concave-Possible convexity must not exceed the tolerances Indicated in the standards.

The finished weld must not present any cracks, crevices, faults of adhesion, uneven and rough surfaces, root defects/ pores, slag inclusions, or other flaws, which may impair the strength of the weld. Butt welds must invariably be finished by backing runs after removal of welding slags, Welded points and similar for fixing grips and clamps to keep the construction aligned in correct position shall only be permitted if they do not impair the construction.

All spatters from welding shall be removed before beginning the painting. All defective welds must be removed and replaced by a satisfactory weld.

No repairs may be carried out without the approval of the Employer or the Project Manager. The

Employer reserves the right to effect testing of important welds to be carried out by an approved institute of control.

If, by ultrasonic or other non destructive tests, it is confirmed that there are welding defects necessitating repairs, the Contractor shall remedy those at his own expense and also meet the costs of the supplementary welding tests until it has been demonstrated in a reassuring manner that the quality of the welding work satisfies the specified requirements. The Employer reserves the right to insist on a more extensive control.

▪ **Erection**

Dismantling, erection and handling of the elements of the construction shall be done with care in order that the surfaces may not be damaged. The elements shall be lifted by means of straps and not by chains.

▪ **Sliding Gate**

The sliding gate shall slide by automatic mechanism efficiently by using guide rail suitable in size to prevent sliding friction, and using mechanical limit stop to regulate the opening and closing stroke.

The gate shall be equipped with:

- Ratio-motor complete with gear case
- Rack
- Limit stop flasks
- Photo-electric cells
- Mechanical stop
- Key or digital keyboard selector
- Blinker
- Antenna

4.9 ROOFING AND INSULATING

4.9.1 General

British Standard (BS) Documents referred to in this section are:

BS 476: Part 7

BS 1105:1994

BS 1494

BS 3416

BS 4254:1991 BS

5493

4.9.2 Corrugated Steel Roofs

All corrugated galvanized steel sheeting (whether fixed to wood or steel framing) shall be of 23 or 24 gauge fixed with a minimum of 50mm end laps and with a minimum of one corrugation side lap.

When instructed to have a one corrugation side lap, the sheets shall have a cover of not less than 20mm and all the lapped sides shall be turned downwards. Where practicable the exposed lapped sides shall be arranged to face away from the prevailing wind. When instructed to have a one and a half corrugations side lap the sheets shall be arranged alternatively with a cover of not less than 90mm, the first sheet being fixed with the lapped sides turned upwards away from the bearer and the cover sheet with the lapped sides turned downwards.



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Sheets shall be secured to purlins at centers not exceeding 300mm by galvanized self parking screws (minimum 75mm long) with galvanized diamond shaped washers and lead sealing washers. All holes for bolts, self parking screws etc., shall be punched from the underside of the sheets and shall be on the crown of the corrugations. Galvanized steel ridge capping shall be supplied and fixed to purlins as described above. Hook bolts, self parking screws and washers shall generally comply with BS 1494.

4.9.3 Screeds

The provisions of Concrete Work section shall apply to the construction of solid reinforced concrete slab roofs and to hollow slab roofs. The actual finish will be specifically shown on the Drawings or in the Bill of Quantity. Lightweight concrete screeds for obtaining falls or as an insulation layer shall be of approved type of foamed concrete. The materials shall be measured, applied and cured in accordance with the manufacturer's instructions and to the satisfaction of the Project Manager.

In all cases the finished screed shall be of an approved proprietary type with a dry density of not less than 300kg/ m3 to receive the applied roofing. Mixing shall take place using approved mechanical mixers.

Concrete screeds for obtaining falls shall be (1:3:6) mix.

All screeds shall be laid in bays not exceeding 10 square meters and formed between stop boards of the correct height and cut on each side to indicate the slope required in the roofing . The screed shall then be trowelled with a wooden float to true and accurate falls or cross falls up to the stop boards . A 10mm side gap shall be left between each screed bay for the full depth of the screed.

The screeds shall be allowed to cure thoroughly to attain maximum shrinkage. Any cracks which appear due to shrinkage shall be made good. The gaps between bays shall then be filled in with cold bitumen.

Where the roof screeds are to be reinforced with one layer of galvanized wire mesh , this shall be supported on top of the base on spacers to ensure that it is maintained at between 10mm and 15mm below the top of the finished screeds. It shall be at least 100mm wide, securely wired together. It shall be stopped 20mm from the edge of each bay.

4.9.4 Insulation

When asphalt sheets is used on the top of the screeds, roof and underground structure, it should have the following properties:

- Asphalt sheets should be supplied in rolls of 1-1.2m width and 4mm thick.
- Top surface should have a layer of medium size white aggregates (2-3mm)

Applying asphalt sheets should be made according to the manufacturer instructions.

Surface should be cleaned and a suitable prime should be sprayed before using asphalt sheets. An overlap of 15-20cm should be made on sheets.

Black bitumen paint should be sprayed before erecting the sheets, which should be heated (bottom side).

Sheets should have at least 15cm vertical edges, all around the roof (a special groove should be made in the roof parapet to erect the vertical side of the sheets). During erecting asphalt sheets, contractor should prevent air pockets entrained under the sheets, which will be full flame applied.

4.9.5 Black Bitumen Paint

The black bitumen paint shall be applied in the thickness and number of coats described in the BOQ or drawings, and to be applied with a coverage rate of 8m2/litre for concrete surfaces.

All surfaces must be sound and free from dust, dirt, all loose material, grease and oil etc., and dry before applying the black bitumen paint.

The black bitumen paint shall comply to BS 3416 Type I and II, as well as BS 476: Part 7 class 1 for fire resistance.

4.9.6 Polyethylene Sheet

Polyethylene sheet of 10 micron thick shall be used in the locations as indicated in the drawings below concrete works attached to soil. An overlap of 10cm should be made on sheets.

4.9.7 Epoxy Resin Coating

Thixotropic pitch extended epoxy resin for all concrete surfaces contacted with sewer. The resin shall comply with BS 5493.



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Two coats minimum shall be applied according to the Project Manager's instructions. All surfaces must be sound and free from dust, dirt, all loose material, grease and oil etc., and dry.

Supply & paint internal sides of the underground water tank & floor, using water proof type for potable water concrete tanks (Work should be according to the manufacturer instructions & as directed & approved by the Project Manager).

4.9.8 Water Stopper

Hydrophilic solid rubber strip that swells (approximately 300% expansion ratio) when exposed to water to prevent leakage paths in concrete, shall be used in the construction joints as shown in the drawings. The strip cross section shall be 10 x 25 mm, and 100mm overlaps shall be secured at the ends. The strip must have a hydrostatic pressure resistance up to 50 m. Concrete surface must be clean, free from loose materials and debris, and dry before fixing the strip. Strip can be fixed either by nails every 30-40 cm at the concrete surface or by an approved bonding adhesive.

4.9.9 Completion

On completion all roofs and surface are to be left sound, water- tight and in clean condition before handing over.

SECTION 5 ELECTRICAL WORKS

5.1 GENERAL PROVISIONS

5.1.1 Completeness of Contract

- A All apparatus, accessories or fittings which may not have been specifically mentioned, but which are usual or necessary in the respective equipment for the completeness of the finished work in an operable status, shall be deemed to be included in the Contract and shall be provided by the Contractor without any extra charge. All equipment shall be complete in all details, whether or not such details are mentioned in the Specifications. This includes fixation details and connection clamps and/or terminals.
- B Any reference in the quantity and price schedules, the delivery period schedule or in the various clauses and schedules of the text of either the Specification or the Bid, to any equipment shall imply that the equipment is complete with all accessories, apparatus and fittings as outlined in sub-clause A (1.1) above.
- C The Bidder shall be responsible for ensuring that the equipment supplied is fit for the purpose intended. Available information on the characteristics of the system to which the works will be connected and associated will be supplied on request to the Bidder who shall be responsible for obtaining and determining all applicable knowledge relevant to the works.

5.1.2 Drawings and Documentation

- A The Contractor shall prepare and submit to the Engineer/GEDCo for approval dimensioned general and detailed design drawings and other pertinent information of all the Equipment specified in the Specifications.
- B The Contractor shall supply detailed instructions for erection, operation and maintenance of all equipment and components in English.
- C In the event of any difference between the drawings and the Specifications, the latter shall prevail.
- D Approval of drawings shall not relieve the Contractor of his obligations to supply the Plant in accordance with the Specifications. In the event of any difference between scaled dimensions and figures on the drawings, the figures shall prevail
- E All text on drawings provided by the Contractor shall be in the English language in addition, if necessary, to that of the country of origin. All drawings shall be dimensioned in millimeters.



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5.1.3 Time of Delivery and Completion

- A The guaranteed delivery times shall be stated in the appropriate schedule in this document.

5.1.4 Quality of Materials

- A All materials supplied under this Contract shall be new and of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions arising under working conditions without distortion or deterioration in the setting up of undue stresses in any parts and also without affecting the suitability of the various parts of the Works for which they were designed. No toxic material (such as Halon, PCB, and Asbestos) shall be utilized.

5.1.5 Contractor's Quality Assurance Procedures

- A The Bidder shall have established a quality assurance system based on ISO 9001 or 9002. The Contractor shall include a documentation of the system with a list of current procedures, an organizational chart of the quality organisation and the name of the quality manager. He shall also submit a list of quality revisions performed the last twelve months with a list of closed and unclosed findings as well planned revisions the coming twelve months.
- B The Contractor shall submit for approval a program of quality control and inspection procedures to assure that the product during manufacture and on completion complies with the specified requirements. The program shall relate the quality control and inspection activities to the production cycle. In support of the quality control and inspection program the Contractor shall provide details of quality control and inspection procedures available for use in the execution of the Contract. The Contractor shall retain responsibility for quality control and inspection activities made by his sub-contractors and shall indicate on the program, which items are to be sub-contracted.

5.1.6 Guarantees and Particulars

- A The Works shall comply with the technical guarantee data stated in the Bid. The Contractor shall be responsible for any discrepancies, errors and omissions in the particulars and guarantees, whether the Engineer/GEDCo has approved such particulars and guarantees or not.

5.1.7 Places of Manufacture and Sub-Contractors

- A The manufacturer's identity and places of manufacture, testing and inspection before shipment for the various portions of the Contract Works shall be specified in the Technical Schedules and shall not be departed from without the agreement of the Engineer/GEDCo.
- B All Sub-contractors and Sub-suppliers of components and materials shall be subject to the approval of the Engineer/GEDCo. Information shall be given on each Sub-order sufficient to identify the material or equipment, to which the sub-order relates, stating that the material is subject to inspection by the Engineer/GEDCo before dispatch.
- C All equipment offered shall be the product of recognized and experienced manufacturers and shall be proven equipment of the same basic design and size similar to that which has been in successful continuous operation for at least three years preferably under similar climatic conditions. Proven plant reliability and high availability are of prime importance and the attention of the Bidder is drawn to these particular requirements.



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5.1.8 Inspection and Testing

- A All materials used in the Contract Works may be to inspection by the Engineer/GEDCo and it is the Contractor's responsibility to advise the Engineer/GEDCo when equipment and materials are available for inspection, at least 1 month in advance.
- B Factory tests on equipment shall be made according to the applicable IEC Standards, or as specifically specified or according to standards approved by the Engineer/GEDCo.
- C Routine tests shall be made on each unit of all equipment.
- D Type tests shall be made on one unit of each type of different equipment. Instead of carrying out the type tests the Contractor may submit suitable certificates of tests made on equipment of the same type; however, the Employer reserves the right of accepting these certificates or to reject them partially or totally.
- E The Engineer/GEDCo shall be at liberty to demand any additional testing at the manufacturer's works, at site or elsewhere in order to verify that the equipment complies with the conditions of the Specifications.
- F A test program shall be submitted to the Engineer/GEDCo for approval at least 1 month ahead of the commencement of testing.
- G Measuring apparatus shall be approved by the Engineer/GEDCo and if required shall be calibrated at the expense of the Contractor at an approved laboratory.

5.1.9 Packing, Transportation and Storage

- A Packing shall give adequate protection to the enclosed materials against mechanical damage during transport to its final destination, including rough handling during sea, rail and road transport and transition from one mode of transport to another.
- B Packing should be stout close-boarded wooden cases of adequate thickness, suitably braced and banded and lined internally with water-resistant material or equally solid enclosures.
- C Steelworks sections and similar items may be bundled provided that the ends are adequately protected and the enclosing bands or wires are robust.
- D Indoor electrical equipment must be enclosed in welded polythene envelopes inside packing cases and the envelopes shall be evacuated or have a desiccant inside.
- E All items in cases or crates shall be secured so that they are not free to move and cannot work loose in transport. If rotating parts are shipped within their bearings or mountings, they must be adequately braced and restrained to prevent relative movement. Loose items shall be placed in bags in a case, each bag having stitched onto it a label indicating the number and nature of its contents. Where a filler material is used in a case to restrict movement or provide additional protection, it must be inorganic and non-hygroscopic.
- F All surfaces liable to corrosion shall be thoroughly cleaned and special steps adapted to the nature of the materials and the time interval between packing and unpacking shall be taken to prevent corrosion. These steps may constitute the greasing on surfaces, the application of a protective coat, enclosure of the items in a hermetically sealed container, the addition of vapour phase inhibitor paper to the package or other approved means.
- G Steps shall be taken to ensure that moisture, moulds, insects or rodents cannot damage insulated materials. Items that include materials liable to be damaged by moisture shall be packed in hermetically sealed containers in which silica gel, or some other approved desiccant has been inserted.



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- H Cases shall be marked with large lettering to show which side of the case is to be up, and if the contents are fragile, marked "FRAGILE" in large letters with the international wineglass symbol. Packages shall be marked with their place of destination in such a way that rough handling or the effect of weather cannot remove or obliterate the marking. Each item shall be marked with its gross weight and, for all lifts over two tonnes, marks on the cases shall show the correct positions for the slings.
- I Special steps shall be taken to guard against theft during transport. No small items such as padlocks nameplates and so forth that could be torn off or unscrewed shall be accessible.
- J Cases, crates, barrels and drums shall be banded in such a manner as to obstruct the theft of any of the timber used for packaging and the bands shall be so secured that they are not rendered ineffective by shrinkage of the wood.
- K A descriptive and fully itemised list shall be prepared of the contents of each packing case. A copy of this list shall be placed in a waterproof envelope under a metal or other suitable plate securely fastened to the outside of one end of the case, and its position indicated by stencilling on the case. Where appropriate, drawings showing the erection markings of the items concerned shall be placed inside the case.
- L All stencilled markings on cases and crates, or other markings on descriptive metal tabs fixed to cable drums, bundles of structural steelworks and so forth, shall be applied in two places with a material which cannot wash off and shall be additional to any erection or other marks or impressions which may be specified elsewhere.
- M Shipping marks are to be stencilled in oil based paint in block letters and symbols. When unobstructed flat smooth surfaces of sufficient size are not available on the case for the shipping marks they are to be stencilled on marine-ply notice boards of adequate size and of at least 6 mm thickness securely fastened to the packing case.
- N All packing cases, though not steel containers, shall remain the property of the Employer.

5.1.10 Tools

- A The Supplier shall supply in lockable boxes, for the Employer's use, any special tools that may be required for assembly, dismantling and adjustments to the equipment. The tools shall be unused and in new condition at the time of hand over. Suitable special spanners shall be provided for bolts and nuts which are not properly accessible by means of an ordinary spanner.

5.2 POWER CABLES

- A The following assumed values of soil thermal resistivity, soil and air temperatures are for Tender evaluation purposes only:
 - o Maximum ground temperature °C 30
 - o Soil thermal resistivity °C m/W 1.8
 - o Max. ambient shade temperature °C 30-40
- B The underground cables shall be designed to withstand a short circuit current of 30 kA for 1 sec.

5.2.1 TECHNICAL DATA SCHEDULES

- A All the Technical Schedules shall be filled in and completed by the Tenderer, and submitted with the Tender.



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- B All documentation necessary to evaluate whether the equipment offered is in accordance with this Specification shall be submitted with the Tender.
- C All data entered in the Schedules of Technical Data are to be regarded as values guaranteed by the Tenderer and shall not be deviated from unless approval to do so is obtained from the Engineer.
- D All data entered in the Schedules of Informative Data are also to be regarded as values guaranteed by the Tenderer. These data may only be deviated from if approval to do so is obtained from the Engineer.
- E Necessary copies of the schedules format shall be used if necessary to provide space to submit data on all the equipment offered.
- F Equipment or Systems offered which are not in accordance with the Specification shall be listed and described in Schedule 'F' - Deviations from Specifications. If there are no deviations, this shall also be stated in Schedule 'F'.
- G The following definitions and abbreviations shall be interpreted as follows:
- Hz shall mean hertz ○ kW shall mean kilowatt
 - MW shall mean megawatt
 - VA (kVA, MVA) shall mean volt-ampere (kilo-, mega-) ○ A (kA) shall mean ampere (kilo-) ○ V (kV) shall mean volt (kilo-) ○ W/m shall mean watt per metre ○ AC shall mean alternating current ○ DC shall mean direct current ○ IN shall mean rated (nominal) current
 - UN shall mean rated (nominal) voltage ○ Ah shall mean ampere-hours
 - lm shall mean lumen
 - lm/w shall mean lumen per watt ○ min shall mean minute ○ min shall mean minimum ○ (prefix) shall mean micro
 - rms shall mean root mean square ○ p.u. shall mean per unit ○ p/p shall mean peak to peak ○ T shall mean Tesla
 - kg shall mean kilogram ○ N shall mean Newton
 - s or sec. shall mean second ○ No. shall mean number ○ dB shall mean decibel ○ Amp shall mean amperes ○ F shall mean Farad ○ °C shall mean centigrade
 - K shall mean degree Kelvin
 - m² shall mean square metre (mm² for millimetre, etc) ○ m³ shall mean cubic metre (mm³ for millimetre, etc)
 - m³/s shall mean cubic metres per second ○ m shall mean metre ○ cm shall mean centimetre ○ mm shall mean millimetre
 - joules shall mean joules per hour
 - tonne shall mean metric tonne ○ % shall mean percentage ○ Pascal shall mean centistoke
 - cst shall mean centistoke



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5.3 STEEL WORKS

5.3.1 GENERAL PROVISIONS

5.3.1.1 Site Conditions

A The site conditions shall be assumed to be as follows:

Description	Unit	Value
1 Altitude of site above sea level	m	0-1000
2 Ambient Temps:- Maximum	°C	+45
Minimum	°C	+ 5
3 Wind Speed Maximum	m/s	38.8
4 Isokeraunic Level		15
5 Pollution Type		Dust
6 Relative Humidity Maximum	%	100
Minimum	%	<10
7 Rainfall Average annual	mm	600
8 Hail		Yes
9 Fog		Yes
10 Sand Storms		Occasional

5.3.1.2 Electrical Design Data

Item	Description	Unit	Nominal voltage level [kV]	
1	Nominal system voltage phase to phase (delta connected)	kV	33	0.4
2	Highest system voltage phase – phase	kV	36	0.42
3	System Frequency	Hz	50	50
4	System earth		Solid	Solid
5	Impulse withstand voltage (1.2/50 μ sec wave)	kV peak	170	
6	Power frequency withstand voltage 1 min.	kV	70	



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7	Assumed highest switching surge		3.5	2.5
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A Other electrical design criteria and parameters, such as electrical clearances in the pole/structure top, mechanical loading, load cases and phase spacing shall comply with the standard practice of Gaza Electricity Distribution Corporation (GEDCo) and the neighbouring IEC.

5.3.2 GENERAL TECHNICAL SPECIFICATIONS

5.3.2.1 Standards

- A Basically, the established standard practice of GEDCo and IEC (Israel) shall be applied. Additionally, well reputed and internationally widely used standards will apply as outlined below.
- B Unless otherwise specified herein, all material used and equipment supplied and all workmanship and tests shall be in accordance with the latest editions of IEC (International Electro-technical Commission) and ISO standards, or other relevant standards e.g. ANSI, ASTM, BS. In all cases, the Contractor must inform the Employer or the Engineer well in advance precisely to which standards the materials.
- C The Contractor will be required to hand over to the Employer or the Engineer two copies of all approved Standards or an English translation thereof.
- D Where no standards exist, as in the case of patented or special materials, all such materials and workmanship shall be of the best quality, and full details of the material and any quality control tests to which they may be subjected shall be submitted to the Employer or the Engineer for approval.
- E The Contractor shall at all times keep copies of the specified standards and codes and all amendments thereto available for reference and inspection at the places of manufacture.

5.3.2.2 Type of Works

- A The Works covered by this part of the Specifications include the following:
 - Standard design of all steel poles/structures and accessories; ○
 - manufacture of steel poles/structures according to standard design; ○
 - galvanising of steel poles/structures;
 - timely delivery of steel poles/structures to sites including transport, handling and on/off loading; and ○ any other works necessary for full compliance to the Employer's standard

5.3.2.3 Materials and Equipment

- A All materials, whether fully specified herein or not, shall be of first class quality particularly with regard to manufacture, strength, ductility, durability and ability to function and shall conform with the best modern practice and comply in all respects with these specifications. Where applicable, all equipment shall be of tropical design.
- B All material shall be inspected and tested in full to prove compliance with the requirements of the specifications to the satisfaction of the Employer or the Engineer, if so required. The testing shall be carried out according to the relevant standards approved by the Employer or the Engineer.



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5.3.2.4 Standardization of Equipment

- A All small mechanical and electrical equipment, material and devices for the works shall as far as possible be of the same make and type.
- B The Contractor shall be responsible for the standardisation of all small mechanical and electrical equipment, materials and devices for the Works. He shall arrange and perform the necessary co-ordination work with his subcontractors for the purpose of such standardisation.

5.3.2.5 Drawings and Calculations

- A The GEDCo standard drawings for poles/structures and accessories shall be used.
- B To the extent that new drawings have to be made, such drawings shall comply with the following:
 - The Contractor shall prepare all drawings necessary for the works, which shall comply with the specifications included in the contract documents. The Contractor shall prepare his drawings to show the most suitable arrangement of all details and accessories having regard to the conditions applicable. The Contractor shall be entirely responsible for all design and drawings applied.
 - The Contractor shall inform himself fully of the actual dimensions, levels, etc., of any other existing or proposed structure before commencing the manufacture of parts dependent on such data.
 - The design calculations for each member forming part of the works shall be based on the most unfavourable combination of all the loads which the said member or part is intended to support or assist in supporting either permanently or temporarily.
 - The Contractor shall submit to the Employer or the Engineer for review and approval, within the times named in the specifications or agreed in accordance with these conditions, such general, workshop and erection drawings, structure lists and calculations, as are called for in the specifications or required by these conditions, or as the Employer or the Engineer may reasonably require.
 - Copies of all drawings to be reviewed by the Employer or the Engineer shall be provided to him in triplicate by the Contractor or more copies if requested by the Employer, and the Contractor shall ensure that such drawings are submitted in sufficient time to permit checking and correcting thereof before they are required to be used. Dispatching of drawings to and from the Employer or the Engineer shall be effected by the most expeditious way of transport.
 - Within a reasonable period not exceeding one month after receiving such drawings and calculation one copy of each document will be returned to the Contractor, dated, signed and marked by the Employer or the Engineer and, where necessary with proposed corrections indicated.
 - Drawings marked "Not Approved" shall be corrected by the Contractor and sent to the Employer or the Engineer for his further review.
 - No drawings prepared by the Contractor which require to be reviewed by the Employer or the Engineer, shall be used for manufacturing purposes until they have been marked "Approved" and signed by the Employer or the Engineer. Manufacturing starting prior to receipt of "Approved" drawing is done at the Contractor's own responsibility.
 - Approval of the Contractor's drawings shall not relieve the Contractor of any of his obligations under this contract or of his responsibility for the correctness of the design and drawings.
 - As soon as the Contractor's transparent copies have been approved, the Contractor shall, in addition to the copies for his own use, distribute copies of the approved drawings and such other particulars as directed by the Employer or the Engineer, to the Employer (3 paper copies) and to any other parties who may, in the opinion of the Employer or the Engineer, require them. One copy of the drawings shall be kept by the Contractor, and shall at all reasonable times be available for inspection and use by the Employer or the Engineer and by any other person authorised in writing by the employer. The latest updated version of drawings shall be used during the manufacturing and erection period.



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- C For all documents, written or drawn, the SI system of units shall be used.
- D Drawing sizes shall conform to the ISO standards, i.e.
- A1 (594 x 841 mm) ○
 - A2 (420 x 594 mm) ○
 - A3 (297 x 420 mm) ○
 - A4 (210 x 297 mm) ○
- Sizes larger than A1 shall be avoided.
- E All measurements on the drawings shall be given in mm. All text in the documentation shall be in the English language. Each calculation and main drawing shall have a blank space in the lower right hand corner for the client's title block and identification numbers. A revision block shall be located adjacent to the title block.
- F Calculations shall be in size A4.
- G The Contractor shall during the total project time maintain a List of Documentation to be updated by him whenever needed. The list of Documentation shall include the date of original issue of each document submitted as well as the dates of every revision. The List of Documentation shall also include a time schedule for submittal of the documentation.

5.4 Cable Installation.

The installation will generally be executed with heavy-duty PVC sheeted; PVC insulated multi-core cables, rodent and vermin resistant. In office, welfare, and toilet/bath room areas single core PVC insulated cables in conduit will be applied. The conduit installation will be concealed in walls and exposed on top of ceiling.

Only exact horizontal or vertical cable runs will be approved and cable routings shall follow girders, etc. in a neat and logical way. All cables from distribution boards shall run in galvanized cable trays.

The cables shall be arranged to give a minimum number of crossings when branching-off the cable tray and no cables shall be directly fixed on insulated surfaces.

Cables in diesel engine rooms and in the pump room shall be located in cable trenches covered with heavy steel check plates. All freestanding, movable or vibrating motors and appliances shall be connected to the cable installation by a short length of high temperature flexible cord. Where the connection is liable to mechanical damage, PVC sheeted flexible metallic conduit shall be provided. The earth continuity shall be maintained by means of an earth conductor running within the flexible conduit.

Cables shall terminate in an approved type of terminal boxes with provisions for fixing and sealing the cable. All cables shall be terminated with suitable compression glands of the correct size. Compression glands shall be provided where surface mounted PVC cables are connected to distribution boards, fittings and accessories.

Special sleeves are to be used where cables pass insulated walls. These sleeves consist of a piece of polyethylene conduit with compression glands in each end sealed to the conduit. One or more sleeves will be located in a rectangular opening in the panels suspended between two plates of suitable material covering the opening. All assemblies will be sealed with silicon mastic to prevent condensing and the space between the plates will be filled up with in-situ foamed insulation material.

All exposed cables shall be protected mechanically until 1.5m above floor level with galvanized steel pipes or 3mm galvanized steel sheet.



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Cables in vertical runs shall be clamped in such a way that stresses in the cables are avoided. Where no trays or trunking are installed the cables shall be fixed by means of screw fixed saddles at a distance not exceeding 20 times the diameter of the cable.

Common saddles shall be used where cables are grouped.

Where parallel cables are used for supply the length of every cable must not differ more than 1 %, and the cables shall be placed not more than 1 m from each other.

All cables shall be NIGH and XPLE with copper conductor.

All cables shall be as per plans.

Wires shall be thermoplastic 750 V.

The minimum size of conductor used for lighting sub-circuit would be 1.5 mm², 2.5 mm² for socket outlet. The bottom of the cable trench shall be freed of sharp stones and such like.

Cable warning tiles of or tape marked: "Danger-electric" in Arabic and English shall applied. All cable must have labels or nameplates of the circuit.

The cables shall be equipped with additional earthing cables with yellow/green sleeve.

6 Electrical special specifications

6.1 LABELS AND NOTICES

Every Item which has to be connected electrically shall have its one significative number as well as all cables. All apparatuses and cables shall be labeled; all warning notices and signs that notify the pumping station operational staff shall be written in Arabic and English.

6.2 MAINS SWITCHBOARD

Mains switchboard shall be constructed as a floor-mounted, and it has to be arranged in sections that could be easily extended. The switchboard shall be equipped with molded case circuit breakers and fuses where the design requires; the protection devices shall be accessible from the front.

Sub-main distribution boards shall generally be wall mounted with miniature circuit breakers (MCB) and residual current devices (RCD) for protection, on power panels and consumer units.

6.3 DISTRIBUTION

All main distribution cables from the main switchboard shall be run in closed trenches, cable ladder or cable trays according to their routings.

XLPE cables shall be used for the main distribution cables.

Local lighting and power distribution boards shall be located in the cupboards to serve each floor. Perforated cable tray shall be provided for all weak current and data cable.

Lighting levels shall be designed according to the specifications and as CIE (International Commission on Illumination).

Dust & weatherproof lighting fitting shall be selected to resist the outdoor climate condition, the Lux density shall be calculated according to architecture recommendations.

6.4 EXTERNAL LIGHTING

Security lighting fittings shall be provided and fixed all around the boundary wall to illuminate the area, and to ensure safe property. The fittings shall be street lighting type. The contractor shall use 8 meters street lighting poles



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6.5 EARTHING

Earthing system installation shall comply with the standards & regulations. Bonding of all metal parts shall be included on the price. The maximum earth resistance is 2 ohm.

6.6 TRENCHES

Underground cables shall be laid direct in trenches unless otherwise indicated. They shall be drawn through ducts as they routed beneath steel or concrete structures to ensure that anyone can draw them out when desired.

When cables trenches are opened all cables shall be laid and trenches shall be backfilled within twenty-four hours. At all times, safety precautions shall be taken and arrangements made to prevent damage to cables. The contractor has to present the calculation of cable de-rating according to IEC 364-5-523 taking into consideration the Ambient temperature, Type of Laying, Number of Cables and Distance Between Cables (grouping factor).

6.7 LV SWITCHBOARDS

The switchboard shall consist of one or more vertical sections joined together to form a freestanding cubicle rigid, floor fixing assembly, which is extendible at either end.

Each vertical section will have built in rollers for easy section aligning and jointing. Designed and Construction of the switchboard in accordance with standards.

The switchboard shall be factory built assemblies in accordance with IEC 60439-1 international standard.

Switch boards shall be executed in accordance with single line diagrams illustrated in design drawings, and have to include minimum 20% free space inside the board after erecting all electrical components.

Contractor shall submit for the Project Manager's approval a master power supply schematic tree including rated panels, bus bars, and cabling routes with all supervisor's recommended details before starting the work. All bottom plates of switchgear panels shall comprise of a vermin barrier plate. Adjustable height gland plate shall be provided, all in and outgoing cables have to be arranged from below.

6.8 MOTOR CONTROL

All motor drivers shall be variable frequency devices with sufficient types such Danfoss , delta , Siemens.

Thus Power factor shall be not less than 0.92 or as recommended by Palestinian Energy Authority (PEA).the work include any parts such contactors and capacitor to reach the accepted power factor.

6.9 POWER METERS (DIGITAL MULTIMETERS)

Each main switchgear shall be provided with two multifunction power meters, one on each busbar section for measuring and remote display at least the following functions:

Voltage, Current, Active power, Reactive power, Power Factor, Energy, Frequency, Voltage and Current Total Harmonic distortion..

The multifunction meter shall have a local display and communication facilities to connect to the plant's SCADA system.

It should be noted that the list of required functions is "indicative but not exhaustive"

6.10 CABLE TRAYS & CABLE LADDERS

Cable ladder and tray shall be formed perforated steel of not less than 0.9mm thickness up to and including 200mm width, 1.25mm thickness from 150mm up to and including 400mm width and above. They shall be galvanized unless otherwise indicated on the drawings.

Tray shall be adequately sized to support the cables without bunching.

All cable tray and ladder shall be made from stainless steel with all other accessories.



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6.11 CONTROLLERS (PLC)

A. Design General

The system comprises controller, I/O and cross-connection terminal groups to interface the system and field equipment, e.g. motor-starters and instrumentation circuits.

The system has to comprise function libraries for digital as well as analogue (floating point, minimum 32 bits, single precision) control. In addition to basic arithmetic calculating functions, the analogue control function library has also to include composite functions e.g.: PID-controller, integration, differentiation, linear ramp, first order filter, limiter, comparator and function generator.

Power supply circuits are, from the aspect of noise suppression, to be designed to meet system manufacturer demands and recommendations.

The system has to include over voltage protection on incoming mains connection.

Outputs from power supplies have to be isolated from mains.

Central units and communications equipment related to the central unit have to use separate power supply.

I/O-stations and related I/O-modules have to use separate power supply. If more than one I/O-station is located within the same cubicle, they may use the same power supply.

Over voltage protection and power supplies have to be individually interfaced to the system and supervised for unit run and unit fault status. Status has to be indicated as described in separate documents.

Fuses have to be interfaced to the system and supervised for tripped fuse. Status has to be indicated as described in separate documents.

Uninterruptible power supplies are to be interfaced to the system and supervised for unit fault and unit operating on battery power. Status has to be indicated as described in separate documents.

I/O-channels belonging to among themselves redundant process objects have to use different I/O-modules.

Units have to feature run and fault indications as a minimum requirement. Status has to be indicated as described in separate documents.

RTU module shall be included to able control of plant from website.

Fusing has to be carried out on an individual module-level basis. Status has to be supervised and indicated as described in separate documents.

I/O-modules have to be possible to exchange on-line, without having to shut down power or disconnect any cables, and without interfering with the functionality of other I/O-modules.

Digital inputs I/O have to be designed for 24 VDC signal level, and have to be current-sinking type. Each channel has to have noise suppression circuits. Each channel has to have indication of signal state. There has to be galvanic separation between field signals and the module electronic circuits. Each channel has to have separate supply and signal connection terminals.

Digital outputs I/O have to be designed for 230 VAC signal level, 3 A continuous current, normally open contact relay type. Each channel has to have indication of signal state. Each channel has to have separate supply and signal Analogue I/O signals have to be individually configurable for 0..20 mA, 4..20 mA, 0..10 V or 2..10 V. There has to be galvanic separation between field signals and the module electronic circuits. Resolution has to be 12 bits or higher. Voltage outputs have to be short circuit proof. Each channel has to have interference suppression and surge suppression circuits. Each channel has to have separate supply and signal connection terminals.

RTD and thermocouple circuits have to use I/O-modules that are specially designed for the purpose.

Analogue signals have to be supervised for abnormal signal levels; Overflow (and underflow where applicable). Status has to be indicated as described in separate documents.

Fault in any I/O-station is not to affect communication with other I/O-stations.

B. Capacity and performance

On completion of commissioning, the system has to have the below stated spare capacity (minimum requirements): Primary memory spare capacity: 50 % (capacity required to perform on-line changes has not to be included),

Processor load: 50 % (10 s average value),

Communications buses load: 50 %,



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Installed I/O: 30 % spare channels for each installed type of I/O, Power supplies: 50 % power spare for each power supply.

On completion of commissioning, the system has to fulfill the below stated performance (minimum requirements):

Time from when a change of signal level at an I/O-terminal is made, and until the change is available for the application program: Digital inputs: 50 ms. Analogue Inputs: 250 ms.

Time from when a change of value is made by an application program, and until the change may be observed at an I/O-terminal: Digital outputs: 20 ms. Analogue outputs: 50 ms.

Applications:

o Motors and valves are generally to be executed each 200 ms. o Other object types, e.g. PID-controllers and sequences are generally to be executed each 500 ms. The system has to allow for shorter execution intervals (≥ 50 ms) for individuals of all object types.

C Power failure

On power failure the PLC unit shall have uninterruptable power supply to avoid losing data .

6.12 DOCUMENTATION

General

Documentation has to be written in English language. In addition, documentation addressing operators are to be written in Arabic language.

Documentation has to be delivered in paper format and in digital format on CD.

Paper format has to be A 4 size paper.

Digital format has to be the file format in which the document was produced, and portable document format (.pdf).

The structure of digitally stored documents has to be equivalent to the structure used for the paper format document.

Documents to be delivered prior to production start up

The documents have to be delivered in two paper copies and one pdf-format copy on CD. The documentation has to comprise:

Document list

Dimensional drawings

Erection drawings

Data sheets

EMC conformity documentation

Installation manuals

System layout diagram

System description describing the components of the system and their respective tasks

Type solutions description describing process-, program and operator interfaces and control functions

Operator interface user s manual describing: o Operator workplace hardware and operation o Display screen contents, layout and operation o Display selection and exchanging o Object presentation

o Object interaction, dialog and maneuvering

o Event handling; Alarm notification and indication, lists layout and contents, alarm acknowledgement

o Report handling; Creating, storing, printing o How to interpret information in system displays

I/O-list

Circuit diagram

Apparatus list

Cable list

External connection list

Internal connection list

Sign list

User manuals

The documents have to be delivered in three paper copies and one CD copy on pdf-format.

The documentation has to include:



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Current versions of previously delivered documents

Complete controller configuration and application program documentation printout

- o Variable list o I/O list

- o Code and comments

Complete controller configuration and application program backup on CD

System software

Software and hardware licenses

Test documentation

Maintenance instructions covering routine and preventative maintenance including:

- o Recommended maintenance intervals, o List of consumable items and suppliers,

Fault finding and corrective maintenance instructions: o How faults are indicated at the operator interface and on the respective component o What tools to use in the fault finding procedure o How to correct the fault o Where to get external support

- o List of recommended spare parts, number of each item and supplier

Descriptions of procedures for application backup and restore of application backup

Descriptions of procedures for system software installation

Description of procedures for restoration of system after system break down.



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